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ABSTRACT

Because of the continuing expansion and acceleration of technology related to the electronics/electrical field, it is necessary to periodically review and revise electronics/electrical curricula to reflect the state of the art. This curriculum guide is the result of such review and revision. Contained are suggested curricula by quarters, course descriptions, job descriptions, job competencies (performance levels compatible with "Dictionary of Occupational Titles" job categories and competencies for selected entry/exit points within the curriculum), course outlines with objectives, and instructional equipment lists. It is noted that, in some cases, the texts suggested will need additional supplementary information. The electronics/electrical curriculum is designed with a common core of courses for the first four quarters, with specialization occurring during subsequent quarters. Areas of specialization include electromechanical technology, electrical technology, instrumentation technology, and electronics technology. The electronics technology curriculum is designed so that a student may specialize in different areas within this curriculum, according to local needs. This manual is available as an aid for institutions wishing to update or to implement an electronics/electrical curriculum. (JDS)

FOREWORD

The Department of Community Colleges encourages institutions to review and update continually curriculums to prepare students to work with current technology in their fields. The Electronics/Electrical Technology Curriculum Manual represents an effort coordinated by the Department to update and improve curriculums in the electronics/electrical cluster. Most of the institutions offering electronically or electrically based technology curriculums have had input into this work. We feel it represents some of the best thinking of instructors involved in these curriculums and we recommend your consideration of its implementation at your institution.

Staff of the Program Development Section and members of the Electronics Curriculum Committee are available to discuss specific concepts of the curriculum with you.

Roger G. Worthington

Roger G. Worthington, Director
Program Development

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President

PREFACE

The Electronic Instructor's group at their winter meeting in 1973 set an electronics curriculum committee to update the electronics/electrical curriculums. This committee thoroughly reviewed the existing curriculums as well as the competencies needed for entry into the job market today.

This manual is largely the outgrowth of the work of this committee and of Mr. Frank Gourley, Jr. of the Department of Community Colleges.

The Electronics Curriculum Committee arrived at the curriculum presented in this manual by considering primarily the needs of the students in our time of ever accelerating and expanding use of more highly sophisticated electronic gear in everything from our everyday living to interplanetary travel and worldwide TV. To get employment today, the technician must primarily have a good and thorough background of basics in electricity, electronics, mathematics and physics that will enable him/her to absorb very quickly the more specialized knowledge in the electronics/electrical fields. Just what constitutes this basic background is in itself a constantly changing and expanding thing that requires that electronic curriculums also be in a continual state of flux. To keep abreast of this field it is essential to continually evaluate the electronic curriculums.

The electronics/electrical technology curriculums now offered in the system differ primarily only in their options or field of specialization in the last few quarters of the curriculum. The local needs and job opportunities necessitate this specialization at the institution. This need to have curriculums that provide for local differences led directly to the development of the broad cluster concept that is presented here.

By appropriate arrangement of the course content, it is possible to provide marketable skills to those who find it necessary to seek employment before completion of the program.

It is intended that the curriculums presented herein be considered by each institution's advisory committee and through their counsel and advice make adjustments and additions to conform to local job opportunities. This manual should serve as a model for institutions to develop a quantity curriculum that provides for local needs.

I strongly recommend that consideration be given to trying the ideas and approaches presented herein as it is based upon the experience, insight, advice and work of a great many individuals. It is hoped that this manual will assist those that may be considering initiating one of these programs or altering an existing curriculum with the intent of improving, vitalizing or modernizing it.

Roy Gull, Chairman
Electronics Curriculum Committee
January, 1977

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INTRODUCTION

Electronics and electrical curriculums have been offered by North Carolina technical institutes and community colleges since their establishment as industrial education centers in 1958. These curriculums have been offered to meet a growing need in the State for personnel trained in the electronics/electrical fields.

Electronics technology was first offered in 1958, with electrical technology initiated in 1962. Other technology curriculums in this field include instrumentation technology and electromechanical technology established in 1967. Other electronically/electrically oriented curriculums include electronics servicing, electrical installation and maintenance, marine electronics, electronic product servicing, electrical appliance repair, vending machine maintenance, and industrial electronic servicing.

In 1965-1966 the electronics and electrical technologies were revised. At that time the curriculum committee revising these programs saw fit to coordinate courses in the two curriculums to the extent that the first three quarters of each curriculum were the same. As the instrumentation, electromechanical and marine electronics curriculums were developed, this same format was followed. This format has proved workable administratively and instructionally.

Due to the rapid and significant changes in the field of electronics and the subsequent revisions in these curriculums in local institutions, instructors in electronics/electrical curriculums felt it necessary to review the curriculums to determine changes that might be desirable.

Other concerns expressed, in addition to that of updating the curriculum, included that of structuring for flexibility in curriculum emphasis among institutions, providing positive alternatives to enhance the success of the under-prepared student, improving the retention rate of students, providing opportunities for multi-exit, developing employable skills early in the program, and defining job performance objectives and educational competencies.

As a result of these concerns the Electronics Curriculum Committee was established. This committee included instructors in electronics/electrical curriculums from technical institutes and community colleges across the State. Curriculums represented included electronics, instrumentation, electromechanical and electronic servicing. The committee proposed that it review the existing state curriculum guide, recommend modifications to update the technical content of the guide, identify core concepts in the curriculum, define performance levels within the curriculum, determine the concepts needed to support each performance level, propose possible early skills development approaches, define admission criteria, explore the commonality of servicing and technology curriculums, propose possible advanced technology programs for graduates, obtain responses to the curriculum from industrial advisory personnel, and present recommendations to electronics/electrical instructors for review, critique and approval.

The committee's activities resulted in updated electronics/electrical curriculums that include: 1. Instruction in recent developments such as digital electronics, integrated circuits and microprocessor fundamentals; 2. Electrical and electronic fundamentals courses organized using the systems approach to provide a qualitative (How) overview of systems which then proceeds to a study of components, after which a quantitative study of components progresses back to a study of the systems; 3. Optional emphases within the electronics technology curriculum to provide institutional flexibility to the curriculum; 4. Content rearranged to provide employable skills early in the curriculum and to provide hands-on skills to motivate students; 5. Performance levels compatable with Dictionary of Occupational Titles (D.O.T.) job categories and competencies for selected entry/exit points within the curriculum; 6. Suggested course schedules for six quarter and seven quarter programs; 7. Performance objectives and course content for the total curriculum; 8. Suggested lab experiences and instructional resources for the instructor ; 9. Course scheduling that provides for the development of mathematical skills prior to their use in science and technical courses; 10. A "light" first quarter to allow for student adjustment and the inclusion of developmental skills courses such as math laboratory and reading skills improvement where necessary; and 11. Revised curriculum guides and course outlines for the Electronics, Electrical, Electro-mechanical and Instrumentation technology curriculums.

Plans exist to explore the feasibility of adapting other electronics/ electrical curriculums to provide for further integration and options to the career cluster established by this project.

This manual provides information developed to support institutions wishing to implement the revised curriculums. Emphasis of the manual is on the software needed to implement the revisions. In addition to curriculum guides, course outlines and equipment lists, the manual includes job descriptions, job competencies, and performance objectives for electronics, electrical, electromechanical, and instrumentation curriculums.

Performance objectives and job competency statements can be used to determine advanced placement of students with prior experience or education in the field of electronics and the employable skills of early leavers. Job competency statements and performance objectives can be used in helping focus the instructional activities of the curriculum. These statements were developed by the Electronics Curriculum Committee, with the help of D.O.T. job descriptions and based on their teaching experiences and their experiences in placing early leavers and graduates in electronics/electrical fields.

The electronics curriculum has been reviewed and discussed in two different statewide meetings of electronics instructors with favorable concensus at both meetings. The electrical, electromechanical, and instrumentation curriculums were updated and reviewed by the institutions offering each curriculum. The concensus of their comments are included in this manual.

PROGRAM IMPLEMENTATION

Planning Considerations

This manual is available as an aid for the institution wishing to update its electronics/electrical technologies as well as for the institution wishing to initiate a new curriculum in the electronics/electrical cluster. The institution wishing to revise its electronics/electrical technology curriculum should be able to make the transition with little difficulty. Suggested curriculums by quarters, course descriptions, job descriptions, job competencies, course outlines with objectives, and equipment lists are provided. Texts suggested in the course outlines should be reviewed and evaluated along with the course outlines to assist in teaching courses where a systems approach is recommended. In some cases the texts suggested will need additional supplementary information. The institution should also evaluate its laboratory equipment to assure that equipment is available to teach newer electronics concepts.

Methods of Implementation

An institution revising its existing curriculum may adopt the suggested curriculum totally, based on the recommendations of its advisory committee. A second method of implementing the suggested curriculum is to choose courses to gradually replace present electronics/electrical technology courses. The initial courses might include second year courses such as Digital Fundamentals and Electronic Systems courses. The second phase of courses might include the basic electronics courses and the final phase completely replacing the present curriculum.

Institutions implementing a curriculum in this cluster are encouraged to adopt the curriculum, as presented in this manual. These curriculums are designed to provide persons in the electronics/electrical fields with the inherent flexibility required to adapt to rapidly changing technology. Instructional materials are available to help outline the concepts to be taught and the order of teaching them. Texts and references have been suggested that are organized in a manner consistent with the proposed course structure or have content compatible to the teaching of these concepts. Objectives and competency statements have been provided to assist in defining the suggested educational outcomes of the courses and the curriculum. In some cases material should be consolidated from several sources to provide the appropriate content for the course. Additional texts should be reviewed to determine the appropriateness of each to the course being taught.

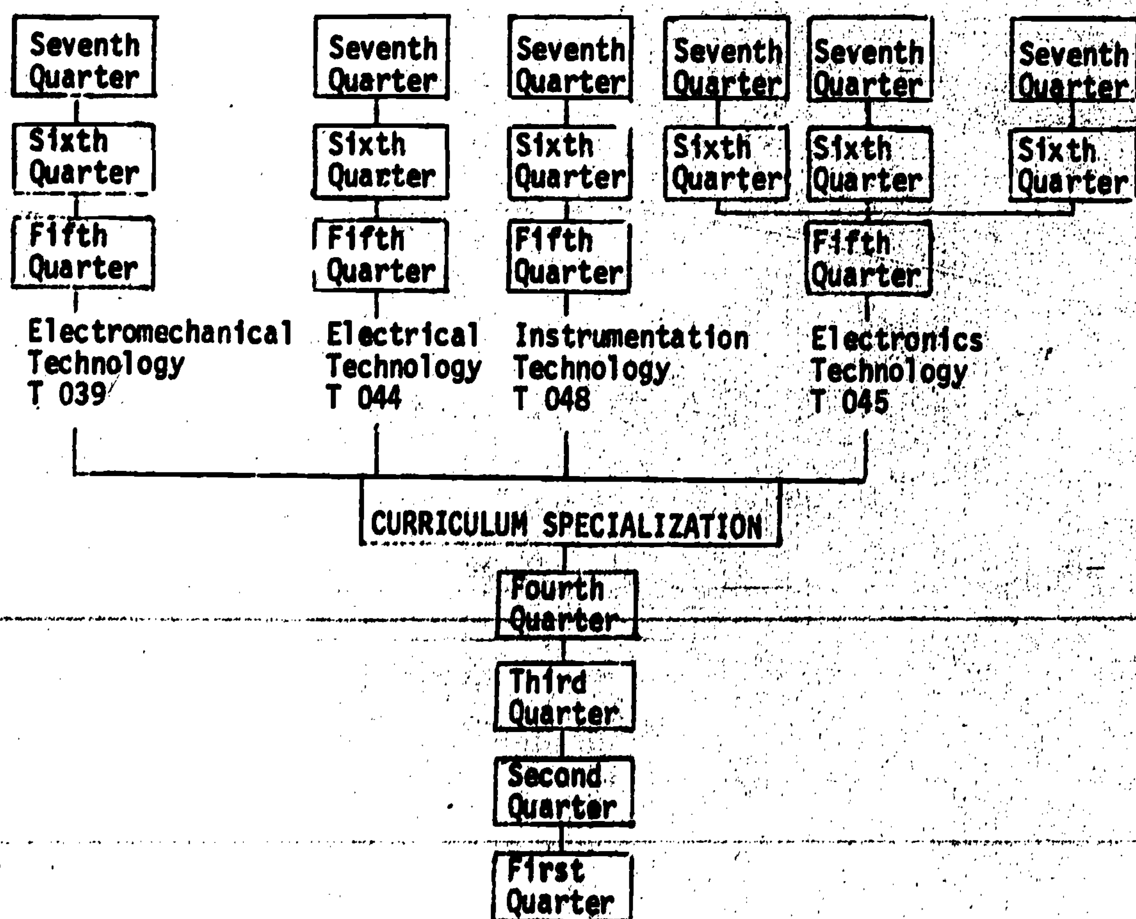
Equipment for the curriculums is identified in Equipment List No. 61 Electronics, No. 60 Electrical, No. 190 Electromechanical and No. 101 Instrumentation. These equipment lists provide a list of equipment that may be selected for use in the technical specialty laboratories. The Electronics equipment list supports the Electromechanical and Instrumentation curriculums also. Estimated costs for equipment can be determined by reviewing the appropriate equipment lists. (See the section titled Equipment Lists.)

The basic equipment found in most institutions offering electronics/ electrical curriculums provides the core support for the curriculums. Additional equipment may be necessary to orient the instructional program to new technology in electronics, depending on the extent to which the institution has kept up to date with the field and the particular option being chosen for emphasis by the institution.

The curriculums included in this manual supersede earlier curriculums by the same numbers and titles. No official action is necessary at the State level for the institution choosing to modify its existing curriculum to the new format unless the curriculum is being extended from six to seven quarters. In the final quarters of the Electronics Technology (T-045) curriculum the institution may wish to emphasize communication, computers, or automatic controls (or a combination of the three) based on the recommendations of the local advisory committee for the curriculum. Institutions wishing to add a new curriculum in the cluster must submit a curriculum application through the normal channels for approval by the State Board of Education.

CURRICULUM DESIGN

The Electronics/Electrical curriculum cluster is designed with a common core of courses for the first four quarters. Each of the four curriculums shown is designed as a separate curriculum and is assigned a separate curriculum code. An institution may wish to implement one or a combination of the curriculums included; however, each curriculum offered must be approved by the State Board of Education. Other curriculums may be developed to branch off or to feed into the matrix as the need arises. The Electronics Technology has specialized electives the last two quarters. This allows an area of concentration to serve local needs if the institution so chooses. For additional information see the Electronics curriculum guide.

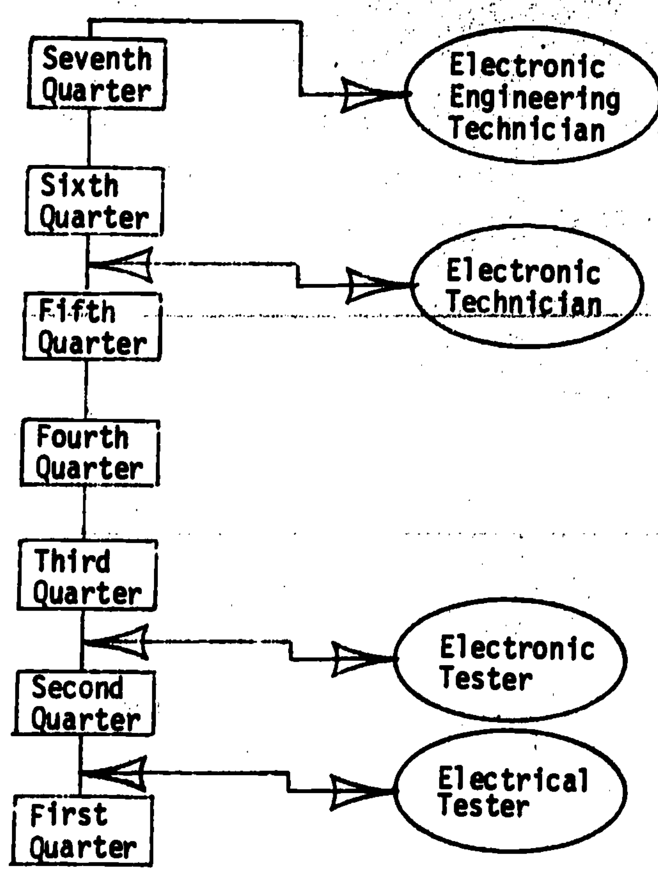


Levels of performance have been identified using job competency and performance objective statements to help in evaluating student entry and exit points. These entry level job categories are the subject of the following section.

JOB DESCRIPTIONS/JOB COMPETENCIES

Suggested job descriptions and job competencies have been identified for the electronics engineering technician, electrical engineering technician, electromechanical technician and instrumentation technician. These general statements can be used to assist in describing the types of educational experiences recommended for students prior to graduation from the particular curriculum. It is recommended that these statements be reviewed and refined by the local advisory committee to assist the institution in meeting local manpower needs. Further assistance might be provided by the local advisory committee by reviewing course objective statements provided in the course outlines and identifying additional specific instructional activities in support of the overall curriculum objectives.

Job descriptions and job competencies are also provided for several job categories at levels intermediate to the completion of the technology curriculum. Job titles for these intermediate levels are electrical tester, electronic tester, and electronic technician. This information is included preceeding the Electronics Engineering Technician information, but it has relationship to the other technologies as well. The following chart suggests typical job categories that could be filled by individuals proceeding through the Electronics Technology curriculum.



Electrical Tester

Job Description

Tests electrical devices using instruments such as bridges, galvanometers, oscilloscopes and variable voltage power supplies. May measure resistance, current, voltage or other electrical characteristics to determine conformance to written specifications. May keep inspection records and write procedure reports.

Job Competencies

Electrical Testers may:

(1) Inspect and/or replace wires, cables and connections
(2) Verify calibrations of instruments and meters via working standards
(3) Verify device control operations
(4) Follow basic electrical and electromechanical specifications
(5) Interpret wiring diagrams
(6) Use basic hand tools and devices common to electrical installation and testing
(7) Record electrical performance data
(8) Read inspection checklists and work orders to conduct inspections
(9) Test installed systems to determine conformance to specifications
(10) Demonstrate operating procedures for installed electrical system(s)

Electronic Tester

Job Description

Tests complete electronic systems, constructs test circuits, compares test data with specifications and records test data. May calibrate systems, trace defective circuits, replace defective wiring and components to return systems to production and perform functional tests of systems to evaluate performance. Uses electronic testing equipment, hand tools, soldering iron, test manuals, and schematics and wiring diagrams. May work as a systems tester, test technician, quality control technician or trouble shooter.

Job Competencies

Possible tasks that may be performed as an electronics tester (in addition to those performed by the electrical tester) include:

(1) Test complete electronics systems in terms of input/output specifications using electronics testing equipment
(2) Record and plot test data in terms of conformance to test specifications
(3) Calibrate systems to obtain specific characteristics
(4) Isolate system malfunctions which can be corrected by replacement of modules or plug-in assemblies or units
(5) Demonstrate operating procedures for installed electronic system(s)
(6) Use basic hand tools and devices common to electronics installation and testing
(7) Use installation wiring diagrams to insure proper operation

Electronic Technician

Job Description

Repairs electronic equipment, such as computers, industrial controls, radar systems, telemetering and missile control systems, transmitters, antennas, and servomechanisms, following blueprints and manufacturers' specifications, and using handtools and test instruments. Tests faulty equipment and applies knowledge of functional operation of electronic units and systems to diagnose cause of malfunction. Tests electronic components and circuits to locate defects, using instruments, such as oscilloscopes, signal generators, ammeters, and voltmeters. Replaces defective components and wiring and adjusts mechanical parts, using handtools and soldering iron. Alines, adjusts, and calibrates equipment according to specifications. Calibrates testing instruments. Maintains records of repairs, calibrations, and tests.

Job Competencies

The electronics technician is primarily responsible for the troubleshooting and repair of electronic apparatus and is capable of performing the following tasks in addition to those of the electronics tester:

(1) Test and repair modules and subassemblies which are a part of a system
(2) Assemble electronic apparatus using blueprints and assembly procedures
(3) Select and use appropriate electronic test equipment and procedures commensurate to the task

(4) Interpret schematic diagrams for troubleshooting of electronics apparatus
(5) Calibrate and align electronic test equipment to specifications
(6) Organize and maintain technical literature pertinent to troubleshooting and servicing electronic equipment

Electronic Engineering Technician

Job Description

Applies electronic theory, principles of electrical circuits, electrical testing procedures, engineering mathematics, physics, and related subjects. Builds, tests, troubleshoots, repairs, and modifies developmental and production electronic equipment, such as computers, missile-control instrumentation, and machine-tool numerical controls. Discusses layout and assembly problems with electronic engineers and draws sketches to clarify design details and functional criteria of electronic units. Assembles experimental circuitry (breadboard) or complete prototype model according to engineering instructions, technical manuals, and knowledge of electronic systems and components and their functions. Recommends changes in circuitry or installation specifications to simplify assembly and maintenance. Sets up standard test apparatus or contrives test equipment and circuitry, and conducts functional, operational, environmental, and life tests to evaluate performance and reliability of prototype or production model. Analyzes and interprets test data. Adjusts, calibrates, alines, and modifies circuitry and components and records effects on unit performance. Writes technical reports and developed charts, graphs, and schematics to describe and illustrate systems operating characteristics, malfunctions, deviations from design specifications, and functional limitations for consideration by professional engineering personnel in broader determinations affecting systems design and laboratory procedures. May check out newly installed equipment to evaluate system performance under actual operating conditions.

Job Competencies

The electronics engineering technician is primarily responsible for providing technical assistance to the engineer. After appropriate orientation to specific projects and with normal supervision, he should be able to perform the following tasks in addition to those identified for the electronics technician:

(1) Verify engineering designs
(2) Collect and analyze data
(3) Assemble and test prototype units
(4) Modify current designs
(5) Write technical reports
(6) Provide liaison between the engineer and other departments
(7) Serve as customer contact for the purposes of sales and service

Electrical Engineering Technician

Job Description

Applies electrical theory and related subjects to test, install and modify electrical machinery and electrical control equipment and circuitry in industrial or commercial plants and laboratories. Assembles and tests motor-control devices, switch panels, transformers, generator windings, solenoids, and other electrical equipment and components, according to engineering data and knowledge of electrical principles. Modifies electrical prototypes to correct functional deviations under direction of electrical engineers. Diagnoses cause of electrical or mechanical malfunction or failure or operational equipment and performs preventative and corrective maintenance. Develops wiring diagrams, layout drawings, and engineering specifications for system or equipment modifications or expansion and directs personnel performing routine isntallation and maintenance duties. Plans, directs, and records periodic electrical testing and recommends or initiates modification or replacement of equipment which fails to meet acceptable operating standards.

Job Competencies

Upon successful completion of the electrical engineering technology curriculum the student should be employable as an electrical engineering technician. After appropriate orientation to specific projects and with normal supervision, he should be able to perform the following tasks:

(1) Design, modify, install or maintain electrical machinery or equipment
(2) Diagnose and correct malfunctioning of electrical machinery, equipment, and controls
(3) Plan, set up, and/or conduct tests on electrical components or units
(4) Interpret test results and prepare technical reports for use of engineers
(5) Select and specify equipment to be purchased
(6) Support engineers by making drawings and sketches of experimental equipment
(7) Interpret wiring diagrams for electrical systems
(8) Install electrical control equipment and systems
(9) Assist engineers in the design of power distribution systems and lighting systems in industrial and commercial buildings
(10) Design the electrical and lighting layouts for residential systems.
(11) Take off materials prior to bidding on a contracting job
(12) Organize and maintain technical literature pertinent to the troubleshooting and servicing of electrical equipment

With additional experience and under normal supervision the electrical engineering technician should be able to perform the following tasks:

(1) Supervise the installation of electrical control equipment and systems
(2) Estimate electrical contracting jobs for control, lighting, and power systems
(3) Design and layout power and control systems
(4) Serve as liaison person between the engineer and production personnel
(5) Test breadboards of new and experimental equipment or processes
(6) Work in a consulting capacity in the design of systems
(7) Serve as a customer contact for the purposes of sales and service

Electromechanical Technician

Job Description

Helps design, fabricate, install, and test devices which utilize the interaction of electric impulses and mechanical controls to produce products, control functions in the manufacturing process. May troubleshoot, repair and maintain specialized electromechanical systems. Uses an analytical approach and the basic principles of electricity, electronics and mechanisms as the foundation of work with automated electromechanical systems. May work in industry or business as an engineering aide, maintenance and troubleshooting technician, field service technician, manufacturing and automated process technician, or research and development technician.

Job Competencies

The electromechanical technician is primarily responsible for providing technical assistance to the engineer. After appropriate orientation to specific projects and with normal supervision he should be able to perform the following tasks:

(1) Maintain machines of production, using electrical, electronic, mechanical, hydraulic and pneumatic mediums for power and control
(2) Maintain test equipment and instrumentation associated with the above mediums
(3) Isolate and repair machine malfunctions
(4) Isolate and repair test equipment and instrumentation malfunctions
(5) Calibrate test equipment and instrumentation

(6) Install new equipment and machines
(7) Adjust, interpret, and calibrate relatively complex equipment
(8) Test completed sub-assemblies, assemblies, and systems
(9) Repair specialized control devices that electrically or electronically sense temperature, thickness, color, pressure, flow rate or other characteristics of a material or process and automatically maintain the continuing manufacture within acceptable tolerances
(10) Understand engineering language so that principles originated by the engineer can be translated into functional products
(11) Operate systems that require an understanding of complex operational procedures where an understanding of the desired results and their purpose is essential to the quality of the final product

After additional company training and under normal supervision:

(1) Develop specifications for materials and methods of production
(2) Devise tests to insure operation, reliability, or quality control of products
(3) Act as liaison between engineering and production
(4) Install new equipment, instrumentation, and machines
(5) Troubleshoot and repair equipment, instrumentation, and machine malfunctions
(6) Serve as liaison person for customer-company relations
(7) Conduct experiments and test on new functions where the principles involved are already understood
(8) Set up, calibrate, and operate instruments in support of engineers developing new concepts, equipment, processes, etc.
(9) Fabricate and test breadboards of new or experimental equipment or processes
(10) Support engineers by making drawings and sketches of experimental equipment, or processes

Instrumentation Technician

Job Description

Selects, installs, calibrates, checks out and maintains sensing, telemetering, and recording instrumentation and circuitry. Other functions include devising, setting up, and operating instrumentation equipment involved in testing mechanical, structural, or electrical equipment. May work as an instrumentation technician, engineering aid or associate, service specialist, laboratory technician, or instrument field service technician.

Job Competencies

Upon successful completion of the instrumentation curriculum the student should be employable as an instrumentation technician. After appropriate orientation to specific projects and with normal supervision he should be able to perform the following tasks:

(1) Troubleshoot and align electronic and pneumatic controllers
(2) Adjust control systems
(3) Align and calibrate recorders and controllers
(4) Stroke control valves
(5) Troubleshoot and maintain control valves
(6) Troubleshoot and maintain test equipment
(7) Check test equipment against accepted standards
(8) Interface various instrumentation systems at different pressure or current levels
(9) Calibrate and maintain linearity of interfaced systems
(10) Work with instrumentation engineers and management in designing and installing instrumentation equipment and systems
(11) Provide liaison between engineers and operating personnel
(12) Communicate with all levels of plant personnel regarding instrumentation of the plant processes
(13) Work with systems in hazardous areas
(14) Make cable and tubing runs and properly orient instrumentation equipment
(15) Collect and analyze data
(16) Write technical reports

CURRICULUM GUIDES/COURSE OUTLINES/EQUIPMENT LISTS

The following sections of the manual include the curriculum guides, course outlines, and equipment lists for Electronics (T-045), Electrical (T-044), Electromechanical (T-039), and Instrumentation (T-048) technologies.

Curriculum guides include purpose of the curriculum, career opportunities, acknowledgements, suggested seven and six quarter curriculum schedules and course descriptions.

Course outlines include the course description, instructional objectives, outline of instruction, and suggested texts and references. They are organized according to subject matter area as identified in the contents.

Equipment lists are included for the specialized electronics/electrical laboratories. These lists are No. 61 Electronics, No. 58 Electrical, No. 190 Electromechanical, and No. 101 Instrumentation. Other equipment lists supporting these curriculums but not included here because of space limitations are No. 52 Drafting and Design, No. 140 Physics-Technical and No. 141 Physics-Vocational.

CURRICULUM GUIDES

ELECTRONICS

INTRODUCTION

Purpose of Curriculum

The Electronics curriculum provides a basic background in practical applications of electronics and in electronics related theory. Courses are designed to present content in an order that will provide the student with progressive levels of job related skills and knowledge. The curriculum is designed so that completion should prepare an individual to work as an assistant to engineers, or as liaison between the engineer and the skilled craftsman.

Career Opportunities

The electronics technician may start in one or more of the following areas: research, design, development, production, maintenance, or sales. He may begin as an electronics engineering technician, electronics technician, engineering aide, laboratory technician, supervisor, or equipment specialist.

ACKNOWLEDGMENTS

The Department of Community Colleges recognizes the valuable contributions of the following persons who served as members of the Electroni Curriculum Committee:

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David Taylor, Lenoir Community College
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ADDITIONAL INFORMATION
ON THE ELECTRONICS CURRICULUM

NOTE TO INSTITUTIONS

The Electronics Engineering Technology curriculum has been updated, modified, and broadened. Institutions adopting this curriculum have several options not previously structured in the curriculum. These are: 1. choice of a six (6) or seven (7) quarter program; 2. choice of curriculum specialties in the last two quarters to meet local industry needs, institutional capabilities, and the interests of students (an institution would normally offer only one specialty or may offer a general electronics curriculum by combining specialty courses); 3. opportunities for more flexible entry and exit levels for students; and 4. lighter course loads for students in the first quarter to improve retention of students in the curriculum.

GENERAL CONSIDERATIONS

The Electronics curriculum is designed to be taught at the engineering technology level. It is structured to provide specific job skills at several points within the two-year program. Content has been arranged in the two-year program to provide experiences appropriate for entry to these jobs. Possible job opportunities corresponding with the curriculum sequence include: first quarter, electrical tester; second quarter, electronics tester; fifth quarter, electronics technician; and seventh quarter, electronics engineering technician. Course sequences are generally structured to proceed from a qualitative study of systems to components then to shift to a quantitative study of components and progress back to systems.

Three courses in math are recommended with two more courses available as institutional electives. One or both of these elective courses may be offered if the institution and local industry feel it important for the student to be exposed to advanced mathematical concepts or if the number of students expecting to transfer from the institution to programs at the baccalaureate technology level is sufficient for a class.

Two courses in specialized electronics systems are suggested during the last two quarters. This allows each institution to develop an area of concentration if it desires. Areas proposed are communications, computers, and automatic control. Other specialized areas might be developed depending on local needs. The institutions would normally choose only one area of specialization. Supporting electives are suggested if the institution wishes to provide students with additional background in one of the designated specialty areas.

ELECTRONICS CURRICULUM

Electronic Engineering Technician → (Quarter 7)
Electronic Technician → (Quarter 6)
Electronic Tester → (Quarter 3)
Electrical Tester → (Quarter 2)

QUARTER	1	2	3	4	5	6	7
ELECTRICAL	ELC 112 5-0-6-7	ELC 113 3-0-6-5	ELC 114 3-2-0-4				
ELECTRONICS		ELN 121 3-4-0-5	ELN 122 5-0-6-7	ELN 123 3-4-0-5	ELN 218 3-4-0-5	ELN 219 3-4-0-5	ELN 246 0-6-0-3
ELECTRONIC SYSTEMS (SPECIALIZED)					ELN 241 3-0-6-5	ELN( ) 5-4-0-7	ELN( ) 5-4-0-7
ELECTIVES	*						(Elect) 4-0-0-4
MATH	MAT 101 5-0-0-5	MAT 102 5-0-0-5	MAT 103 5-0-0-5				
ENGLISH	ENG 101 3-0-0-3	ENG 102 3-0-0-3	ENG 103 3-0-0-3	ENG 204 3-0-0-3			
PHYSICS				PHY 101 3-2-0-4	PHY 102 3-2-0-4	PHY 104 3-2-0-4	
SOCIAL SCIENCE					SSC... 3-0-0-3	SSC... 3-0-0-3	
DRAFTING				DFT 113 2-0-6-4			
TOTALS Cl.-Lab.-Shop-Cr. Contact	13-0-6-15 (19)	14-4-6-18 (24)	16-2-6-19 (24)	11-6-6-16 (23)	12-6-6-17 (24)	14-10-0-19 (24)	9-10-0-14 (19)

* Institution or student may choose an institutional elective to satisfy student needs or interests.

Qualitative - How it works./Applied/Conceptual/Overview. Proceeding generally from a study of systems to components.

Quantitative - Why it works./Analytical/Mathematical/Detailed. Proceeding generally from a study of components to systems.

JOB SKILLS

Students successfully completing specified phases of the program should be qualified with certain job skills that will enable them to perform typical tasks associated with a generally recognized job title. Upon successful completion of the first quarter of the curriculum, the student should be employable in positions requiring skill in electrical testing and inspecting. Some of the possible tasks that may be performed on such a job include:

1. Inspecting and/or replacing wires, cables and connections
2. Verifying calibrations of instruments and meters via working standards
3. Verifying device control operations
4. Following basic electrical and electromechanical specifications
5. Interpreting wiring diagrams
6. Using basic hand tools and devices common to electrical installation and testing
7. Recording electrical performance data
8. Reading inspection checklists and work orders to conduct inspections
9. Testing installed systems to determine conformance to specifications
10. Demonstrating operating procedures for installed electrical system(s)

Upon successful completion of the second quarter of the curriculum, the student should be employable in positions requiring skill in electronics testing. Possible tasks that may be performed as an electronics tester (in addition to those of the electrical tester) include:

1. Testing complete electronics systems in terms of input/output specifications using electronics testing equipment
2. Recording and plotting test data in terms of conformance to test specifications
3. Calibrating systems to obtain specific characteristics
4. Isolating system malfunctions which can be corrected by replacement of modules or plug-in assemblies or units
5. Demonstrating operating procedures for installed electronic system(s)

6. Using basic hand tools and devices common to electronics installation and testing

7. Using installation wiring diagrams to insure proper operation

Upon successful completion of the fifth quarter of the curriculum, the student should be employable in positions requiring skill as an electronics technician. The electronics technician is primarily responsible for the troubleshooting and repair of electronic apparatus and is capable of performing the following tasks in addition to those of the electronics tester:

1. Testing and repairing modules and subassemblies which are a part of a system

2. Assembling electronic apparatus using blueprints and assembly procedures

3. Selecting and using appropriate electronic test equipment and procedures commensurate to the task

4. Interpreting schematic diagrams for troubleshooting of electronics apparatus

5. Calibrating and aligning electronic test equipment to specifications

6. Organizing and maintaining technical literature pertinent to troubleshooting and servicing electronic equipment

Upon successful completion of the entire curriculum, the student should be employable as an electronics engineering technician. The electronics engineering technician is primarily responsible for providing technical assistance to the engineer. After appropriate orientation to specific projects and with normal supervision, he should be able to perform the following tasks in addition to those identified for the electronics technician:

1. Verifying engineering designs

2. Collecting and analyzing data

3. Assembling and testing prototype units

4. Modifying current designs

5. Writing technical reports

6. Providing liaison between the engineer and other departments

7. Serving as customer contact for the purposes of sales and service

Electronics

SUGGESTED SEVEN QUARTER CURRICULUM

Course Title			Hours Per Week Class	Hours Per Week Lab.	Quarter Hours Credit
FIRST QUARTER					
T-ENG	101	Grammar	3	0	3
T-MAT	101	Technical Mathematics	5	0	5
T-ELC	112	Electrical Fundamentals I	5	6	7
			13	6	15
SECOND QUARTER					
T-ENG	102	Composition	3	0	3
T-MAT	102	Technical Mathematics	5	0	5
T-ELC	113	Electrical Fundamentals II	3	6	5
T-ELN	121	Electronics I	3	4	5
			14	10	18
THIRD QUARTER					
T-ENG	103	Report Writing	3	0	3
T-MAT	103	Technical Mathematics	5	0	5
T-ELC	114	Electrical Fundamentals III	3	2	4
T-ELN	122	Electronics II	5	6	7
			16	8	19
FOURTH QUARTER					
T-ENG	204	Oral Communication	3	0	3
T-PHY	101	Physics: Properties of Matter	3	2	4
T-DFT	113	Electronic Drafting	2	6	4
T-ELN	123	Electronics III	3	4	5
			11	12	16

			Hours Per Week		Quarter Hours
FIFTH QUARTER			Class	Lab.	Credit
		Social Science Elective*	3	0	3
T-PHY	102	Physics: Work, Energy, Power	3	2	4
T-ELN	241	Electronic Systems I	3	6	5
T-ELN	218	Pulse, Logic & Digital Circuits	3	4	5
			12	12	17

SIXTH QUARTER					
		Social Science Elective*	3	0	3
T-PHY	104	Physics: Light & Sound	3	2	4
T-ELN	___	Electronic Systems II: (Specialized Elective)	5	4	7
T-ELN	219	Digital Fundamentals	3	4	5
			14	10	19

SEVENTH QUARTER					
T-ELN	246	Electronics Design Project	0	6	3
T-ELN	___	Electronic Systems III: (Specialized Elective)	5	4	7
_____	___	Elective			4
			5	10	14

Total Quarter Hours in Courses	100
Electives	18
Total	118

*Refer to electives suggested in this guide.

ENGINEERING TECHNOLOGY

(ALTERNATE LENGTH CURRICULUM)

Electronics

SUGGESTED SIX QUARTER CURRICULUM

Course Title			Hours Per Week Class	Lab.	Quarter Hours Credit
FIRST QUARTER					
T-ENG	101	Grammar	3	0	3
T-MAT	101	Technical Mathematics	5	0	5
T-DFT	113	Electronic Drafting	2	6	4
T-ELC	112	Electrical Fundamentals I	5	6	7
			15	12	19
SECOND QUARTER					
T-ENG	102	Composition	3	0	3
T-MAT	102	Technical Mathematics	5	0	5
T-ELC	113	Electrical Fundamentals II	3	6	5
T-ELN	121	Electronics I	3	4	5
			14	10	18
THIRD QUARTER					
T-ENG	103	Report Writing	3	0	3
T-MAT	103	Technical Mathematics	5	0	5
T-ELC	114	Electrical Fundamentals III	3	2	4
T-ELN	122	Electronics II	5	6	7
			16	8	19
FOURTH QUARTER					
T-ENG	204	Oral Communication	3	0	3
T-PHY	101	Physics: Properties of Matter	3	2	4
T-ELN	241	Electronic Systems I	3	6	5
T-ELN	123	Electronics III	3	4	5
			12	12	17

			Hours Per Week Class	Lab.	Quarter Hours Credit
FIFTH QUARTER					
____	___	Social Science Elective*	3	0	3
T-PHY	102	Physics: Work, Energy, Power	3	2	4
T-ELN	___	Electronic Systems II: (Specialized Elective)	5	4	7
T-ELN	218	Pulse, Logic & Digital Circuits	3	4	5
			14	10	19
SIXTH QUARTER					
____	___	Social Science Elective*	3	0	3
T-PHY	104	Physics: Light & Sound	3	2	4
T-ELN	219	Digital Fundamentals	3	4	5
T-ELN	246	Electronics Design Project	0	6	3
		Elective			1
			9	12	16

Total Quarter Hours in Courses	100
Electives	8
Total	108

*Refer to electives suggested in this guide.

ELECTRONICS

COURSE DESCRIPTIONS BY QUARTERS

FIRST QUARTER	Hours Per Week Class	Lab.	Quarter Hours Credit
T-ENG 101 Grammar	3	0	3

Designed to aid the student in the improvement of self-expression through writing. Emphasis is on grammar, diction, sentence structure, punctuation, and spelling. It is intended to stimulate students in applying the basic principles of English grammar in their day-to-day situations in industry and social life.
Prerequisite: None.

T-MAT 101 Technical Mathematics	5	0	5

The real number systems is developed as an extension of natural numbers. Number systems of various bases are introduced. Fundamental algebraic operations, the rectangular coordinate system, as well as fundamental trigonometric concepts and operations are introduced. The application of these principles to practical problems is stressed.
Prerequisite: Satisfactory evidence that admission requirements have been met.

T-ELC 112 Electrical Fundamentals I	5	6	7

A qualitative study of units of measurement, electrical quantities, simple circuits, electromotive forces, current, power, laws, basic electrical instruments and measurements, resistance, impedance and basic circuit components. Concepts taught are generally limited to fundamentals with very little emphasis placed on quantitative aspects. Laboratory work will teach the proper use and care of basic hand tools and the basic manual skills used in working with electricity. Measurement techniques and safety practices will be stressed throughout.
Prerequisite: None.

SECOND QUARTER

T-ENG 102 Composition	3	0	3

English composition is designed to aid the student in improvement of self-expression by means of practical application in business and technical writing. Emphasis is on writing sentences, paragraphs and compositions. Prerequisite: T-ENG 101.

T-MAT 102 Technical Mathematics	5	0	5

A continuation of T-MAT 101. Advanced algebraic and trigonometric topics including quadratics, logarithms, determinants, progressions, the binominal expansion, complex numbers, solution of oblique triangles and graphs of the trigonometric functions are studied in depth.
Prerequisite: T-MAT 101.

T-ELC 113 Electrical Fundamentals II 3 6 5

Additional electrical concepts and circuit analysis procedures as applied to more complex two terminal and simple two port networks are introduced. Laboratory work will include additional measurement techniques with emphasis on verification of theoretical concepts.
Prerequisites: T-ELC 112 (or equivalent), T-MAT 101.

T-ELN 121 Electronics I 3 4 5

Presents qualitative electronics concepts beginning with systems and networks and proceeding to devices. Typical networks such as power supplies, amplifiers, oscillators, and feedback circuits are introduced. Solid state devices and vacuum tubes are introduced as idealized devices. Experience is provided in basic troubleshooting techniques. Instruments are introduced as needed for simple testing and measurements.
Corequisite: T-ELC 113.

THIRD QUARTER

T-ENG 103 Report Writing 3 0 3

The fundamentals of English are utilized as a background for the organization and techniques of modern report writing. Exercises in developing typical reports, using writing techniques and graphic devices are completed by the students. Practical application in the preparation of a full-length report is required of each student at the end of the term. The report must relate to the student's specific curriculum.
Prerequisite: T-ENG 102.

T-MAT 103 Technical Mathematics 5 0 5

The fundamental concepts of analytical geometry, differential and integral calculus are introduced. Topics included are graphing techniques, geometric and algebraic interpretation of the derivative, differentials, rate of change, the integral and basic integration techniques. Applications of these concepts to practical situations are stressed.
Prerequisite: T-MAT 102.

T-ELC 114 Electrical Fundamentals III 3 2 4

Advanced circuit analysis techniques as applied to two port passive networks are introduced with emphasis on analysis and mathematical computations. Laboratory experiences are used to support analysis activities.
Prerequisites: T-ELC 113, T-MAT 102.

T-ELN 122 Electronics II 5 6 7

A quantitive study beginning with active control devices and proceeding to networks. A variety of equivalent circuit models are used to evaluate device and system parameters and predict circuit performance. Instruments are used in the laboratory to collect data, verify math predictions, and troubleshoot.
Prerequisite: T-ELN 121.

FOURTH QUARTER

T-ENG 204 Oral Communication 3 0 3
The principles, techniques, and practical applications of communicating the thoughts and personality through the voice and visible action of the individual to one or more persons for the purpose of achieving a previously determined response. Areas covered vary according to class needs, but, in general, include: basic concepts, nonverbal and verbal language, vocal usage, speech preparation (analyzing audience and occasion, determining purpose, selecting and narrowing subject, gathering and organizing material, wording, and practicing aloud), and effective listening.
Prerequisite: None.

T-PHY 101 Physics: Properties of Matter 3 2 4
A fundamental course covering several basic principles of physics. The divisions included are solids and their characteristics, liquids at rest and in motion, gas laws and applications. Laboratory experiments and specialized problems dealing with these topics are part of this course.
Prerequisite: None.

T-DFT 113 Electronic Drafting 2 6 4
The fundamentals of drafting are presented with an emphasis on applications in the electronics field. Basic skills and techniques are included such as the use of drafting instruments, types of drawings, construction of drawings both with instruments and freehand, lettering and dimensioning, and how to read prints. In addition to basic skills, specialized experience will be included which directly relates to the electronics industry, such as types of drawings common to electronics, special symbols used, schematic diagrams, and layout diagrams with an emphasis on printed circuit work.
Prerequisite: None.

T-ELN 123 Electronics III 3 4 5
Continues the study of active networks. Emphasis is on the analysis and design of both networks and active circuits. In addition fundamentals, design techniques, and typical applications of linear integrated circuits are introduced.
Prerequisites: T-ELN 122, T-MAT 103.

FIFTH QUARTER

T-PHY 102 Physics: Work, Energy, Power 3 2 4
Major areas covered in this course are work, energy, and power. Instruction includes such topics as statics, forces, center of gravity and dynamics. Units of measurement and their applications are a vital part of this course. A practical approach is used in teaching students the use of essential mathematical formulas.
Prerequisites: T-MAT 101, T-PHY 101.

T-ELN 241 Electronic Systems I 3 6 5
A general survey of electronic systems with emphasis on their description in block diagram format. Systems to be studied are those used in communications, computing, measurement, automatic control, and others of a specialized nature as appropriate.
Prerequisite: T-ELN 123.

T-ELN 218 Pulse, Logic and Digital Circuits 3 4 5

Emphasizes the study of wave shaping and non-sinusoidal wave generating circuits using discrete and integrated components. Wave shaping topics include simple passive wave shaping circuits and more complicated wave shaping circuits using active devices. Topics covered under non-sinusoidal wave generating circuits include multivibrators, sweep generators, and other types of special purpose circuits using discrete and integrated components. An introduction to Boolean algebra and its applications for the simplification of logic circuits is also included. Prerequisite: T-ELN 123.

SIXTH QUARTER

T-PHY 104 Physics: Light & Sound 3 2 4

A survey of the concepts involving wave motion leads to a study of sound, its generation, transmission and detection. The principles of wave motion also serve as an introduction to a study of light, illumination and the principles involved in optical instruments. Application is stressed throughout.
Prerequisites: T-MAT 101, T-PHY 101.

T-ELN (242/247/249) Electronic Systems II: 5 4 7
Options: (1) Communications, (2) Computers, or (3) Automatic Control

(Choose appropriate title and course description from elective section.)

T-ELN 219 Digital Fundamentals 3 4 5

Emphasizes the study of combinational and sequential logic circuits using discrete and integrated components. Topics include: binary arithmetic, numbering systems, Boolean algebra, storing, timing, gating, and counting. Typical applications in industry will be presented.
Prerequisite: T-ELN 123.

SEVENTH QUARTER

T-ELN 246 Electronics Design Project 0 6 3

A laboratory class emphasing independent research and design work by the student. The student will select a project in consultation with the instructor; perform the required research; compile data; formulate a theoretical model; and construct, test, and evaluate a working model of the selected project.
Prerequisite: T-ELN 241.

T-ELN (243/248/250) Electronic Systems III: 5 4 7
Options: (1) Communications, (2) Computers, or (3) Automatic Control

(Choose appropriate title and course description from elective section.)

ELECTIVES

The following is a list of electives for this curriculum from which the institution may select courses to complete the program of study. The institution has the prerogative to develop new courses for the electives or modify courses from the suggested list to fulfill local objectives. It is suggested, however, that technical courses be related to the major area of study. These courses should not change or alter the major objectives of the program nor create a false impression of proficiency in an area either related or foreign to the major.

Elective courses selected must be associate degree courses or new courses should be developed at a comparable level. The institution may elect to require certain electives or may let the student select an appropriate elective.

ELECTRONICS

T-ELN 242 Electronic Systems II: Communications	5	4	7

Introduction to fundamental aspects of electronic communication systems with special emphasis on need for modulation, types of modulation, frequency spectra and bandwidth requirements. Qualitative study of the principles of AM, SSB, and FM including the generation and detection of signals and their frequency spectra. Transmission and propagation of radio signals will be studied.
Prerequisite: T-ELN 241.

T-ELN 243 Electronic Systems III: Communications	5	4	7

Study of specialized electronic communication systems such as TV, microwave, radar, and optical communication systems. Discussion of sampling and pulse systems including techniques of multiplexing such as PAM, PDM, PCM, and PPM.
Prerequisite: T-ELN 242.

T-ELN 247 Electronic Systems II: Computers	5	4	7

The course consists of a functional block diagram analysis of a number of digital computer systems. Emphasis is placed on the mini/micro computer variety currently being used in industry. The lab will provide practice in manipulating the hardware and software associated with such computers.
Prerequisite: T-ELN 241.
Corequisite: T-ELN 217.

T-ELN 248 Electronic Systems III: Computers	5	4	7

This course deals with the detailed theory of the computer systems pre-

viously covered followed by troubleshooting and maintenance procedures. The lab consists of digital measurements in support of operation theory followed by actual troubleshooting practice, dealing with systems analysis and diagnostic procedures.
Prerequisite: T-ELN 247.

T-ELN 249 Electronic Systems II: Automatic Control 5 4 7

Automatic control concepts including calibration, measurement and standards are introduced. Laboratory exercises are provided on simulated or generalized measurement and control systems that include indicators, recorders, and controllers. Emphasis is placed on process or system stability using various types of controllers. Final control elements and their characteristics are studied. Graphical analyses and solutions of process control systems are included.
Prerequisite: T-ELN 241.

T-ELN 250 Electronic Systems III: Automatic Control 5 4 7

A study of automatic control theory and processes including the characteristics and mathematical models of linear systems. Practice is provided in specifying and selecting process or automatic control parameters and equipment. Electronic and mechanical controls are introduced as well as the use of the minicomputer in the control loop. Practical analysis and evaluation on actual or simulated processes or systems is covered in the laboratory.
Prerequisite: T-ELN 249.

SUPPORTING TECHNICAL ELECTIVES

T-MAT 201 Technical Mathematics 5 0 5

A continuation of T-MAT 103. More advanced concepts of differentiation and integration are considered. Included are graphs and derivatives of the trigonometric functions, exponential and logarithmic differentiation and integration, advanced integration techniques, polar equations, parametric equations and Fourier series.
Prerequisite: T-MAT 103.

T-ELN 225 Transmission and Propagation 3 0 3

An introduction to the electromagnetic radiation, principles of antenna, radiation patterns and field strength. The characteristics and use of transmission lines in radio frequency application. Factors involved in propagation, ground waves, reflections, sky waves, atmospheric effects, ionosphere, fading, noise, static, wire radiators, directive gain, effect of ground, impedence, antenna systems and arrays.
Prerequisite: T-ELN 105.
Corequisite: T-ELN 205.

T-ELN 227 UHF and Microwave Systems 5 4 7

A study of UHF and VHF components, circuits, and measurement techniques. The use of distributed constant elements, waveguides and coaxial cables, microwave links, high frequency oscillators, magnetrons, klystrons,

traveling wave tubes. An introduction to the use of the Smith Chart.
Prerequisite: T-ELN 225.

T-MAT 208 Calculus and Laplace Transforms for Electronics	5	0	5

An investigation of the methods of calculus which are the most direct use in the study of electronic circuits. Introduction to selected topics from differential equations and laplace transforms and applications of these methods to the solution of electronic circuit problems.
Prerequisite: T-MAT 201.
Corequisite: T-ELN 218 or T-ELN 214.

T-ELN 233 F.C.C. First and Second Class License	4	0	4

To provide a knowledge of transmitter electronics to the level required of an examinee for the F.C.C. Radiotelephone Operator 1st and 2nd Class License.
Prerequisite: Instructor's approval.

T-EGR 106 Fortran with Engineering Applications	3	0	3

Deals with the method in which computers are used to solve engineering problems. A scientific programming language (FORTRAN) is used to solve practical examples of engineering problems.
Prerequisite: Instructor's approval.

T-ELN 240 Digital Computers	3	0	3

An exploration into the methodology of counting and computing. Various computer techniques will be investigated including: non-sinusodial waveforms, binary and decade counters, industrial counters, readout devices, logic circuits, arithmetic circuits, storage devices, input-output devices, computer control, analog and digital converters.
Prerequisite: T-ELN 218 or T-ELN 214.

T-MEC 110 Fundamental Mechanisms	2	4	4

A study of the purpose and actions of cams, cables, gear trains, differentials, screws, belts, pulleys, shafts, levers, and other mechanical devices used to transmit or control signals.
Prerequisite: T-PHY 102.

T-ELN 235 Industrial Instrumentation	4	6	7

Broad introduction to use of industrial electromechanical and elect circuits and equipment. Provides an understanding of the methods, techniques, and skills required for installation, service and operation of a variety of industrial control systems. Analysis of sensing devices for detecting changes in pressure, temperature, humidity, sound, light, electricity, the associated circuitry and indicating and recording devices.
Prerequisites: T-ELN 205, T-PHY 104.

T-MEC 235 Hydraulics and Pneumatics	3	3	4

The basic theories of hydraulic and pneumatic systems. Combinations

of systems in various circuits. Basic designs and functions of circuits and motors, controls, electrohydraulic servomechanisms, plumbing, filtration, accumulators and reservoirs.
Prerequisite: T-PHY 102.

T-PHY 231 Fluid Mechanics 3 0 3
Fundamental laws of fluid flow and applications of these laws to the sizing of hot and cold water piping, steam piping, refrigerant piping, air ducts, pumps, and fans. Particular emphasis will be directed to calculations of capacity, horsepower, and head requirements of pump and fans; to comparison of the several methods of piping and air duct sizing; and to methods of fluid flow measurement.
Prerequisites: T-MAT 103, T-PHY 102.

T-MEC 240 Measuring Principles 1 3 2
A study of the more common sensing elements and components which are generally classified as mechanical instruments. The devices studied are those which are employed for measurement of temperature, pressure, flow and related phenomena. Emphasis is placed upon the few basic principles which are used in a wide variety of instruments available for process control.
Prerequisites: T-MAT 103, T-PHY 101.

T-PHY 209 Thermodynamics 3 0 3
A basic course to familiarize the student with the principles of thermodynamics. Topics include heat, temperature, work and the first and second laws of thermodynamics, with basic applications. Gases, vapor cycles, combustion and the internal combustion engine are studied.
Corequisite: T-PHY 102.

T-MAT 225 Numerical Analysis 5 0 5
A development of the mathematical principles upon which many computing methods are based. Topics introduced include theory of errors, numerical integration and differentiation, summation procedures, numerical solution of equations, and approximations of various types.
Prerequisite: T-MAT 201.

T-ELN 208 Industrial Electronics 5 3 6
Electronics as applied to a production system, rectification; electronically controlled rectifiers, servomechanisms, motors; magnetic amplifiers; ultrasonic cleaning; and variable strobe light.
Prerequisite: T-ELN 121 or T-ELN 105.

T-EGR 105 Computer Techniques 3 2 4
Fundamental concepts and operational principles of the computer are introduced. Various computer subsystems will be investigated including input-output devices, arithmetic units, storage systems, and computer control. Typical applications in industry will be presented.
Prerequisite: None.

T-ELN 230 Television Systems 4 6 7
A study of the principles of television including the television system, camera tubes, scanning and synchronization, composite video signal,

receiver circuits, transmitting equipment, color television, and closed-loop systems.
Corequisite: T-ELN 218, T-ELN 214.

T-ELN 236 Color Television 5 6 7

Principles of colorimetry and the physics of color as they relate to the NTSC Standard Color Television System are introduced. The color camera, chrominance section, matrixing sections and synchronization sections of color transmitting equipment and basic color receiver circuits are studied from schematics. Specialized color testing and alignment equipment are studied and used in the laboratory.
Prerequisite: T-ELN 230.

T-ELN 226 Control Systems Analysis 3 6 5

A study of the response of systems to instrument control based upon consideration of the systems components. Negative and positive feedback along with the implications of closed-loop control are covered. Sequence of operation to include ladder diagrams and interlocks, logic diagrams, and relay circuits.
Prerequisite: T-ELN 101.

T-CHM 104 Industrial Chemistry 3 3 4

Study of fundamental principles of chemistry including structures, chemical bonding, the periodic system, chemical reactions, and solution chemistry. Descriptive chemistry illustrating various industrial applications. Designed to develop a background for further studies in metallurgy and other engineering materials.
Prerequisite: None.

T-ELC 210 Rotating Devices 2 2 3

Introduction to electrical machinery. AC and DC motor and generator principles, synchros and servomechanisms, alternators and dynamotors, Ward-Leonard and amplidyne control systems will be analyzed. A general knowledge of the theory, operation, and maintenance of these devices and systems will be stressed.
Prerequisites: T-ELC 114 or T-ELC 102, T-PHY 102.

T-ELN 244 Feedback Control Systems 3 2 4

An introduction to the theory and application of feedback control principles, including the characteristics of linear feedback systems, transfer functions, open and closed-loop networks, first and second order damping circuits, complex-plane analysis, the root locus, flow diagrams, gain-phase relationships, and systems design utilizing Bode and Nichols charts.
Prerequisites: T-ELN 122, T-MAT 102.

T-MAT 211 Basic Statistics 3 0 3

An introduction to basic concepts of statistics including point and interval estimates; chi-square; frequency distribution; ratios, rates and percentages. Normal distribution, mean and standard deviation, interval estimates, t-distribution, and coefficient of variation are covered.
Prerequisite: None.

SOCIAL SCIENCE ELECTIVES

T-SSC 201 Social Science 3 0 3
An integrated course in the social sciences drawing from the fields of anthropology, psychology, history, and sociology.
Prerequisite: None.

T-SSC 202 Social Science 3 0 3
A further study of social sciences with emphasis on economics, political science, and social problems as they relate to the individual.
Prerequisite: T-SSC 201.

T-PSY 206 Applied Psychology 3 0 3
A study of the principles of psychology that will be of assistance in the understanding of inter-personal relations on the job. Motivation, feelings, and emotions are considered with particular reference to on-the-job problems. Other topics investigated are: employee selection, supervision, job satisfaction, and industrial conflicts. Attention is also given to personal and group dynamics so that the student may learn to apply the principles of mental hygiene to his adjustment problems as a worker and a member of the general community.
Prerequisite: None.

T-SSC 205 American Institutions 3 0 3
A study of the effect of American social, economic, and political institutions upon the individual as a citizen and as a worker. The course dwells upon current local, national, and global problems viewed in the light of our political and economic heritage.
Prerequisite: None.

T-POL 201 United States Government 3 0 3
A study of government with emphasis on basic concepts, structure, powers, procedures and problems.
Prerequisite: None.

T-SOC 207 Rural Society 3 0 3
A study of selected elements of rural sociology with emphasis on current social changes. The course provides a sociological background for the understanding of rural social changes. Areas of study include rural culture, group relationships, social classes, rural and suburban communities, farm organizations, the communication of agricultural technology, rural social problems, agricultural adjustment and population change.
Prerequisite: None.

T-ECO 108 Consumer Economics 3 0 3
Designed to help the student use his resources of time, energy, and money to get the most out of life. It gives the student an opportunity to build useful skills in buying, managing his finances, increasing his resources, and to understand better the economy in which he lives.
Prerequisite: None.

ELECTRICAL

INTRODUCTION

Purpose of Curriculum

The Electrical curriculum provides a basic background in practical applications of electricity and in electrical related theory in power, lighting, and control systems. Courses are designed to present content in an order that will provide the student with progressive levels of job related skills and knowledge. The curriculum is designed so that completion should prepare an individual to work as an assistant to engineers, or as liaison between the engineer and the skilled craftsman. The program also provides instruction on current electrical practice in the commercial, residential, utility, and industrial fields.

Career Opportunities

The electrical technician may perform such duties as estimating, specification writing, engineering sales, supervision of installations, and electrical contracting. He may work as an electrical engineering technician, engineering aide, laboratory technician, industrial electrician, or foreman.

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ENGINEERING TECHNOLOGY

ELECTRICAL

SUGGESTED SEVEN QUARTER CURRICULUM

Course Title	Hours Per Week Class	Hours Per Week Lab.	Quarter Hours Credit
FIRST QUARTER			
T-ENG 101 Grammar	3	0	3
T-MAT 101 Technical Mathematics	5	0	5
T-ELC 112 Electrical Fundamentals I	5	6	7
	13	6	15
SECOND QUARTER			
T-ENG 102 Composition	3	0	3
T-MAT 102 Technical Mathematics	5	0	5
T-ELC 113 Electrical Fundamentals II	3	6	5
T-ELN 121 Electronics I	3	4	5
	14	10	18
THIRD QUARTER			
T-ENG 103 Report Writing	3	0	3
T-MAT 103 Technical Mathematics	5	0	5
T-ELC 114 Electrical Fundamentals III	3	2	4
T-ELN 122 Electronics II	5	6	7
	16	8	19
FOURTH QUARTER			
T-ENG 204 Oral Communication	3	0	3
T-PHY 101 Physics: Properties of Matter	3	2	4
T-DFT 113 Electronic Drafting	2	6	4
T-ELN 123 Electronics III	3	4	5
	11	12	16

49

			Hours Per Week		Quarter Hours Credit
FIFTH QUARTER			Class	Lab.	
		Social Science Elective*	3	0	3
T-PHY	102	Physics: Work, Energy, Power	3	2	4
T-ELC	211	Electrical Machines I	3	3	4
T-ELC	221	Electromagnetic Controls	2	3	3
T-ELC	204	Electrical Circuits	3	3	4
			14	11	18

SIXTH QUARTER					
		Social Science Elective*	3	0	3
T-PHY	104	Physics: Light & Sound	3	2	4
T-ELC	212	Electrical Machines II	3	3	4
T-ELC	222	Solid State Controls	3	3	4
		Elective			2
			12	8	17

SEVENTH QUARTER					
T-ELN	237	Industrial Instrumentation	3	3	4
T-ELC	235	Planning Electrical Installations	3	6	5
		Elective			6
			6	9	15

Total Quarter Hours in Courses	110
Electives	8
Total	118

*Refer to electives suggested in this guide.

(ALTERNATE LENGTH CURRICULUM)

ELECTRICAL

SUGGESTED SIX QUARTER CURRICULUM

Course Title			Hours Per Week Class	Lab.	Quarter Hours Credit
FIRST QUARTER					
T-ENG	101	Grammar	3	0	3
T-MAT	101	Technical Mathematics	5	0	5
T-DFT	113	Electronic Drafting	2	6	4
T-ELC	112	Electrical Fundamentals I	5	6	7
			15	12	19
SECOND QUARTER					
T-ENG	102	Composition	3	0	3
T-MAT	102	Technical Mathematics	5	0	5
T-ELC	113	Electrical Fundamentals II	3	6	5
T-ELN	121	Electronics I	3	4	5
			14	10	18
THIRD QUARTER					
T-ENG	103	Report Writing	3	0	3
T-MAT	103	Technical Mathematics	5	0	5
T-ELC	114	Electrical Fundamentals III	3	2	4
T-ELN	122	Electronics II	5	6	7
			16	8	19
FOURTH QUARTER					
T-ENG	204	Oral Communication	3	0	3
T-PHY	101	Physics: Properties of Matter	3	2	4
T-ELC	211	Electrical Machines I	3	3	4
T-ELN	123	Electronics III	3	4	5
			12	9	16

			Hours Per Week		Quarter Hours
FIFTH QUARTER			Class	Lab.	Credit
____	___	Social Science Elective*	3	0	3
T-PHY	102	Physics: Work, Energy, Power	3	2	4
T-ELC	204	Electrical Circuits	3	3	4
T-ELC	221	Electromagnetic Controls	2	3	3
T-ELC	212	Electrical Machines II	3	3	4
			15	11	18

SIXTH QUARTER					
____	___	Social Science Elective*	3	0	3
T-ELC	222	Solid State Controls	3	3	4
T-ELN	237	Industrial Instrumentation	3	3	4
T-ELC	235	Planning Electrical Installations	3	6	5
____	___	Elective			1
			12	12	17

Total Quarter Hours in Courses	107
Electives	1
Total	108

*Refer to electives suggested in this guide.

ENGINEERING TECHNOLOGY

ELECTRICAL

COURSE DESCRIPTIONS BY QUARTERS

	Hours Per Week		Quarter Hours
FIRST QUARTER	Class	Lab.	Credit
T-ENG 101 Grammar	3	0	3

Designed to aid the student in the improvement of self-expression through writing. Emphasis is on grammar, diction, sentence structure, punctuation, and spelling. It is intended to stimulate students in applying the basic principles of English grammar in their day-to-day situations in industry and social life.
Prerequisite: None.

	Class	Lab.	Credit
T-MAT 101 Technical Mathematics	5	0	5

The real number systems is developed as an extension of natural numbers. Number systems of various bases are introduced. Fundamental algebraic operations, the rectangular coordinate system, as well as fundamental trigonometric concepts and operations are introduced. The application of these principles to practical problems is stressed.
Prerequisite: Satisfactory evidence that admission requirements have been met.

	Class	Lab.	Credit
T-ELC 112 Electrical Fundamentals I	5	6	7

A qualitative study of units of measurement, electrical quantities, simple circuits, electromotive forces, current, power, laws, basic electrical instruments and measurements, resistance, impedance and basic circuit components. Concepts taught are generally limited to fundamentals with very little emphasis placed on quantitative aspects. Laboratory work will teach the proper use and care of basic hand tools and the basic manual skills used in working with electricity. Measurement techniques and safety practices will be stressed throughout.
Prerequisite: None.

SECOND QUARTER

	Class	Lab.	Credit
T-ENG 102 Composition	3	0	3

English composition is designed to aid the student in improvement of self-expression by means of practical application in business and technical writing. Emphasis is on writing sentences, paragraphs and compositions.
Prerequisite: T-ENG 101.

	Class	Lab.	Credit
T-MAT 102 Technical Mathematics	5	0	5

A continuation of T-MAT 101. Advanced algebraic and trigonometric topics including quadratics, logarithms, determinants, progressions, the binomial expansion, complex numbers, solution of oblique triangles and graphs of the trigonometric functions are studied in depth.
Prerequisite: T-MAT 101.

T-ELC 113 Electrical Fundamentals II 3 6 5
Additional electrical concepts and circuit analysis procedures as applied to more complex two terminal and simple two port networks are introduced. Laboratory work will include additional measurement techniques with emphasis on verification of theoretical concepts.
Prerequisites: T-ELC 112 (or equivalent), T-MAT 101.

T-ELN 121 Electronics I 3 4 5
Presents qualitative electronics concepts beginning with systems and networks and proceeding to devices. Typical networks such as power supplies, amplifiers, oscillators, and feedback circuits are introduced. Solid state devices and vacuum tubes are introduced as idealized devices. Experience is provided in basic troubleshooting techniques. Instruments are introduced as needed for simple testing and measurements.
Corequisite: T-ELC 113.

THIRD QUARTER

T-ENG 103 Report Writing 3 0 3
The fundamentals of English are utilized as a background for the organization and techniques of modern report writing. Exercises in developing typical reports, using writing techniques and graphic devices are completed by the students. Practical application in the preparation of a full-length report is required of each student at the end of the term. The report must relate to the student's specific curriculum.
Prerequisite: T-ENG 102.

T-MAT 103 Technical Mathematics 5 0 5
The fundamental concepts of analytical geometry, differential and integral calculus are introduced. Topics included are graphing techniques, geometric and algebraic interpretation of the derivative, differentials, rate of change, the intergral and basic integration techniques. Applications of these concepts to practical situations are stressed.
Prerequisite: T-MAT 102.

T-ELC 114 Electrical Fundamentals III 3 2 4
Advanced circuit analysis techniques as applied to two port passive networks are introduced with emphasis on analysis and mathematical computations. Laboratory experiences are used to support analysis activities.
Prerequisites: T-ELC 113, T-MAT 102.

T-ELN 122 Electronics II 5 6 7
A quantitive study beginning with active control devices and proceeding to networks. A variety of equivalent circuit models are used to evaluate device and system parameters and predict circuit performance. Instruments are used in the laboratory to collect data, verify math predictions, and troubleshoot.
Prerequisite: T-ELN 121.

FOURTH QUARTER

T-ENG 204 Oral Communication 3 0 3

The principles, techniques, and practical applications of communicating the thoughts and personality through the voice and visible action of the individual to one or more persons for the purpose of achieving a previously determined response. Areas covered vary according to class needs, but, in general, include: basic concepts, nonverbal and verbal language, vocal usage, speech preparation (analyzing audience and occasion, determining purpose, selecting and narrowing subject, gathering and organizing material, wording, and practicing aloud), and effective listening.
Prerequisite: None.

T-PHY 101 Physics: Properties of Matter 3 2 4

A fundamental course covering several basic principles of physics. The divisions included are solids and their characteristics, liquids at rest and in motion, gas laws and applications. Laboratory experiments and specialized problems dealing with these topics are part of this course.
Prerequisite: None.

T-DFT 113 Electronic Drafting 2 6 4

The fundamentals of drafting are presented with an emphasis on applications in the electronics field. Basic skills and techniques are included such as the use of drafting instruments, types of drawings, construction of drawings both with instruments and freehand, lettering and dimensioning, and how to read prints. In addition to basic skills, specialized experience will be included which directly relates to the electronics industry, such as types of drawings common to electronics, special symbols used, schematic diagrams, and layout diagrams with an emphasis on printed circuit work.
Prerequisite: None.

T-ELN 123 Electronics III 3 4 5

Continues the study of active networks. Emphasis is on the analysis and design of both networks and active circuits. In addition, fundamentals, design techniques, and typical applications of linear integrated circuits are introduced.
Prerequisites: T-ELN 122, T-MAT 103.

FIFTH QUARTER

T-PHY 102 Physics: Work, Energy, Power 3 2 4

Major areas covered in this course are work, energy, and power. Instruction includes such topics as statics, forces, center of gravity and dynamics. Units of measurement and their applications are a vital part of this course. A practical approach is used in teaching students the use of essential mathematical formulas.
Prerequisites: T-MAT 101, T-PHY 101.

T-ELC 211 Electrical Machines I 3 3 4
Principles, construction, characteristics, applications and control of direct current generators and motors. Advanced alternating current circuit analysis in polyphase systems is covered. Includes a survey of induction motors, transformers, alternators, and generators. Experience provided in specifying and wiring machines.
Prerequisite: T-ELC 114.

T-ELC 204 Electrical Circuits 3 3 4
Advanced alternating current circuit analysis, network equations and theorems, polyphase circuits, balanced and unbalanced three-phase circuits, polyphase rectifiers and measuring power in polyphase systems are covered.
Prerequisite: T-ELC 114.

T-ELC 221 Electromagnetic Controls 2 3 3
A study of control components and schematic motor control wiring diagrams. Motor starters, master controllers, protective devices, rotating and magnetic amplifiers and regulators are introduced.
Prerequisite: T-ELC 114.

SIXTH QUARTER

T-PHY 104 Physics: Light & Sound 3 2 4
A survey of the concepts involving wave motion leads to a study of sound, its generation, transmission and detection. The principles of wave motion also serve as an introduction to a study of light, illumination and the principles involved in optical instruments. Application is stressed throughout.
Prerequisites: T-MAT 101, T-PHY 101.

T-ELC 212 Electrical Machines II 3 3 4
Principles, construction, operation, application, and control of single-phase and polyphase power converters, and motors and generators, specialized motors. Single-phase and polyphase transformers, auto transformers and parallel operation of alternators are covered.
Prerequisite: T-ELC 211.

T-ELC 222 Solid State Controls 3 3 4
Introduction to static switching circuits and controls, Boolean algebra, static switching applications involving logic components, and design of control circuits. Dynamic controls involving solid state devices such as the transistor, integrated circuit, and digital readout. Minicomputers and their relationship to the control of machines and manufacturing processes will be studied.
Prerequisite: T-ELC 211.

SEVENTH QUARTER

T-ELN 237 Industrial Instrumentation 3 3 4
A study of basic principles and instruments for the measurement and control of industrial processes. Laboratory experiments in the use and application of electronic, pneumatic, and hydraulic measurement devices to measure temperature, pressure, flow, light, and pH.
Prerequisite: T-ELN 122, T-ELC 211.

T-ELC 235 Planning Electrical Installations 3 6 5
A familiarization with the National Electrical Code; the power requirements and typical design of industrial and commercial installations. Design and calculation of illumination and electrical cooling and heating.
Prerequisite: T-ELC 114.

ELECTIVES

The following is a list of electives for this curriculum from which the institution may select courses to complete the program of study. The institution has the prerogative to develop new courses for the electives or modify courses from the suggested list to fulfill local objectives. It is suggested, however, that technical courses be related to the major area of study. These courses should not change or alter the major objectives of the program nor create a false impression of proficiency in an area either related or foreign to the major.

Elective courses selected must be associate degree courses or new courses should be developed at a comparable level. The institution may elect to require certain electives or may let the student select an appropriate elective.

ELECTRICAL

T-ELC 238 Power Distribution 3 3 4
Design of electrical distribution systems for power, lighting and heating, including services, switchboards, control and power panels, motor control centers, unit substations, low and high voltage switchgear and underground systems.
Prerequisites: T-ELC 211, T-ELC 221.

T-ELC 245 Illumination 2 3 3
Study of illumination principles, light sources, luminaries, illumination levels, interior lighting layouts, store and office lighting, industrial and architectural lighting, and roadway and floodlighting design.
Prerequisite: T-ELC 114.

T-ELN 208 Industrial Electronics 5 3 6
Electronics as applied to a production system; rectification; electronically controlled rectifiers, servomechanisms, and motors; magnetic amplifiers; ultrasonic cleaning; and variable strobe light.
Prerequisites: T-ELN 121 or T-ELN 105.

T-ELC 124 Commercial Wiring and Distribution 3 6 5
Layout, planning and installation of wiring systems in commercial and industrial buildings. Emphasis on blueprint reading, electrical symbols, and the National Electrical Code. Application of fundamentals to conduit preparation, wiring, and installation of complete electrical systems.
Prerequisite: T-ELC 112.

T-ELC 240 Electrical Analysis and Maintenance 3 3 4
An introduction to troubleshooting techniques of the common problems of direct current and alternating current machines, transformers, circuit breakers and regulators. Emphasis will be on scheduling of maintenance, lubrication; and principles of plant maintenance.
Prerequisites: T-ELC 225, T-ELN 208.

T-MEC 110 Fundamental Mechanisms 2 4 4
A study of the purpose and actions of cams, cables, gear trains, differentials, screws, belts, pulleys, shafts, levers, and other mechanical devices used to transmit or control signals.
Prerequisite: T-PHY 102.

T-ELC 220 Electrical Instrumentation 3 4 5
Electrical meters and their movements: indicating, integrating, recording; instrument transformers; and special metering applications. Care, operation, calibration and maintenance of electrical meters and instruments.
Prerequisite: T-ELN 101.

T-ELC 250 Illumination and Estimating 3 3 4
Study of light sources, luminaries, illumination levels, interior lighting layouts, roadway lighting and floodlighting design. Analysis of plans and specifications for the preparation of electrical estimates covering industrial, commercial and residential wiring installations.
Prerequisites: T-PHY 104, T-ELC 102.

SOCIAL SCIENCE ELECTIVES

T-SSC 201 Social Science 3 0 3
An integrated course in the social science drawing from the fields of anthropology, psychology, history, and sociology.
Prerequisite: None.

T-SSC 202 Social Science 3 0 3
A further study of social sciences with emphasis on economics, political science, and social problems as they relate to the individual.
Prerequisite: T-SSC 201.

T-PSY 206 Applied Psychology 3 0 3
A study of the principles of psychology that will be of assistance in the understanding of inter-personal relations on the job. Motivation, feelings, and emotions are considered with particular reference to on-the-job problems. Other topics investigated are: employee selection, supervision, job satisfaction, and industrial conflicts. Attention is also given to personal and group dynamics so that the student may learn to apply the principles of mental hygience to his adjustment problems as a worker and a member of the general community.
Prerequisite: None.

T-SSC 205 American Institutions 3 0 3
A study of the effect of American social, economic, and political institutions upon the individual as a citizen and as a worker. The course dwells upon current local, national, and global problems viewed in the light of our political and economic heritage.
Prerequisite: None.

T-POL 201 United States Government 3 0 3
A study of government with emphasis on basic concepts, structure, powers, procedures and problems.
Prerequisite: None.

T-SOC 207 Rural Society 3 0 3
A study of selected elements of rural sociology with emphasis on current social changes. The course provides a sociological background for the understanding of rural social changes. Areas of study include rural culture, group relationships, social classes, rural and suburban communities, farm organizations, the communication of agricultural technology, rural social problems, agricultural adjustment and population change.
Prerequisite: None.

T-ECO 108 Consumer Economics 3 0 3
Designed to help the student use his resources of time, energy, and money to get the most out of life. It gives the student an opportunity to build useful skills in buying, managing his finances, increasing his resources, and to understand better the economy in which he lives.
Prerequisite: None.

ELECTROMECHANICAL

INTRODUCTION

Purpose of Curriculum

Advances in both manufacturing and maintenance techniques over the past decade have made it necessary to bridge the gap between electronics and mechanics with a technician versed in both disciplines. The multi-discipline approach of the electromechanical technology presents overall system functions as well as in depth study of subject areas to effect repairs and make design changes or operational changes that would normally require the services of two or three single discipline technicians. This curriculum provides courses to give the student a background in electricity-electronics, in mechanical operations and functions, and in electromechanical systems covering such devices as computers, servo-mechanisms, and numerical control systems.

Career Opportunities

An electromechanical technician may find employment in many areas of industry. He may help design, fabricate, install, and test devices which utilize the interaction of electric impulses and mechanical controls to produce products; control temperature, pressure, and flow rate; or perform quality control functions in the manufacturing process. The technician may troubleshoot, repair, and maintain specialized electro-mechanical systems. He will be required to use an analytical approach and the basic principles of electricity, electronics and mechanisms as the foundation of his work with automated electromechanical systems.

A graduate of this curriculum is prepared to enter employment in industry and business as an engineering aide, maintenance and troubleshooting technician, field service technician, manufacturing and automated process technician, or research and development technician.

ACKNOWLEDGMENTS

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Jerry Thompson, Catawba Valley Technical Institute

The Department of Community Colleges also recognizes the assistance of the following persons who served as members of the Electronics Curriculum Committee.

Roy Gull, Catawba Valley Technical Institute, Chairman
Janaki Potukuchi, Central Carolina Technical Institute
Bob Reaves, Durham Technical Institute
John Jamison, Fayetteville Technical Institute
Stewart Reed, Forsyth Technical Institute
Arthur Dunn, Lenoir Community College
David Taylor, Lenoir Community College
Peter Resta, Nash Technical Institute
Larkin Walker, Roanoke-Chowan Technical Institute
Guy Tolbert, Surry Community College
John Wiles, Wilkes Community College
Frank Gourley, Jr., Department of Community Colleges

ENGINEERING TECHNOLOGY

ELECTROMECHANICAL

SUGGESTED SEVEN QUARTER CURRICULUM

Course Title			Hours Per Week Class	Lab.	Quarter Hours Credit
FIRST QUARTER					
T-ENG	101	Grammar	3	0	3
T-MAT	101	Technical Mathematics	5	0	5
T-ELC	112	Electrical Fundamentals I	5	6	7
			13	6	15
SECOND QUARTER					
T-ENG	102	Composition	3	0	3
T-MAT	102	Technical Mathematics	5	0	5
T-ELC	113	Electrical Fundamentals II	3	6	5
T-ELN	121	Electronics I	3	4	5
			14	10	18
THIRD QUARTER					
T-ENG	103	Report Writing	3	0	3
T-MAT	103	Technical Mathematics	5	0	5
T-ELC	114	Electrical Fundamentals III	3	2	4
T-ELN	122	Electronics II	5	6	7
			16	8	19
FOURTH QUARTER					
T-ENG	204	Oral Communication	3	0	3
T-PHY	101	Physics: Properties of Matter	3	2	4
T-DFT	113	Electronic Drafting	2	6	4
T-ELN	123	Electronics III	3	4	5
T-MEC	100	Machine Practices	2	3	3
			13	15	19

			Hours Per Week		Quarter
FIFTH QUARTER			Class	Lab.	Hours Credit
		Social Science Elective*	3	0	3
T-MEC	107	Applied Mechanics	5	0	5
T-ELM	211	Electromechanical Devices	3	4	5
T-MEC	110	Fundamental Mechanisms	2	4	4
			13	8	17

SIXTH QUARTER					
T-PHY	104	Physics: Light and Sound	3	2	4
T-ELN	219	Digital Fundamentals	3	4	5
T-ELM	212	Control System Technology I	3	4	5
T-MEC	235	Hydraulics and Pneumatics	3	3	4
			12	13	18

SEVENTH QUARTER					
		Social Science Elective*	3	0	3
T-ELN	224	Computer and Microprocessor Fundamentals	3	4	5
T-ELM	213	Control System Technology II	3	4	5
		Elective			3
			9	8	16

Total Quarter Hours in Courses	115
Electives	3
Total	118

ENGINEERING TECHNOLOGY

(ALTERNATE LENGTH CURRICULUM)

ELECTROMECHANICAL

SUGGESTED SIX QUARTER CURRICULUM

Course Title			Hours Per Week Class	Lab.	Quarter Hours Credit
FIRST QUARTER					
T-ENG	101	Grammar	3	0	3
T-MAT	101	Technical Mathematics	5	0	5
T-DFT	111	Electronics Drafting	2	6	4
T-ELC	112	Electrical Fundamentals	5	6	7
			15	12	19
SECOND QUARTER					
T-ENG	102	Composition	3	0	3
T-MAT	102	Technical Mathematics	5	0	5
T-ELC	113	Electrical Fundamentals II	3	6	5
T-ELN	121	Electronics I	3	4	5
			14	10	18
THIRD QUARTER					
T-ENG	103	Report Writing	3	0	3
T-MAT	103	Technical Mathematics	5	0	5
T-ELC	114	Electrical Fundamentals III	3	2	4
T-ELN	122	Electronics II	5	6	7
			16	8	19
FOURTH QUARTER					
T-ENG	204	Oral Communication	3	0	3
T-PHY	101	Physics: Properties of Matter	3	2	4
T-MEC	110	Fundamental Mechanisms	2	4	4
T-ELN	123	Electronics III	3	4	5
T-MEC	100	Machine Practices	2	3	3
			13	13	19

FIFTH QUARTER			Hours Per Week Class	Lab.	Quarter Hours Credit
		Social Science Elective*	3	0	3
T-MEC	107	Applied Mechanics	5	0	5
T-ELM	211	Electromechanical Devices	3	4	5
T-ELN	219	Digital Fundamentals	3	4	5
			14	8	18

SIXTH QUARTER			Class	Lab.	Credit
		Social Science Elective*	3	0	3
T-PHY	104	Physics: Light and Sound	3	2	4
T-ELM	212	Control System Technology I	3	4	5
		Elective			3
			9	6	15

Total Quarter Hours in Courses	105
Electives	3
Total	108

* Refer to electives suggested in this guide.

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ELECTROMECHANICAL

COURSE DESCRIPTIONS BY QUARTERS

FIRST QUARTER	Hours Per Week Class	Lab.	Quarter Hours Credit
T-ENG 101 Grammar	3	0	3

Designed to aid the student in the improvement of self-expression through writing. Emphasis is on grammar, diction, sentence structure, punctuation, and spelling. It is intended to stimulate students in applying the basic principles of English grammar in their day-to-day situations in industry and social life.
Prerequisite: None.

T-MAT 101 Technical Mathematics	5	0	5

The real number systems is developed as an extension of natural numbers. Number systems of various bases are introduced. Fundamental algebraic operations, the rectangular coordinate system, as well as fundamental trigonometric concepts and operations are introduced. The application of these principles to practical problems is stressed.
Prerequisite: Satisfactory evidence that admission requirements have been met.

T-ELC 112 Electrical Fundamentals I	5	6	7

A qualitative study of units of measurement, electrical quantities, simple circuits, electromotive forces, current, power, laws, basic electrical instruments and measurements, resistance, impedance and basic circuit components. Concepts taught are generally limited to fundamentals with very little emphasis placed on quantitative aspects. Laboratory work will teach the proper use and care of basic hand tools and the basic manual skills used in working with electricity. Measurement techniques and safety practices will be stressed throughout.
Prerequisite: None.

SECOND QUARTER

T-ENG 102 Composition	3	0	3

English compostion is designed to aid the student in improvement of self-expression by means of practical application in business and technical writing. Emphasis is on writing sentences, paragraphs and compositions.
Prerequisite: T-ENG 101

T-MAT 102 Technical Mathematics	5	0	5

A continuation of T-MAT 101. Advanced algebraic and trigonometric topics including quadratics, logarithms, determinants, progressions, the binominal expansion, complex numbers, solution of oblique triangles and graphs of the trigonometric functions are studied in depth.
Prerequisite: T-MAT 101.

T-ELC 113 Electrical Fundamentals II 3 6 5

Additional electrical concepts and circuit analysis procedures as applied to more complex two terminal and simple two port networks are introduced. Laboratory work will include additional measurement techniques with emphasis on verification of theoretical concepts.
Prerequisites: T-ELC 112 (or equivalent), T-MAT 101.

T-ELN 121 Electronics I 3 4 5

Presents qualitative electronics concepts beginning with systems and networks and proceeding to devices. Typical networks such as power supplies, amplifiers, oscillators, and feedback circuits are introduced. Solid state devices and vacuum tubes are introduced as idealized devices. Experience is provided in basic troubleshooting techniques. Instruments are introduced as needed for simple testing and measurements.
Corequisite: T-ELC 113.

THIRD QUARTER

T-ENG 103 Report Writing 3 0 3

The fundamentals of English are utilized as a background for the organization and techniques of modern report writing. Exercises in developing typical reports, using writing techniques and graphic devices are completed by the students. Practical application in the preparation of a full-length report is required of each student at the end of the term. The report must relate to the student's specific curriculum.
Prerequisite: T-ENG 102

T-MAT 103 Technical Mathematics 5 0 5

The fundamental concepts of analytical geometry, differential and integral calculus are introduced. Topics included are graphing techniques, geometric and algebraic interpretation of the derivative, differentials, rate of change, the integral and basic integration techniques. Applications of these concepts to practical situations are stressed.
Prerequisite: T-MAT 102.

T-ELC 114 Electrical Fundamentals III 3 2 4

Advanced circuit analysis techniques as applied to two port passive networks are introduced with emphasis on analysis and mathematical computations. Laboratory experiences are used to support analysis activities.
Prerequisites: T-ELC 113, T-MAT 102.

T-ELN 122 Electronics II 5 6 7

A quantitive study beginning with active control devices and proceeding to networks. A variety of equivalent circuit models are used to evaluate device and system parameters and predict circuit performance. Instruments are used in the laboratory to collect data, verify math predictions, and troubleshoot.
Prerequisite: T-ELN 121.

FOURTH QUARTER

T-ENG 204 Oral Communication 3 0 3

The principles, techniques, and practical applications of communicating the thoughts and personality through the voice and visible action of the individual to one or more persons for the purpose of achieving a previously determined response. Areas covered vary according to class needs, but, in general, include: basic concepts, nonverbal and verbal language, vocal usage, speech preparation (analyzing audience and occasion, determining purpose, selecting and narrowing subject, gathering and organizing material, wording, and practicing aloud), and effective listening.
Prerequisite: None.

T-PHY 101 Physics: Properties of Matter 3 2 4

A fundamental course covering several basic principles of physics. The divisions included are solids and their characteristics, liquids at rest and in motion, gas laws and applications. Laboratory experiments and specialized problems dealing with these topics are part of this course.
Prerequisite: None.

T-DFT 113 Electronic Drafting 2 6 4

The fundamentals of drafting are presented with an emphasis on applications in the electronics field. Basic skills and techniques are included such as the use of drafting instruments, types of drawings, construction of drawings both with instruments and freehand, lettering and dimensioning, and how to read prints. In addition to basic skills, specialized experience will be included which directly relates to the electronics industry, such as types of drawings common to electornics, special symbols used, schematic diagrams, and layout diagrams with an emphasis on printed circuit work.
Prerequisite: None.

T-ELN 123 Electronics III 3 4 5

Continues the study of active networks. Emphasis is on the analysis and deisgn of both networks and active circuits. In addition fundamentals, design techniques, and typical applications of linear integrated circuits are introduced.
Prerequisites: T-ELN 122, T-MAT 103.

T-MEC 100 Machine Practices 2 3 3

A course designed to familiarize the student with the machine shop and machine processes. Although not an in-depth study of machine shop practice, it covers a wide variety of techniques, machines, and procedures while giving enough shop practice to enable the student to "get the feel" of most of the machines.
Prerequisite: None.

FIFTH QUARTER

T-MEC 107 Applied Mechanics 5 0 5
Concepts and applications of statics and dynamics. Force systems, moments and couples, equilibrium, trusses, friction, centroids, center of gravity, moments of inertia, motion, work, energy, momentum, and impulse are covered. Applications relating to the particular technology are introduced.
Prerequisite: T-MAT 102.

T-ELM 211 Electromechanical Devices 3 4 5
A study of the fundamental devices used in electromechanical technology. Devices such as electrical motors, generators, transformers, relays, and transducers will be investigated. Concepts of work, energy, power, time constants, and efficiency as related to electromechanical devices will be stressed. Study of the instrumentation required to perform the investigation of electromechanical devices will form an integral part of the course.
Prerequisites: T-ELC 114, T-PHY 101.

T-MEC 110 Fundamental Mechanisms 2 4 4
A study of the purpose and actions of cams, cables, gear trains, differentials, screws, belts, pulleys, shafts, levers, and other mechanical devices used to transmit or control signals.
Prerequisite: T-PHY 102.

SIXTH QUARTER

T-PHY 104 Physics: Light and Sound 3 2 4
A survey of the concepts involving wave motion leads to a study of sound, its generation, transmission and detection. The principles of wave motion also serve as an introduction to a study of light, illumination and the principles involved in optical instruments. Application is stressed throughout.
Prerequisites: T-MAT 101, T-PHY 101.

T-ELN 219 Digital Fundamentals 3 4 5
Emphasizes the study of combinational and sequential logic circuits using discrete and integrated components. Topics include binary arithmetic, numbering systems, Boolean algebra, storing, timing, gating, and counting. Typical applications in industry will be presented.
Prerequisite: T-ELN 123.

T-ELM 212 Control System Technology I 3 4 5
A study of control system technology. Basic concepts and terminology are investigated. Methods used to evaluate open-loop, closed-loop, regulator, follow-up, process, servomechanism, sequential, numerical, analog and digital control systems are introduced. Methods of describing control system components are investigated for electrical, liquid, gas, thermal and mechanical systems. Characterisitcs of processes, measuring means, and controllers are covered.
Prerequisite: T-ELM 211.

T-MEC 235 Hydraulics and Pneumatics 3 3 4

The basic theories of hydraulic and pneumatic systems. Combinations of systems in various circuits. Basic designs and functions of circuits and motors, controls, electrohydraulic servomechanisms, plumbing, filtration, accumulators and reservoirs.
Prerequisite: T-PHY 102.

SEVENTH QUARTER

T-ELN 224 Computer and Microprocessor Fundamentals 3 4 5

An in-depth study of computing principles. Subjects covered include analog and digital computers, memory devices, input-output devices, analog to digital converters, and digital to analog converters. Laboratory work using integrated circuits as computer building blocks will reinforce the classroom material.
Prerequisite: T-ELN 219.

T-ELM 213 Control System Technology II 3 4 5

Control system transducers, final control elements, and performance are covered. Transducer topics include position, displacement, velocity, acceleration, force, temperature, flow rate, pressure, and liquid level measurement. Control element topics include control valves, armature controlled DC motors, two-phase AC motors, and amplifiers. Topics include frequency response analysis and testing, Bode diagrams, closed-loop response, stability, and controller adjustment.
Prerequisite: T-ELM 212.

ELECTIVES

The following is a list of electives for this curriculum from which the institution may select courses to complete the program of study. The institution has the prerogative to develop new courses for the electives or modify courses from the suggested list to fulfill local objectives. It is suggested, however, that technical courses be related to the major area of study. These courses should not change or alter the major objectives of the program nor create a false impression of proficiency in an area either related or foreign to the major.

Elective courses selected must be associate degree courses or new courses should be developed at a comparable level. The institution may elect to require certain electives or may let the student select an appropriate elective.

ELECTROMECHANICAL

T-ELC 214 Industrial Electrical Control Systems 3 4 5

A study of industrial electrical control systems. Emphasis is placed on practical circuit analysis as it pertains to starting, rapid stopping, reversing, speed control, and circuit protection for electrical motors. Travel limits for control of mechanical systems are investigated as is timing of multimotor drive . Control building blocks such as switches, relays, contractors, transformer, rectifiers, brakes, protective units and power amplifiers form an integral part of the course. Prerequisite: T-ELM 211.

T-ELN 218 Pulse, Logic, and Digital Circuits 3 4 5

Emphasizes the study of wave shaping and non-sinusoidal wave generating circuits using discrete and integrated components. Wave shaping topics include simple passive wave shaping circuits and more complicated wave shaping circuits using active devices. Topics covered under non-sinusoidal wave generating circuits include multivibrators, sweep generators, and other types of special purpose circuits using discrete and integrated components. An introduction to Boolean algebra and its applications for the simplification of logic circuits is also included. Prerequisite: T-ELN 123.

T-DFT 101 Technical Drafting 0 6 2

The field of drafting is introduced as the student begins study of drawing principles and practices for print reading and describing objects in the graphic language. Basic skills and techniques of drafting included are: use of drafting equipment, lettering, freehand orthographic and pictorial sketching, geometric construction, orthographic instrument drawing of principal views, and standards and practices of dimensioning. The principles of isometric, oblique, and perspective are introduced.
Prerequisite: None.

T-DFT 102 Technical Drafting 0 6 2

The application of orthographic projection principles to the more complex drafting problems, primary and secondary auxilliary views, simple and successive revolutions, and sections and conventions will be studied. Most important is the introduction of the graphical analysis of space problems. Problems of practical design elements involving points, lines, planes, and a combination of these elements shall be studied. Dimensioning practices, approved by the American Standards Association will also be included. Introduction is given to intersections and developments of various types of geometrical objects.
Prerequisite: T-DFT 101.

T-ELN 246 Electronics Design Project 0 6 3

A laboratory class emphasing independent research and design work by the student. The student will select a project in consultation with the instructor; perform the required research; compile data; formulate a theoretical model; and construct, test, and evaluate a working model of the selected project.
Prerequisite: T-ELN 241.

T-EGR 101 Introduction to Engineering Technology 0 3 1

An overview of the field of engineering technology, with a discussion of the work of the technician, and his role in the engineering and industrial organizations. The "conceptual approach" will give the student an idea of the whole engineering technology spectrum. This is followed by discussions of the various aspects of engineering technology; design calculation, material selection, production techniques, etc. Practice in engineering methodology will be stressed, including development of carefulness and orderliness, use of curves and tables, calculations, experimental laboratory procedures, etc. Field trips give the student an opportunity to see the engineering technician in action. Permanent placement and summer work opportunities will be discussed.
Prerequisite: None.

T-EGR 102 Programming of Engineering Problems 0 2 1

A course in the development of skill of computer programming of engineering and scientific problems. Special emphasis on repetitive and progressive calculation situations. Skill with the available computer terminal equipment will be subordinate to the skill of writing programs in the appropriate high-level computer language.
Prerequisite: None.

T-EGR 107 Techniques of Problem Solving 0 3 1

This course presents an introduction to a variety of problem solving tools including the hand-held calculator, the programmable desk-top calculator, and the minicomputer. The purpose is to equip the student to use these available tools in solving complex mathematical problems.
Prerequisite: None.

T-MAT 201 Technical Mathematics 5 0 5

A continuation of T-MAT 103. More advanced concepts of differentiation and integration are considered. Included are graphs and derivatives of the trigonometric functions, exponential and logarithmic differentiation and integration, advanced integration techniques, polar equations, parametric equations and Fourier series.
Prerequisite: T-MAT 103.

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SOCIAL SCIENCE ELECTIVES

T-SSC 201 Social Science	3	0	3

An integrated course in the social sciences drawing from the fields of anthropology, psychology, history, and sociology.
Prerequisite: None.

T-SSC 202 Social Science	3	0	3

A further study of social sciences with emphasis on economics, political science, and social problems as they relate to the individual.
Prerequisite: T-SSC 201.

T-PSY 206 Applied Psychology	3	0	3

A study of the principles of psychology that will be of assistance in the understanding of inter-personal relations on the job. Motivation, feelings, and emotions are considered with particular reference to on-the-job problems. Other topics investigated are: employee selection, supervision, job satisfaction, and industrial conflicts. Attention is also given to personal and group dynamics so that the student may learn to apply the principles of mental hygience to his adjustment problems as a worker and a member of the general community.
Prerequisite: None.

T-SSC 205 American Institutions	3	0	3

A study of the effect of American social, economic, and political institutions upon the individual as a citizen and as a worker. The course dwells upon current local, national, and global problems viewed in the light of our political and economic heritage.
Prerequisite: None.

T-POL 201 United States Government	3	0	3

A study of government with emphasis on basic concepts, structure, powers, procedures and problems.
Prerequisite: None.

T-SOC 207 Rural Society	3	0	3

A study of selected elements of rural sociology with emphasis on current social changes. The course provides a sociological background for the understanding of rural social changes. Areas of study include rural culture, group relationships, social classes, rural and suburban communities, farm organizations, the communication of agricultural technology, rural social problems, agricultural adjustment and population change.
Prerequisite: None.

T-ECO 108 Consumer Economics	3	0	3

Designed to help the student use his resources of time, energy, and money to get the most out of life. It gives the student an opportunity to build useful skills in buying, managing his finances, increasing his resources, and to understand better the economy in which he lives.
Prerequisite: None.

INSTRUMENTATION

INTRODUCTION

Purpose of Curriculum

The Instrumentation Technology curriculum provides a program of study to develop knowledge of measuring and controlling devices and to develop the technical skills involved in the application of instrument control to processes, systems, and operations of modern industry. The instrumentation technician is involved in both production and process control and must deal with variables that affect manufacturing processes, such as temperature, pressure, flow, level, humidity, density, viscosity, etc. Instrumentation men are key personnel in keeping a manufacturing firm running. Should a major piece of equipment break down, the instrumentation man is usually the person to make repairs to the equipment so that production may be resumed. His knowledge of mechanics, electronics, and manufacturing processes are key factors in maintaining an efficient plant operation.

Career Opportunities

The instrumentation technician in most manufacturing plants works with or assists engineers in their work. He selects, installs, calibrates, checks out and maintains sensing, telemetering, and recording instrumentation and circuitry. Other functions include devising, setting up, and operating instrumentation equipment involved in testing mechanical, structural, or electrical equipment. He may work as an instrumentation technician, engineering aid or associate, service specialist, laboratory technician, or instrument field service technician.

ACKNOWLEDGMENTS

The Department acknowledges with appreciation the constructive comments of administrators and staff members from the following institutions offering Instrumentation Technology:

Bill Coleman, Cape Fear Technical Institute
Matt Donahue, Cape Fear Technical Institute
Peter Resta, Nash Technical Institute

The Department of Community Colleges also recognizes the valuable contributions of the following persons who served as members of the Electronics Curriculum Committee:

Roy Gull, Catawba Valley Technical Institute, Chairman
Janaki Potukuchi, Central Carolina Technical Institute
Bob Reaves, Durham Technical Institute
John Jamison, Fayetteville Technical Institute
Stewart Reed, Forsyth Technical Institute
Arthur Dunn, Lenoir Community College
David Taylor, Lenoir Community College
Peter Resta, Nash Technical Institute
Larkin Walker, Roanoke-Chowan Technical Institute
Guy Tolbert, Surry Community College
John Wiles, Wilkes Community College
Frank Gourley, Jr., Department of Community Colleges

INSTRUMENTATION

SUGGESTED SEVEN QUARTER CURRICULUM

Course Title			Hours Per Week Class	Hours Per Week Lab.	Quarter Hours Credit
FIRST QUARTER					
T-ENG	101	Grammar	3	0	3
T-MAT	101	Technical Mathematics	5	0	5
T-ELC	112	Electrical Fundamentals I	5	6	7
			13	6	15
SECOND QUARTER					
T-ENG	102	Composition	3	0	3
T-MAT	102	Technical Mathematics	5	0	5
T-ELC	113	Electrical Fundamentals II	3	6	5
T-ELN	121	Electronics I	3	4	5
			14	10	18
THIRD QUARTER					
T-ENG	103	Report Writing	3	0	3
T-MAT	103	Technical Mathematics	5	0	5
T-ELC	114	Electrical Fundamentals III	3	2	4
T-ELN	122	Electronics II	5	6	7
			16	8	19
FOURTH QUARTER					
T-ENG	204	Oral Communication	3	0	3
T-PHY	101	Physics: Properties of Matter	3	2	4
T-DFT	113	Electronic Drafting	2	6	4
T-ELN	123	Electronics III	3	4	5
			11	12	16

			Hours Per Week Class	Lab.	Quarter Hours Credit
FIFTH QUARTER					
		Social Science Elective*	3	0	3
T-PHY	102	Physics: Work, Energy, Power	3	2	4
T-ELN	203	Measurement and Control I	3	6	5
T-ELN	218	Pulse, Logic and Digital Circuits	3	4	5
			12	12	17
SIXTH QUARTER					
		Social Science Elective*	3	0	3
T-PHY	104	Physics: Light and Sound	3	2	4
T-ELN	213	Measurement and Control II	3	6	5
T-ELN	219	Digital Fundamentals	3	4	5
			12	12	17
SEVENTH QUARTER					
T-ELN	223	Measurement and Control III	3	9	6
T-CHM	117	Instrumentation Chemistry	5	3	6
		Elective	4	0	4
			12	12	16

Total Quarter Hours in Courses	116
Electives	4
Total	120

* Refer to electives suggested in this guide.

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COURSE OUTLINE

T-ELC 114 ELECTRICAL FUNDAMENTALS III

COURSE DESCRIPTION:

Advanced circuit analysis techniques as applied to two port passive networks are introduced with emphasis on analysis and mathematical computations. Laboratory experiences are used to support analysis activities.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 2.

QUARTER HOURS CREDIT: 4.

PREREQUISITE: T-ELC 113, T-MAT 102.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution, oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Solve complex electrical circuit problems for two terminal, two port passive networks involving:

a. series circuits
b. parallel circuits
c. combinational circuits
d. resistance
e. capacitance
f. inductance

with various repetitive and non-repetitive driving functions applied to the network,

(2) Use equivalent circuits in the solution of complex network problems.

(3) Solve complex problems involving coupled circuits with various loads.

(4) Solve various transformer problems involving resistive and reactive loads, efficiency, transformation ratios, impedance notching, core sizes, core materials and voltage regulation.

(5) Predict transformer performance from the open circuit and short circuit transformer tests.

(6) Solve problems involving resonance and coupled impedances encountered in tuned transformers.

(7) Solve problems involving voltage, current and power for three phase circuits that are both Y connected and Δ connected and combinations of the above.

(8) Set up, test, troubleshoot, and repair the troubles encountered in commonly used passive electrical networks.

(9) Properly use all commonly encountered laboratory electrical test instruments.

CONDUCT OF COURSE:

Electrical Fundamentals III is a quantitative course with the emphasis shifting from components to systems. Advanced circuit analysis techniques, involved with more complex passive networks, will be solved. Analysis techniques will be compared one with another.

Laboratory experiences, involved with more complex passive networks, will be used to support and reinforce the analysis activities of the course.

Additional electrical instruments will be introduced throughout the course as needed.

OUTLINE OF INSTRUCTION:

I. Electrical Fundamentals (quantitative approach)

   A. Driving functions
      1. Nonrepetitive
         a. Step
         b. Square wave
         c. Saw tooth
         d. Pulse
      2. Repetitive
         a. Sinusoidal
         b. Step
         c. Exponential
         d. Pulse
   B. Passive newtork characteristics
      1. Resonant (series and parallel)
      2. Filter
      3. Integrator/differentiator
      4. Attenuator
         a. Types
         b. Uses

C. Passive network analysis
   1. Equivalent circuit theorems
   2. Resistive networks
   3. Reactive networks
   4. Resonant circuits
   5. Coupled circuits and tuned transformers
   6. Power
   7. Harmonics
   8. Integrators/differentiators

II. Transducers

III. Measurements and Instruments Not Previously Covered

SUGGESTED TEXTS:

Boylestad, Robert L. Introductory Circuit Analysis; Second Edition. Columbus, OH: Charles E. Merrill Publishing Co., 1972.

Jackson, Herbert W. Introduction to Electric Circuits; Third Edition. Englewood Cliffs, NJ: Prentice-Hall Inc., 1970.

Malvino, Albert Paul. Resistive and Reactive Circuits. New York: McGraw-Hill Book Co., 1974.

Oppenheimer, S. L. and Ness, F. R. Direct and Alternating Current. New York: McGraw-Hill Book Co., 1973.

Romanek, Richard J. Introduction to Electronic Technology. Englewood Cliffs, NJ: Prentice-Hall Inc., 1975.

SUGGESTED REFERENCES:

Boylestad, Robert L. Experiments in Circuit Analysis. Columbus, OH: Charles E. Merrill Publishing Co., 1968.

Cox, Cyrus, W. and Reuter, William L. Circuits, Signals, and Networks. New York: Macmillan Publishing Co., 1969.

Cutler, Phillip. A.C. Circuit Analysis (with illustrative problems). McGraw-Hill Book Co., 1974.

Cutler, Phillip. Outline for D. C. Circuit Analysis (with illustrative problems). New York: McGraw-Hill Book Co., 1968.

Edminster, Joseph A. Electric Circuits - Theory and Problems. New York: McGraw-Hill Book Co., 1967.

Gillie, A. C. Electrical Principles of Electronics. New York: McGraw-Hill Book Co., 1969.

Grod, Bernard. <u>Basic Electronics</u>; Third Edition. New York: McGraw-Hill Book Co.

Romanowitz, A. H. <u>Introduction to Electric Circuits</u>. New York: John Wiley and Sons Inc., 1970.

COURSE OUTLINE

T-ELN 121 ELECTRONICS I

February, 1976

Developed by:

Arthur Dunn, Lenoir Community College
Dr. Janaki Potukuchi, Central Carolina Technical Institute
Stewart Reed, Forsyth Technical Institute

ELECTRONICS CURRICULUM COMMITTEE

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELN 121 ELECTRONICS I

COURSE DESCRIPTION:

Presents qualitative electronic concepts beginning with systems and networks and proceeding to devices. Typical networks such as power supplies, amplifiers, oscillators, and feedback circuits are introduced. Solid state devices and vacuum tubes are introduced as idealized devices. Experience is provided in basic troubleshooting techniques. Instruments are introduced as needed for simple testing and measurements.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 4.

QUARTER HOURS CREDIT: 5.

COREQUISITE: T-ELC 113.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution, oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Draw the block diagram of a power supply and explain the function of the transformer, rectifier, filter, and regulator.

(2) Connect voltmeters and ammeters to measure and evaluate voltage, current, ripple content, and regulation of a power supply.

(3) Define the properties of an amplifier such as gain, bandwidth, impedances, distortion and power output.

(4) Measure the voltage gain, input and output impedances, frequency response, distortion, and power output when given an amplifier and appropriate test equipment.

(5) Define the properties of an oscillator in terms of frequency, stability, and waveform.

(6) Measure the output frequency and waveform, and determine the factors which contribute to frequency instability such as temperature, power supply variation, and loading, when given an oscillator and appropriate test equipment.

(7) Draw the schematic diagrams of both vacuum tube and semiconductor diodes and explain forward and reverse biasing.

(8) Be able to list the most important diode ratings and interpret them through the use of reference material.

(9) Perform simple diode testing procedures using ohmmeter, curve tracer, or in-circuit testers.

(10) Draw and identify schematic diagrams, for CE, CB, & CC transistor amplifier configurations and explain the characteristics of each.

(11) Explain bipolar transistor ratings such as breakdown voltage, collector dissipation, maximum currents, etc.

(12) Perform simple bipolar transistor testing procedures using ohmmeter, curve tracer, or in-circuit testers.

(13) Draw and identify schematic diagrams for some basic bipolar transistor amplifiers and oscillators.

(14) Accurately connect the circuit in breadboard fashion and perform all tests as outlined in item four or item six above when given a schematic diagram of a simple bipolar transistor oscillator/amplifier and appropriate hardware.

(15) Draw and identify schematic diagrams for field effect transistors (FET) and explain their ratings.

(16) Perform simple FET test procedures and explain special handling precautions.

(17) Draw schematic diagram of amplifiers and oscillators which use FETs.

(18) Draw and identify the schematic symbols of other semiconductor devices such as UJT, DIAC, SCR, TRIAC, etc.

(19) Be able to list a number of basic applications for the semiconductors in item 18.

(20) Draw and identify vacuum tube type symbols.

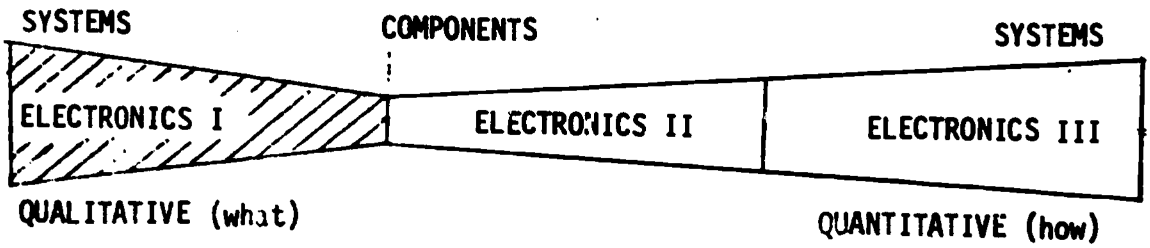
(21) Draw and identify vacuum tube schematic diagrams of basic amplifiers and oscillators.

(22) Isolate basic or subsystem malfunctions using appropriate test equipment and procedures to determine a defective module or plug-in.

(23) Utilize appropriate test equipment and procedures to identify system malfunctions in terms of input/output data.

CONDUCT OF COURSE:

Functional concepts beginning with systems and networks and proceeding to devices will be presented. The treatment of these networks at this time should be of a qualitative nature only, the objective being the development of the learner's knowledge of what these networks do and not how they do it. This knowledge will be directed toward troubleshooting electronic systems by signal tracing through functional blocks. Ordinary systems will be used to provide exposure to troubleshooting techniques and input/output analysis. Progression through the three electronics courses, Electronics I, II, and III, is graphed below. Electronics I begins with a qualitative (what) investigation of electronic systems, then proceeds into various systems for a look at the function of circuits that contribute individually to the systems overall performance. These circuits are then reduced to the devices or components with which they are constructed and a qualitative investigation is completed with the smallest electronic component in the system.



Instruments and measuring techniques will be introduced as needed.

Upon completion of this course the student is ready to begin a quantitative (how) study of electronics beginning with components and expanding into systems.

OUTLINE OF INSTRUCTION:

I. D.C. Power Supplies

   A. Circuits
      1. Transformer
      2. Rectifier
      3. Filter
      4. Regulator
   B. Output characteristics
      1. Voltage
      2. Current
      3. Ripple
      4. Regulation
   C. Types
      1. D.C.
      2. Constant voltage

    3. Constant current
  D. Faults
    1. Ripple
    2. Regulation

II. Amplifiers

  A. Properties
    1. Gain
    2. Input impedance
    3. Output impedance
    4. Frequency response
    5. Distortion
    6. Power output
  B. Types
    1. Voltage amplifier
    2. Current amplifier
    3. Power amplifier
  C. Faults
    1. Low gain
    2. Distortion, etc.

III. Oscillators

  A. Properties
    1. Frequency
    2. Stability, etc.
  B. Types
    1. Sinusoidal
    2. Nonsinusoidal
  C. Faults
    1. Drift
    2. Amplitude stabilization
    3. Distortion

IV Diodes

  A. Types
    1. Semiconductor
    2. Vacuum tube
  B. Device ratings
  C. Basic circuit applications
    1. Rectifiers
    2. Regulators
    3. Oscillators
  D. Testing
    1. Ohmmeter
    2. Curve tracer
    3. Dynamic testing

V. Bipolar Junction Transistors

  A. Circuit configurations and characteristics

1. CE
2. CB
3. CC

B. Device ratings
C. Basic circuit applications
   1. Amplifiers
   2. Oscillators
D. Testing
   1. Ohmmeter
   2. Transistor tester
   3. Curve Tracer

VI. Field Effect Transistors (FET)

A. Types
   1. J FFT
   2. Mos FET
B. Device rating
C. Input characteristics
D. Circuit applications
   1. Amplifiers
   2. Oscillators
E. Testing and handling precautions

VII. Other Semiconductor Devices

A. Unijunction transistor (UJT)
B. A.C. trigger diode (DIAC)
C. Shockley diode
D. SCR
E. TRIAC
F. LED
G. Photo transistors

VIII. Vacuum tubes

A. Types
B. Applications

IX. Suggested Laboratory Exercises

A. Power supply
   1. Testing components for a 12 volt D.C. power supply (full wave rectifier with a filter)
   2. Practice in soldering
   3. Fabricating, assembling, and testing 12 volt D.C. power supply
   4. Analyzing power supply characteristics (input-output relationships only)
   5. Inserting zener diode at output and evaluating the regulation effects
   6. Determining diode characteristics - one component of power supply in detail

    7. Determining characteristics of a zener diode
B. Simple two transistor radio
    1. Identifying components and performing simple test procedures
    2. Assembling radio
    3. Testing radio
    4. Drawing the schematic and measuring and marking voltages at important test points
    5. Checking amplifier characteristics in terms of input-output
    6. Determining characteristics of transistors
C. Simple SCR speed control
    1. Fabricating, assembling, and testing SCR speed controls
    2. Determining SCR characteristics

SUGGESTED TEXTS:

Boylestad, Robert L. and Nashelsky, Louis. Electronic Devices and Circuit Theory. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1972.

Malvino, Albert Paul. Electronic Principles. New York: McGraw-Hill Book Co., 1973.

SUGGESTED REFERENCES:

Bell, David A. Fundamentals of Electronic Devices. Reston, VA: Reston Publishing Co., 1975.

Churchman, Lee W. Survey of Electronics. New York: Holt, Rinehart, and Winston, Inc., 1971.

Crystal, Delbert G. and Alvarez, Charles E. Electron Devices Laboratory Manual. New York: McGraw-Hill Book Co., 1971.

Herrick, Clyde N. Survey of Electronics. New York: Macmillan Publishing Co., Inc., 1973.

Matthews, John I. Experiments in Solid-State Electronics. New York: McGraw-Hill Book Co., 1972.

Matthews, John I. Solid-State Electronic Concepts. New York: McGraw-Hill Book Co., 1972.

Villanucci, Autgis, and Megow. Electronic Techniques: Shop Practices and Construction. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1974.

SUPPORTING EQUIPMENT:

Oscilloscope
Voltmeter A.C.

Multimeter, VOM
Signal generator, audio
Standard passive and active components for projects to include: resistors, capacitors, transformers, diodes, transistors, variable capicators, variable indicators, silicone controlled rectifiers, switches, clips, and assorted hardware and sheet metal for assembly.

COURSE OUTLINE

T-ELN 122 ELECTRONICS II

February, 1976

Developed by:

Arthur Dunn, Lenoir Community College
Dr. Janaki Potukuchi, Central Carolina Technical Institute
Stewart Reed, Forsyth Technical Institute

ELECTRONICS CURRICULUM COMMITTEE

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELN 122 ELECTRONICS II

COURSE DESCRIPTION:

A quantitative study beginning with active control devices and proceeding to networks. A variety of equivalent circuit models are used to evaluate device and system parameters and predict circuit performance. Instruments are used in the laboratory to collect data, verify math predictions, and troubleshoot.

COURSE HOURS PER WEEK: Class, 5; Laboratory, 6.

QUARTER HOURS CREDIT: 7.

PREREQUISITE: T-ELN 121.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution, oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Explain the crystal structures of semiconductors in terms of free-electrons, holes, doping, P and N type semiconductor materials.

(2) Explain the PN junction theory in terms of barrier potential, forward and reverse bias, depletion and recombination.

(3) Explain the circuit theory of diode rectification, clipper action and limiter action.

(4) Produce the volt-ampere characteristics of any diode using point-by-point technique or the curve tracer.

(5) Do a load line analysis when given a volt-ampere characteristic of a diode.

(6) Specify component values, breadboard a prototype, and evaluate the performance using appropriate test procedures and equipment when given the specification for a rectifier circuit.

(7) Explain transistor amplifier actic for CB, CE, and CC configurations.

(8) Produce a volt-ampere characteristic curve of a transistor as in item 4.

(9) Draw an appropriate load line, determine the optimum operating point, determine all voltage and current distributions, make all calculations necessary for correct component values, breadboard the circuit, and evaluate against predicted performance when given a volt-ampere characteristic of a bipolar transistor and a set of operating specifications for an amplifier.

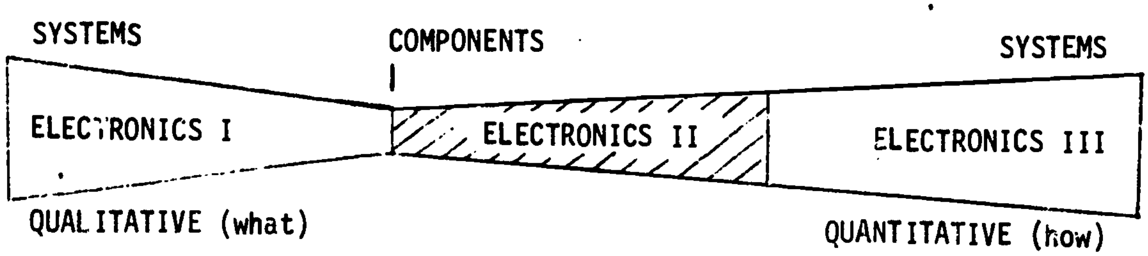
(10) Approximate input and output current, voltage gain, and bandwidth for either bipolar or FET transistors when given a schematic diagram of a transistor amplifier.

(11) Calculate all component values, breadboard the prototype and evaluate the performance against the specifications when given a set of specifications for either bipolar or FET transistor amplifiers.

(12) Specify and use appropriate test equipment and procedures to isolate defective components in an amplifier, oscillator, or power supply system.

CONDUCT OF COURSE:

Electronics II begins the quantitative study of electronic devices and networks. Note that the order of presentation is the reverse of that for Electronics I preceeding from active devices to active networks. This arrangement provides a smooth transition from the qualitative (what) approach to the quantitative (how) approach. The "how" approach dictates that the learner use mathematics to indicate circuit parameters and predict circuit performance. Techniques of troubleshooting and data collection are developed along with the use of instruments to verify mathematical predictions.



OUTLINE OF INSTRUCTION:

I. Semiconductor Physics

   A. Germanium and silicon atoms
   B. Germanium and silicon crystals

C. Doped semiconductors
D. Conduction in semiconductors
E. The hole concept

II. The PN Junction

A. Recombination
B. Depletion
C. Barrier potential
D. Biasing the PN junction

III. Semiconductor Diodes

A. I-V Characteristic curves
    1. Forward characteristic
    2. Reverse characteristic
    3. Zener effect
    4. Avalanche effect
B. Diode equivalent circuits
    1. The ideal diode
        a. Half-wave rectifier
        b. Clipper circuits (negative and positive)
        c. Diode limiter
    2. The practical diode
        a. Half-wave rectifier
        b. Clipper circuits
        c. Diode limiter
        d. Load line analysis
    3. Diode parameters
        a. Power rating
        b. Peak inverse voltage
        c. A.C. resistance
        d. Junction capacitance and resistance
    4. Special purpose diodes
        a. Rectifier
        b. Zener diodes
        c. Variactor diodes
        d. Tunnel diodes
        e. Varicap
        f. Led
    5. Diode applications
        a. The D.C. regulated power supply
        b. Tunnel diode oscillator
        c. Frequency control diode
        d. Frequency multiplier
        e. Display

IV. Bipolar Junction Transistors

A. Types
    1. NPN
    2. PNP
B. Currents in the BJT

1. Alpha current
2. Beta current

C. Static characteristics
   1. Common base
   2. Common emitter
   3. Common collector
D. Biasing
   1. Load line analysis
      a. Calculation of the operating point
      b. Gain
      c. Input/output impedance
   2. Stability factor (s)
E. Equivalent circuit models
   1. Low frequency
   2. High frequency
F. Junction transistor applications
   1. D.C. regulated power supply
   2. Small signal
   3. Large signal
   4. Oscillators

V. The Field Effect Transistor

A. The junction FET
   1. Biasing the J-FET
   2. Load line analysis
B. Mos FET
   1. Depletion mode
   2. Enhancement mode
   3. Biasing the mos FET
   4. Load line analysis
   5. Equivalent circuit models
C. FET applications
   1. Amplifiers
   2. Oscillators

VI. Suggested Laboratory Exercises:

A. Laboratory exercises for Electronics II may follow a similar format to those for Electronics I. More emphasis should be directed to component characteristics and analysis. Exercises may be focused on the following systems:

   1. Integrated circuit or transistor regulated power supply
   2. Feedback amplifiers and oscillators
   3. Phase shift control of SCR speed control
B. Additional exercises may be included as necessary to cover other concepts presented in the course.

SUGGESTED TEXTS:

Boylestad, Robert L. and Nashelsky, Louis. Electronic Devices and Circuit Theory. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1972.

Malvino, Albert Paul. Electronic Principles. New York: McGraw-Hill Book Co., 1975.

SUGGESTED REFERENCES:

Alvarez, E.C. and Fleckles, David E. Introduction to Electron Devices; Second Edition. New York: McGraw-Hill Book Co., 1974.

Cutler, Phillip. Linear Electronic Circuits (with illustrative problems). New York: McGraw-Hill Book Co., 1972.

Faber, Rodney B. Introduction to Electronic Amplifiers. Columbus, OH: Charles E. Merrill Publishing Co., 1971.

T-ELN 123

COURSE OUTLINE

T-ELN 123 ELECTRONICS III

February, 1976

Developed by:

Arthur Dunn, Lenoir Community College
Stewart Reed, Forsyth Technical Institute
Dr. Janaki Potukuchi, Central Carolina Technical Institute

ELECTRONICS CURRICULUM COMMITTEE

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELN 123 ELECTRONICS III

COURSE DESCRIPTION:

Continues the study of active networks. Emphasis is on the analysis and design of both networks and active circuits. In addition fundamentals, design techniques, and typical applications of linear integrated circuits are introduced.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 4.

QUARTER HOURS CREDIT: 5.

PREREQUISITE: T-ELN 122, T-MAT 103.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution, oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Match one amplifier stage to another using either RC transformer or direct coupling methods, and compute the gain and frequency response of the coupling network.

(2) Predict overall gain of a multistage amplifier.

(3) Predict overall frequency response of a multistage amplifier.

(4) Design the required amplifier system, specifying all components, assembling a breadboard prototype and testing performance against specifications when given an audio signal source with a set of specifications and a specific load.

(5) Design appropriate feedback circuits for amplifiers to satisfy gain, bandpass, and impedance requirements.

(6) Design feedback, bias, and frequency determining networks for all standard sinusoidal oscillators such as Armstrong, Hartley, Colpitts, Wien-bridge, phase-shift, and crystal types.

(7) Select the test equipment and specify the test procedures needed to diagnose and troubleshoot problems in amplifier and oscillator systems.

(8) Draw the schematic diagram, design and specify all component values, assemble a breadboard prototype and test performance against the specifications, such as output voltage, output current, regulation and ripple factor when given a set of specifications for a conventional power supply and filter system.

(9) Design and specify all component values, assemble a prototype and test performance against the specifications when given a diagram for a given electronically regulated power supply.

(10) Select the test equipment and specify the test procedures needed to diagnose and troubleshoot problems in power supply systems.

(11) Test and evaluate a variety of the more common linear IC devices such as, op amps, diff-amps, wideband amps, and regulators. Representative tests may include device dissipation, input/output impedances, input/output offsets, bandpass, gain, and distortion.

(12) Specify and design external bias networks for linear IC amplifiers.

(13) Specify and design feedback networks to control gain and bandpass characteristics in linear IC amplifiers.

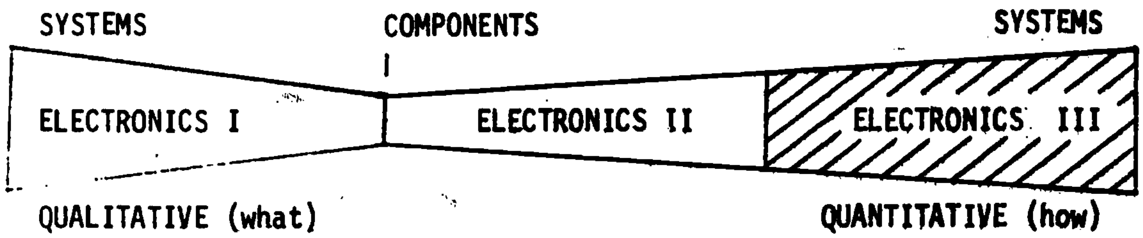
(14) Specify and design oscillator feedback networks for linear IC amplifiers.

(15) Select the test equipment and specify the test procedures for evaluating performance and diagnosing problems in systems using linear IC amplifiers.

(16) Remove, test, and replace IC amplifier packages by unsoldering and soldering.

CONDUCT OF COURSE:

The student at this point is ready to apply the theoretical and mathematical skills acquired to the design of electronic circuits. An understanding of fundamental design principles and the development of sound design practices should be stressed. The material should be presented as a design-oriented semiconductor electronics course prepared around networks and circuits previously studied.



OUTLINE OF INSTRUCTION:

I. Amplifiers

A. RC coupled
B. Transformer
C. Multistage
D. Feedback
E. Operational (op amps)

II. Sinusoidal Oscillators

A. LC
B. RC

III. D.C. Power Supply

A. Half-wave
B. Full-wave
C. Regulated

IV. Active Filters

A. Low pass
B. High pass
C. Band pass
D. Band eliminator

V. Linear Integrated Circuit Fundamentals

A. Terminology
B. Fabrication
C. Equivalent circuits

VI. Linear Integrated Circuit Applications

A. Amplifiers
B. Power supplies
C. Oscillators
D. Others

VII. Suggested Laboratory Exercises

A. Operating amplifier gain control
B. Frequency response control
C. RC oscillators using op amps
D. LC oscillators using op amps
E. Crystal oscillators using op amps
F. Active low-pass filters - fabricate
G. Active high-pass filters - fabricate
H. Active band-pass filters - fabricate
I. Active band eliminator filters - fabricate
J. Swept frequency technique for determining the frequency response of any network
K. Swept frequency technique for obtaining the characteristics of filters and amplifiers
L. Regulated D.C. power supplies

SUGGESTED TEXTS:

Boylestad, Robert L. and Nashelsky, Louis. Electronic Devices and Circuit Theory. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1972.

Malvino, Albert Paul. Electronic Principles. New York: McGraw-Hill Book Co., 1975.

SUGGESTED REFERENCES:

Deboo, Gordon J. and Burrows, Clifford N. Integrated Circuits and Semiconductor Devices: Theory and Application. New York: McGraw-Hill, 1971.

Manera, Anthony S. Solid State Electronic Circuits: For Engineering Technology. New York: McGraw-Hill Book Co., 1973.

RCA Corporation. Solid-State Power Circuits: RCA Designers Handbook; Technical Series SP-52. Somerville, NJ: RCA Corporation, 1971.

SUPPORTING EQUIPMENT:

Oscilloscopes
Meters
Power supplies
Operational amplifiers
Frequency counters
Passive components
Sweep oscillators
X-Y recorder or scope with camera
Junction boxes with rectifiers
Filter boxes
Cable connections

COURSE OUTLINE

T-ELN 218 PULSE, LOGIC AND DIGITAL CIRCUITS

February, 1976

Developed by:

Dr. Janaki Potukuchi, Central Carolina Technical Institute
ELECTRONICS CURRICULUM COMMITTEE

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELN 218 PULSE, LOGIC AND DIGITAL CIRCUITS

COURSE DESCRIPTION:

Emphasizes the study of wave shaping and non-sinusoidal wave generating circuits using discrete and integrated components. Wave shaping topics include simple passive wave shaping circuits and more complicated wave shaping circuits using active devices. Topics covered under non-sinusoidal wave generating circuits include multivibrators, sweep generators, and other types of special purpose circuits using discrete and integrated components. An introduction to Boolean algebra and its applications for the simplification of logic circuits is also included.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 4.

QUARTER HOURS CREDIT: 5.

PREREQUISITES: T-ELN 123, MAT 103.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution, oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Differentiate between ideal and practical square waves and pulses and identify the important characteristics such as rise time, over and under shoots and sag of practical square waves.

(2) Use an oscilloscope to measure the above parameters of any given square wave or a pulse signal.

(3) Predict the outputs of R-C and R-L differentiating and integrating circuits for given input conditions.

(4) Discuss the dependence of the output on the time constant of the circuit and the frequency of the input signal and select the correct time constant of the circuit to achieve proper differentiation and integration.

(5) Analyze and predict the outputs of simple clamping, clipping and slicing circuits using L, C, or R components and diodes for a given set of input conditions.

(6) Select from the above circuits, an appropriate wave shaping circuit for a given set of input and output conditions, perform necessary measurements and be able to discuss and compare the results with specifications.

(7) Recognize important practical applications of the above circuits as well as their limitations.

(8) Recognize important advantages of using active devices such as transistors and IC op amps in wave shaping circuits.

(9) Using active devices, recognize appropriate wave shaping circuits and predict their output for a set of input conditions.

(10) Recognize the differences between astable, monostable, and bistable multivibrators and suggest practical applications for each of these circuits.

(11) Select appropriate IC's and design astable, monostable, and bistable multivibrators and a Schmitt trigger for given specifications.

(12) Draw a simple schematic of a sawtooth generator using an IC op amp and discuss the dependence of the output characterisitcs on the components used in the circuit.

(13) Identify the symbolic representation for digital gates such as AND, OR, NOT, EX-OR, NAND, NOR, etc. and write the Boolean expressions for their outputs.

(14) Prepare the truth tables for the above logic gates.

(15) Distinguish between different logic families (TTL, ECL, CMOS, Schotkky, etc.) and some important advantages and limitations of each class.

(16) List simple Boolean theories (such as $A+\overline{A}=1$, $A\cdot\overline{A}=0$, $A\cdot 1=A$, $A+1=A$, etc.)

(17) List the two De Morgan's laws and be able to apply these laws for simplication of simple expressions. (such as $\overline{A\cdot B\cdot C}$, $\overline{A+B+C}$, etc.)

(18) Use the simple Boolean theorems and De Morgan's laws to simplify given logic expressions and implement logic expressions using logic gates.

(19) Demonstrate in the laboratory, the ability to fabricate the designed circuits and make necessary tests to check conformity with specifications.

OUTLINE OF INSTRUCTION:

I. Waveform Analysis

A. Ideal and practical rectangular pulses
B. Periodic waveforms
C. Frequency spectrum analysis
D. Bandwidth requirements of pulse amplifiers

II. RC Circuit

A. Charging and discharging of capacitors
B. Time constants
C. Charging and discharging equations
D. RC differentiating and integrating circuits

III. RL and RLC Circuits

A. Time constant of RL circuits
B. RL differentiating and integrating circuits
C. Transient response of series RLC circuit
D. Transient response of parallel RLC circuits

IV. Introduction to Pulse Transformers and Delay Lines

A. Ideal and practical pulse transformers
B. Delay lines-general discussion
C. Lumped parameter delay lines
D. Distributed parameter delay lines

V. The Diode Switch

A. Ideal and practical diode characteristics
B. Diode clamping and clipping circuits
C. Other waveshaping circuits using diodes

VI. The Transistor Switch

A. Basic transistor operation
B. Approximate analysis of transistor circuits
C. Loading effects
D. Transient operation of transistors
E. Transistor as an inverter

VII. Introduction to Non-sinusoidal Signal Generating Circuits Using Discrete Components

A. Bistable multivibrators
B. Monostable multivibrators
C. Astable multivibrators
D. Schmitt trigger circuits
E. Sweep waveform generators

VIII. Introduction to Logic Gates and Boolean Algebra

A. Properties and symbolic representation of AND, OR, NOT, NAND, and NOR logic gates

B. Boolean expressions and truth tables for the above gates
C. Boolean algebra, theorems and simplication of logic expressions using the Boolean theorems
D. Types of digital integrated circuits and their important characteristics
   1. Fan-in and fan-out considerations
   2. Noise margins

IX. Applications of Digital and Linear IC for the Generation of Non-sinusoidal Wave Forms

   A. Flip-flops of different types, and their characteristics
   B. Monostable multivibrators and Schmitt trigger circuits
   C. Astable multivibrators
   D. Sweep generators
   E. Other wave generation and shaping circuits

SUGGESTED TEXTS:

Oppenheimer, Samuel. Semiconductor Logic and Switching Circuits; Second Edition. Columbus OH: Charles E. Merrill Publishing Co., 1973.

Mitchell, Brinton B. Semiconductor Pulse Circuits with Experiments. New York: Holt, Rinehart and Winston, Inc., 1970.

SUGGESTED REFERENCES:

Tocci, Ronald J. Fundamentals of Pulse and Digital Circuits. Columbus, OH: Charles E. Merrill Publishing Co., 1972.

Veatch, Henry C. Pulse and Switching Circuit Action. New York: McGraw-Hill Book Co., 1971.

Veatch, Henry C. Pulse and Switching Circuit Measurements. New York: McGraw-Hill Book Co., 1971.

T-ELN 219

COURSE OUTLINE

T-ELN 219 DIGITAL FUNDAMENTALS

February, 1976

Developed by:

Stewart Reed, Forsyth Technical Institute

ELECTRONICS CURRICULUM COMMITTEE

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELN 219 DIGITAL FUNDAMENTALS

COURSE DESCRIPTION:

Emphasizes the study of combinational and sequential logic circuits using discrete and integrated components. Topics include: binary arithmetic, numbering systems, Boolean algebra, storing, timing, gating, and counting. Typical applications in industry will be presented.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 4.

QUARTER HOURS CREDIT: 5.

PREREQUISITE: T-ELN 218.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution, oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Perform conversion from one numbering system to another, specifically binary, octal, and decimal.

(2) Calculate problems of addition, subtraction, multiplication, and division in binary.

(3) Draw and identify logic symbols for AND, OR, NAND, NOR, and NOT gating circuits.

(4) Prepare and explain truth tables for all standard gates, latches, and flip-flops.

(5) Explain and draw circuit element differences among each of the logic families such as RTL, DTL, TTL, ECL and MOS.

(6) Write Boolean expressions for combinational logic.

(7) Implement Boolean expressions using combinational logic gates.

(8) Perform NAND conversions for all standard logic gates, using only NAND gates to achieve all other gating functions.

(9) Perform NOR conversions for all standard logic gates, using only NOR gates to achieve all other gating functions.

(10) Prove De Morgan's theorem using logic gates and truth tables.

(11) Minimize a logic expression using Karnaugh mapping.

(12) Draw the logic diagrams of counters such as asynchronous, synchronous, ring, mobius and modulo-N.

(13) Draw timing diagrams for each of the counters listed.

(14) Explain the sequential operational events for each of the counters listed.

(15) Draw and explain basic digital encoding and decoding systems.

(16) Draw and explain a basic parallel data transmission system.

(17) Draw and explain a basic serial data transmission system.

(18) Prepare truth tables for adders and subtractors.

(19) Draw and identify logic symbols for adders and subtractors.

(20) Implement adders and subtractors using standard gates.

(21) Implement and test gating devices and systems included in the course when provided with appropriate and sufficient hardware.

OUTLINE OF INSTRUCTION:

I. Review of Numbering Systems

  A. Base 10
  B. Base 8
  C. Base 2
  D. Binary to octal and octal to binary conversions
  E. Binary to decimal and decimal to binary conversions
  F. Binary arithmetic
    1. Addition
    2. Subtraction
    3. Multiplication
    4. Division
  G. Binary coded decimal

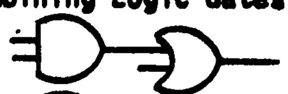
II. Review of Logic Gates, Truth Tables and Written Expressions

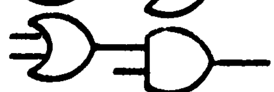
A. AND
B. OR
C. NOT
D. NAND
E. NOR
F. Boolean algebra

III. Types of Logic

A. RTL
B. DTL
C. TTL
D. ECL
E. MOS

IV. Combining Logic Gates, Truth Tables and Output Expressions

A. 

B.  etc.

C. Additional examples increasing in difficulty

V. NAND Conversions

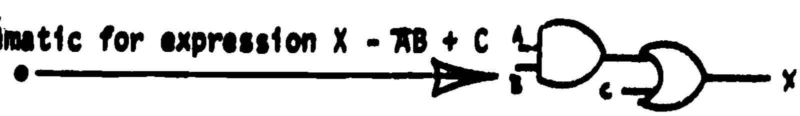
A. AND - NAND with inverts
B. OR - negated input NAND
C. NOR - negated input NAND with inverter

VI. NOR Conversions

A. AND - negated input NOR
B. OR - NOR with inverter
C. NAND - negated input NOR with inverter

VII. Conversion from Written Expressions to Gates (Implementation of Expression)

A Example
1. Draw schematic for expression $X = \bar{A}B + C$
2. Solution:



B. Provide additional examples gradually increasing in difficulty

VIII. Designing with NAND Logic

A. Start with logic expression and draw schematic diagram of original expression
B. Replace each gate with its equivalent NAND conversion

C. Remove double insertions and redraw schematic diagram
D. Provide several examples gradually increasing in difficulty

IX. Boolean Algebra

A. Correlate logic gates and Boolean algebra
B. De Morgan's theorem
   1. Prove using gates and truth tables
   2. Provide several examples for students to work
C. Karnaugh mapping
   1. Three-variable map
   2. Four-variable map
   3. Factoring

X. Exclusive OR

A. Schematic
B. Truth table
C. Implementation with NAND gates

XI. Other Gates

A. Exclusive NOR
B. Wired AND, wired OR
C. Expanders
D. Buffers

XII. Flip-Flops

A. Latches
   1. NAND
   2. NOR
   3. Invertors
B. Gated latch applications
C. RS flip-flop
D. D type flip-flop
E. T type flip-flop
F. JK type flip-flop

XIII. Counters and Registers

A. Asynchronous counters (ripple, up and down)
B. Synchronous counters (up and down)
C. Ring counters
D. Mobius counters
E. Modulo-N counters
F. Shift registers

XIV. Parallel Data Transmission

XV. Serial Data Transmission

XVI. Codes and Decodes

A. 8421
B. 2421
C. Excess - 3
D. Gray code
E. Mobius decode
F. Manchester code

XVII. Arithmetic Operations

A. Half-adder
B. Full-adder
C. Half-subtractor
D. Full-subtractor
E. Parallel-adder
F. Serial-adder

XVIII. Read-out Devices and Decode Drivers

A. Nixie
B. Seven-segment
   1. Tube
   2. LED

XIX. Converters

A. Analog to digital
B. Digital to analog

XX. Matrices

SUGGESTED TEXTS:

Malvino, Albert Paul and Leach, Donald P. Digital Principles and Applications; Second Edition. New York: McGraw-Hill Book Co., 1975.

SUGGESTED REFERENCES:

Baron, Robert C. and Piccirilli, Albert T. Digital Logic and Computer Operations. New York: McGraw-Hill Book Co., 1967.

Bartee, Thomas C. Digital Computer Fundamentals; Third Edition. New York: McGraw-Hill Book Co., 1972.

Levine, Morris E. Digital Theory and Experimentation Using IC Circuits. Englewood Cliffs, NJ: Prentice-Hall Inc., 1974.

Texas Instruments Inc. Designing with TTL Integrated Circuits. New York: McGraw-Hill Book Co., 1971.

SUGGESTED EQUIPMENT:

Digital trainer and/or logic equipment with laboratory built additions (see Electronics equipment list for suggested equipment)

Training manuals for the above equipment

T-ELN 237

COURSE OUTLINE

T-ELN 237 INDUSTRIAL INSTRUMENTATION

December, 1976

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELN 237 INDUSTRIAL INSTRUMENTATION

COURSE DESCRIPTION:

A study of basic principles and instruments for the measurement and control of industrial processes. Laboratory experiments in the use and application of electronic, pneumatic, and hydraulic measurement devices to measure temperature, pressure, flow, light, and pH.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 3.

QUARTER HOURS CREDIT: 4.

PREREQUISITE: T-ELN 122, T-ELC 211.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution, oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Specify appropriate input transducers to be used in industrial control systems to measure temperature, pressure, flow, level, light and pH.

(2) Specify appropriate output transducers and/or devices for indicating, recording, displaying or controlling industrial process parameters.

(3) Integrate input and output transducers or devices with electronic process control systems.

COURSE OUTLINE

T-ELN 241 ELECTRONIC SYSTEMS I

February, 1976

Developed by:

Roy Gull, Catawba Valley Technical Institute
Robert Reaves, Durham Technical Institute
Peter Resta, Nash Technical Institute

ELECTRONICS CURRICULUM COMMITTEE

And

V.A. Pace, Nash Technical Institute

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELN 241 ELECTRONIC SYSTEMS I

COURSE DESCRIPTION:

A general survey of electronics systems with emphasis on their description in block diagram format. Systems to be studied are those used in communications, computing, measurement, and automatic control and others of a specialized nature as appropriate.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 6.

QUARTER HOURS CREDIT: 5.

PREREQUISITES: T-ELN 123.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Understand the terms used to describe electronic and/or electromechanical systems.

(2) Understand the block diagram format for analysis of electronic systems.

(3) Synthesize overall systems operation from the knowledge of characteristics of each functional block of the system.

(4) Analyze and understand the contribution of each functional block to overall system operation.

(5) Calculate overall system performance based upon worst-case performance of functional blocks.

(6) Use test instruments to analyze an assigned system in the laboratory.

(7) Identify functional blocks of the assigned system.

(8) Measure and document operating characteristics of each functional block of the assigned system.

(9) Analyze the assigned system to identify areas of possible error and simulate such errors where plausible.

(10) Analyze an assigned problem.

(11) Design, in block diagram format, the system required to accomplish the desired objective.

(12) Establish operating characteristics and specifications for each functional block of the system.

(13) Construct and verify operation of the system to the extent feasible.

CONDUCT OF COURSE:

During this course the study emphasis should be on electronic systems from a functional point of view. Each system is then examined or explored by dividing it into appropriate functional blocks or units.

The types of systems to be studied should be selected to offer the student the broadest background possible.

OUTLINE OF INSTRUCTION:

I. Introduction to Electronic Systems

   A. Definitions and terminology
   B. Block diagramming concepts
      1. Signal considerations list representive of the various types
      2. Interfacing techniques

II. Communication Systems

   A. Purpose of communication systems
   B. Typical communication systems
      1. Amplitude modulated
      2. Frequency modulated
      3. Single-sideband
      4. Television
      5. Microwave links

III. Measurement Systems

   A. Purpose of measurement systems
   B. Typical measurement systems
      1. Metering
         a. Non-electronic
         b. Electronic
      2. Counters
      3. Analyzers

a. Distortion
b. Frequency
c. Spectrum
4. Generators
a. Audio frequency
b. Radio frequency
5. Displays
a. CRT
b. Digital
c. Printer

IV. Computing Systems

A. Purpose of computing systems
B. Computer types (a classification, basic)
1. Digital
2. Analog
C. Typical computers (a classification by size)
1. Full size
2. Mini
3. Micro

V. Control Systems

A. Purpose of control systems
B. Typical control systems
1. Analog types
a. Servo-mechanisms
b. Electromechanical (relays)
2. Digital types
a. Numerical
b. Others
3. Electro-optic

VI. Other Systems

(These are to be chosen as considered appropriate student and instructional needs)

SUGGESTED SYSTEMS:

Navigational systems
Radar systems
Telemetry systems
Ultrasonic and sonar systems
Data systems
Instrumentation systems

SUGGESTED TEXTS AND REFERENCES:

Adam, Stephen F. Microwave Theory and Applications. New Jersey: Prentice Hall Inc. Latest Edition.

Angerbauer, George J. Electronics for Modern Communications. Englewood Cliffs, NJ: Prentice Hall Inc., 1974.

Balakrishman, A. V. Communication Theory. New York: McGraw-Hill Book Co., 1968.

Bannister, B.R. Fundamentals of Digital Systems. New York: McGraw-Hill Book Co., 1973.

Belove, Charles and Drossman, Melvyn M. Systems and Circuits for Electrical Engineering Technology. New York: McGraw-Hill Book Co.

Bennett, William R. Introduction to Signal Transmission. New York: McGraw-Hill Book Co., 1970.

Blukis, Juris & Mark. Practical Digital Electronics. New Jersey: Hewlett Packard Inc., Latest Edition.

Bull, Gordon M. Time Sharing Systems. New York: McGraw-Hill Book Co., 1972.

Chute, George M. and Chute, Robert D. Electronics in Industry; Fourth Edition. New York: McGraw-Hill Book Co,

Clarke, Kenneth K. and Hess, Donald T. Communication Circuits: Analysis and Design. Massachusetts: Addison-Wesley Publishing Co., 1971.

Cooper, William D. Electronic Instrumentation and Measurement Techniques. New Jersey: Prentice Hall Inc., 1970.

Dearholt, Donald W. and McSpadden, William R. Electromagnetic Wave Propagation. New York: McGraw-Hill Book Co., 1973.

DeRossi, Claude J. Exploring the World of Data Processing. Virginia: Reston Publishing Co., 1975.

Dorf, Richard C. Modern Control Systems; Second Edition. Massachusetts: Addison-Wesley Publishing Co., 1974.

Doyle, John M. Pulse and Digital Circuits; Second Edition. New Jersey: Prentice Hall, Inc.

Eaton, J. R. Electric Power Transmission Systems. New Jersey; Prentice Hall, Inc., 1971.

Elgerd, Olle I. Electric Energy Systems Theory: An Introduction. New York: McGraw-Hill Book Co., 1971.

Grob, Bernard C. Basic Television: Principles and Servicing; Fourth Edition. New York: McGraw-Hill Book Co.

Herrick, Clyde N. Audio Systems. Virginia: Reston Publishing Co., 1974.

Herrick, Clyde N. Instruments and Measurements for Electronics. New York: McGraw-Hill Book Co., 1972.

Humphrey, William M. Introduction to Servomechanism Design. New Jersey: Prentice Hall Inc., 1973.

Kennedy, George. Electronic Communication Systems. New York: McGraw-Hill Book Co., 1970.

Kosow, Irving L. Control of Electric Machines. New Jersey: Prentice Hall Inc., 1973.

Mandl, Mathew. Modern Television Systems Theory and Servicing. New Jersey: Prentice Hall Inc., 1974.

Mandl, Mathew. Principles of Electronic Communication. New Jersey: Prentice Hall Inc., 1973.

Northrup Institute of Technology. Electricity and Electronics for Aerospace Vehicles; Second Edition. New York: McGraw-Hill Book Co., 1972.

Norton, Harry N. Handbook of Transducers for Electronic Measuring Systems. New Jersey: Prentice Hall, Inc., 1969.

Robinson, Vester. Basic Principles of Digital Computers. Virginia: Reston Publishing Co., Inc., 1974.

Robinson, Vester. Handbook of Electronic Instrumentation, Testing and Troubleshooting. Virginia: Reston Publishing Co. Inc., 1974.

Schrader, Robert L. Electronic Communication; Third Edition. New York: McGraw-Hill Book Co., 1975.

Stanley, William. Digital Signal Processing. Virginia. Reston Publishing Co. Inc., 1975.

Temes, Lloyd. Communication Electronics for Technicians. New York: McGraw-Hill Book Co., 1974.

Thomas, Harry E. Handbook of Biomedical Instrumentation and Measurement. Virginia: Reston Publishing Co. Inc., 1974.

Wheeler, Gershan J. Radar Fundamentals. New Jersey: Prentice Hall Inc., 1967.

Zeines, Ben. Electronic Communications Systems. New Jersey: Prentice Hall Inc., 1970.

Zeines, Ben. Automatic Control Systems. New Jersey: Prentice Hall Inc. 1972.

T-ELN 242

COURSE OUTLINE

T-ELN 242 ELECTRONIC SYSTEMS II: COMMUNICATIONS

August, 1976

Developed by

ELECTRONICS CURRICULUM COMMITTEE
and
K. H. Bailey, Wake Technical Institute

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELN 242 ELECTRONIC SYSTEMS II: COMMUNICATIONS

COURSE DESCRIPTION:

Introduction to fundamental aspects of electronic communication systems with special emphasis on need for modulation, types of modulation, frequency spectra and bandwidth requirements. Qualitative study of the principles of AM, SSB, and FM including the generation and detection of signals and their frequency spectra. Transmission and propagation of radio signals will be studied.

COURSE HOURS PER WEEK: Class, 5; Laboratory, 4.

QUARTER HOURS CREDIT: 7.

PREREQUISITE: T-ELN 241.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Explain how RF energy propagates along a transmission line and compute reflection coefficients and VSWRs for given loads and characteristic impedance.

(2) Distinguish between Hertzian and Marconi antennas with respect to such parameters as polarization, characteristic impedance, best employment, radiation patterns, directivity and gain.

(3) Recognize and explain the construction, advantages, and disadvantages of the more common types of antenna arrays.

(4) Demonstrate competence in the use of the Smith Chart to include solving for VSWR; location of nulls, loads, shorts and opens; and placement and length of stub tuners.

(5) Identify the type tuned circuits used in receiver input circuits, transmitter output circuits, and other electronic applications.

(6) Identify from comparisons and schematics the various types of oscillator used in communications, e.g. Hartley, Colpitts, Pierce, and crystal.

(7) Explain the theory behind biasing and neutralizing methods, why and where used, and in detail, how amplifiers work in communication circuitry. With proper supervision in accordance with FCC Rules and Regulations, the student should be able to demonstrate in the laboratory that he can:

a. Load a transmission line to obtain a flat response, or 1:1 VSWR.
b. Design and erect a simple dipole that will resonate on a given frequency within an acceptable VSWR.
c. Solve transmission line problems with the use of the Smith Chart in an expeditious and accurate manner.
d. Develop sound troubleshooting procedures using both signal injection and signal substitution methods, static testing, dynamic testing and, as a minimum, identify simple malfunctions in amplifier and oscillator circuits used at radio frequencies.
e. Utilize properly those instruments commonly used in communication engineering technology e.g. SWR bridge, grid dip oscillator (or tunnel dipper), antenna current meter and other RF recording instruments, transmatchers.
f. Tune a receiver to a CW,AM, and SSB signal so that each can be heard and understood easily and categorized using standard RST reporting procedure.

OUTLINE OF INSTRUCTION:

I. Amplitude Modulation

A. Principles
B. Mathematical description of waveform
C. Percent modulation
D. Power content in carrier and in sidebands
E. Components of the AM transmitter
F. Modulation amplification
G. Classes of modulation
H. Early types of receivers
I. The superheterodyne receiver
J. Receiver performance; sensitivity, selectivity, stability
K. Reception of CW; the BFO
L. Frequency conversion and bandpass

II. Frequency Modulation

A. Principles of angle modulation
B. Mathematical description of waveform
C. Noise and the AM signal
D. Frequency deviation and noise
E. Direct and indirect methods of generating FM signals
F. Reactance modulation
G. Multiplying and heterodyning
H. Limiters; detector; the ratio detector; the gated-beam
I. Preemphasis and deemphasis; squelch circuits

III. RF Phenomena

A. Fields of energy
B. The Poynting vector
C. Propagation of RF energy
D. The TEM mode

IV. The Transmission Line

A. Purpose
B. Characteristic impedance
C. Lumped constants
D. Impedance matching

V. Antennas

A. Elementary types
B. Radiation resistance and power
C. Gain and directivity
D. Impedance matching; polarization
E. Antenna arrays

VI. Propagation of RF Energy

A. Sky, space, and ground waves
B. Atmospheric effects, general
C. The ionosphere
D. Predictions

VII. The Smith Chart

A. The reactance chart
B. Advantages of the Smith Chart
C. Plotting X, Y, and VSWR
D. Radial scales
E. Stub tuning

VIII. Tuned Circuits

A. Series circuits
B. Parallel circuits
C. RF coupling

IX. RF Amplifiers and Oscillators

A. Feedback
B. Types of amplifiers and oscillators
C. Biasing
D. Neutralization
E. Crystals

SUGGESTED TEXT:

Temes, L. Communication Electronics for Technicians. New York: McGraw-Hill Book Co., 1974.

SUGGESTED REFERENCES:

Kennedy, G. Electronic Communication Systems. New York: McGraw-Hill Book Co., 1970.

American Radio Relay League. The Radio Amateur's Handbook. Conn: 1976.

Shrader, R. Electronic Communications. New York: McGraw-Hill Book Co., 1967.

T-ELN 243

COURSE OUTLINE

T-ELN 243 ELECTRONIC SYSTEMS III: COMMUNICATIONS

August, 1976

Developed by

Electronics Curriculum Committee
and
K. H. Bailey, Wake Technical Institute

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELN 243 ELECTRONIC SYSTEMS III: COMMUNICATIONS

COURSE DESCRIPTION:

Study of specialized electronic communication systems such as TV, microwave, radar, and optical communication systems. Discussion of sampling and pulse systems including techniques of multiplexing such as PAM, PDM, PCM, and PPM.

COURSE HOURS PER WEEK: Class, 5; Laboratory, 4.

QUARTER HOURS CREDIT: 7.

PREREQUISITE: T-ELN 242.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Recognize, through the use of instrumentation such as the oscilloscope, typical AM, SSB, and FM waveforms.

(2) Develop the basic equations involved with AM, and SSB, to show the relationships existing between carrier and sidebands in these types of modulation.

(3) Solve problems dealing with percent of modulation, frequency deviation, frequency swing, and similar parameters important to AM, SSB and FM signals.

(4) Understand the theory behind the various types of pulse modulation and multiplexing, particularly with respect to PCM and TDM.

(5) Distinguish between the requirements for the transmission of analog and digital data and display a knowledge of interfacing the UART chip with such devices as the teletype, CRT and modems.

In institutions emphasizing broadcast communication the student should, in addition to the above, be able to:

(6) Describe in detail the components of the typcial broadcast station.

(7) Develop a program distribution plan that utilizes to advantage a typical master control room, remoting of broadcasting transmitters, and telephone company facilities.

(8) Identify likely causes of trouble in the audio and RF circuitry of the broadcast transmitter.

(9) Discuss the advantages and disadvantages in using AM or FM at the broadcast station, to include modulation, limiting and compression circuits.

(10) Compare the various types of equipment found at the typical broadcast station; e.g. microphones, recorders, stereo and multichannel facilities.

In institutions emphasizing TV communication the student should, in addition to the qualifications stated in paragraphs 1 through 5 above, be able to:

(11) Identify the major components of the monochrome and the color receiver.

(12) Describe completely the operation of the iconoscope and the image orthicon tubes.

(13) Describe the composition of the TV frequency channel in complete detail.

(14) Demonstrate a working knowledge of composite video, synchronization pulses and vertical synchrononization.

(15) Discuss the additional requirements of the color TV set to include hue, color, luminosity, Y signal, and chrominance signals.

(16) Describe in detail the multiplexing of I and Y signals into the Y signal and the composite video signal.

In institutions emphasizing microwave communications, the student should be able to, in addition to the qualifications enumerated in paragraphs 1 through 5 above:

(17) Explain the reasons for the development of the klystron tube, the problem with density modulation, and how the klystron exploits the theory of velocity modulation.

(18) Discuss the basic theory involved in the use of such typical microwave hardware as the slotted line, waveguides, various tees, isolators, circulators, crossed field amplifiers and linear beam amplifiers or oscillators.

(19) Explain exactly how, in what modes, RF energy is propagated at microwave frequencies.

(20) Identify the type losses and attenuation encountered at microwave frequencies, how to measure them, and the extent to which they affect routine measurements.

(21) Discuss the advantages and disadvantages of the various solid state devices and generators existing today in the microwave engineering technology area.

In institutions emphasizing the telemetry communications, the student should, in addition to the qualifications listed in paragraphs 1 through 5 above, be able to:

(22) Explain the general requirements for transmitting and receiving telemetry to include types of sensors and signal conditioning.

(23) Distinguish between and discuss the advantages/disadvantages of FDM and TDM to include demodulation techniques, specific applications and relative importance of each to modern communications.

(24) Describe fully existing display techniques and systems used in modern telemetry.

In institutions emphasizing radar communications the student should, in addition to the qualifications enumerated in paragraphs 1 through 5 above, be able to:

(25) Discuss the components of the basic radar system.

(26) Identify the major properties or characteristics of typical radar targets.

(27) Describe in detail the capabilities and limitations of both pulse and CW radar in terms of range, PRF, scanning speed, bandwidth, power, clutter, information rate, and effectiveness against stationary as well as moving targets.

(28) Discuss the various methods by which radar data is presented e.g. azimuth, height, range, speed.

(29) Explain how radar is useful in such areas as navigation on land, sea, and air, plotting, control and relaying of information.

OUTLINE OF INSTRUCTION:

I. Pulse Modulation and Multiplexing

A. PAM, PTM, PPM
B. Advantages and disadvantages of PCM
C. Multiplexing, general
D. FDM, TDM
E. FSK; ASCII and Baudot coding

II. Microprocessors in Communications

A. Parallel data transmission
B. Serial data transmission
C. Asynchronous serial data transmission
D. Use of the UART
E. Interfacing techniques

III. Single Sideband

A. Principles
B. Methods of generation
C. The balanced modulator
D. Advantages and disadvantages

IV. Specialized Systems

A. Broadcasting
B. Television
C. Microwave
D. Telemetry
E. Radar

V. Broadcasting Option

1. The Broadcast System
   a. Program origination facilities
   b. Physical layout of broadcast (BC) studio
   c. Types of consoles
   d. Complete control room
   e. Attenuation and VU meters

2. Program Distribution
   a. Master control room
   b. Remote broadcasting
   c. Telephone company facilities
3. Transmitter Plant
   a. Audio facilities
   b. RF facilities
4. Fidelity
   a. Measure of quality
   b. Limitations of AM system
   c. Advantages of FM
   d. Percent modulation
   e. Limiting and compression
5. BC Microphones
   a. Carbon, crystal, and ceramic
   b. Velocity and dynamic
   c. Condensor
   d. Three basic directive patterns: polar, cardiod, bidirectional
   e. Polar response
   f. Broadcast microphones: lavalian, ribbon, shotgun
6. Studio Techniques
   a. Microphone placement
   b. Studio acoustics
   c. Measuring audio levels
   d. BC audio standards
   e. Attenuators
7. Program Recording
   a. Disc playback equipment
   b. Program recording
   c. Tape recorders
   d. Stereo and multichannel recording
8. Audio Signal Processing
   a. Studio and transmitter location
   b. Line equalizers
   c. Volume compression and limiting
   d. Frequency and modulation monitoring
9. BC Transmitter
   a. AM
   b. FM
   c. Power supplies
   d. Control system
   e. Protective circuits and cooling
10. TV System
   a. Camera, tube, visual and aural transmissions
   b. Scanning and image analysis
   c. Video signal waveform
   d. Camera chains and synchronizing generator
   e. Transmission and reception of color
   f. Video pairs, waveform and color phase monitoring

g. Encoding and cameras
h. Film equipment
i. Video switching, distribution systems, tape and recorders
j. Color transmitter operation, test equipment and remote control.

VI. Television Option

1. Monochrome
   a. Receiving picture tube
   b. Picture format, scanning, standards
   c. The iconoscope
   d. The image orthicon
   e. Composite video
   f. Synchronization pulse
   g. Vertical synchronization
   h. Composition of TV frequency channel
   i. The receiver
   j. The transmitter
   k. The antenna system
2. Color
   a. Hue, primary colors, saturation, luminosity
   b. The Y signal
   c. Chrominance signals
   d. Forming the video color
   e. Transmission of chrominance signals
   f. Multiplexing I and ~~Q~~ signals into Y
   g. Composite video system
   h. Receiving; demodulation
   i. The picture tube

VII. Microwave Option

1. The Klystron
   a. Density versus velocity modulation
   b. Development of the klystron
   c. Multicavity and reflex klystrons
   d. Capabilities and limitations
2. The Slotted Line
   a. Purpose and usefulness
   b. Basic theory
   c. Importance in microwave measurements
3. The Waveguide
   a. Transmission line, general
   b. Review of the TEM mode
   c. TE and TM modes
   d. Propagation of energy through rectangular waveguide at microwave frequencies
4. Waveguide Components
   a. E and H plane tees

b. Hybrid junction; hybrid ring
c. Crossed field tee
5. Attenuation
a. Types
b. Measurement
c. Directional coupler
6. Antennas
a. Methods of propagation
b. The dipole, the horn and the parabolic reflector
c. Measuring power and voltage patterns
d. Radiation plotting; RFI
7. Microwave devices and generators
a. Ferrite isolators
b. TW; BWC
c. Magnetrons
d. Parametric amplifiers
8. Solid State Devices
a. Schottky barrier diode mixers and detectors
b. PIN diodes
c. IMPATT-TRAPATT devices
d. GUNN and ISA devices
e. BARITT devices
f. Step recovery diodes
g. YIG tuned oscillators
h. Masers and lasers

VIII. Telemetry Option

1. General
a. Types of sensors
b. Signal conditioning
2. FDM
a. General
b. VCO
c. Data degradation
3. Frequency Division Demultiplexing
a. Filters
b. Pulse-averaging detection
c. The PLL
d. Output filter
e. Discriminant specifications
4. TDM
a. Fixed time and demand multiplex
b. Sampling rate
c. Base electron multiplexing circuit
d. Analog to digital converter
e. Data compression
f. Tape coding and formatting
g. Multiplex errors: digitizing, static, dynamic, environmental, aging

5. Time Division Demultiplexing
    a. Decommutation
    b. Synchronization
    c. Bit timing and DC levels
    d. Distribution of data/analog and digital
6. Display Techniques
    a. Basic displays: electroluminescence, laser light, electron beam, mechanical deflection, electric
    b. Systems: Eidophor oil filter, GE thermoplastic filter, and Packel electro-optics
    c. Considerations: data rate and response time, quantity of data visibility; quality

IX. Radar Option

1. Components of radar system
2. The radar equation
3. Properties of radar targets
    a. Cross-section
    b. Rayleigh scattering
    c. Corner reflection
    d. Target shaping
    e. Complicated targets
    f. Ground painting by airborne radar
4. Limitations of pulse radar
    a. Range, PRF, and scan speed
    b. Bandwidth, power, and information rate
    c. Pulse and CW radar
    d. Clutter
    e. Moving targets
    f. Stationary targets
5. CW radar
    a. General
    b. Transmitter spectra
    c. Target effect
    d. Classes of systems
6. Presentation of Radar Data
    a. Types of indicators
    b. Major operational requirements: EW, PPI for search, PPI for control, height finding, homing, precision tracking
    c. Calibration
7. Employment of Radar Data
    a. Aid to navigation
    b. Aid to plotting and control
    c. Relay of radar displays
8. Radar Beacon
    a. System
    b. IFF
    c. Coding
    d. Statistical considerations

SUGGESTED TEXT:

Temes, L. Communication Electronics for Technicians. New York: McGraw-Hill Book Co., 1976.

Lance, Al. Introduction to Microwave Theory and Measurements. New York: McGraw Hill Book Co., 1964.

SUGGESTED REFERENCES:

Mandl, M. Principles of Electronic Communications. Englewood Cliffs, NJ: Prentice Hall Inc., 1973.

Chaffin, R.J. Microwave Semiconductor Devices. John Wiley & Sons Inc., 1973.

Kraus, J. D. and Carver, K.R. Electromagnetics. New York: McGraw-Hill Book Co., 1973.

Angerbauer, G.J. Electronics for Modern Communication. Englewood Cliffs, NJ: Prentice Hall Inc., 1972.

Analog Devices. Analog Digital Conversion Handbook. Norwood, MA. 1972.

DeFrance, JJ. Communication Electronics Circuits. New York: Holt, Rinehart & Winston Inc., 1976.

Adams, S.F. Microwave Theory and Applications. Englewood Cliffs, NJ: Prentice Hall Inc., 1969.

Ridenhour, LN. Radar System Engineering. New York: McGraw-Hill Book Co., 1947.

T-ELN 246

COURSE OUTLINE

T-ELN 246 ELECTRONICS DESIGN PROJECT

February, 1976

Developed by:

Larkin Walker, Roanoke-Chowan Technical Institute
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ELECTRONICS CURRICULUM COMMITTEE

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELN 246 ELECTRONICS DESIGN PROJECT

COURSE DESCRIPTION:

A laboratory class emphasing independent research and design work by the student. The student will select a project in consultation with the instructor; perform the required research; compile data; formulate a theoretical model; and construct, test, and evaluate a working model of the selected project.

COURSE HOURS PER WEEK: Class, 0; Laboratory, 6.

QUARTER HOURS CREDIT: 3.

PREREQUISITE: T-ELN 241.

OBJECTIVES:

Having chosen a project and when presenting it for instructor's approval the student should be able to:

(1) Explain the reasons for choosing such a project.

(2) Explain the operation and specifications of the project.

(3) Estimate the approximate cost of the project.

(4) Estimate the amount of time it would take to complete the project.

(5) Identify any special components needed, their complete specifications and a source from which they can be procured.

After getting instructors approval, the student should within a reasonable period of time be able to:

(6) Complete design of either all or those stages of the project that are within the scope of the course.

(7) Explain the operation of the project stage by stage with technical specifications of each stage.

(8) Present, through relevant schematics and drawings, information related to layout, fabrication, and assembly procedures, etc.

After approval of his plans, the student should be able to:

(9) Complete the project on a breadboard model and verify the operation of the complete unit.

(10) If the unit does not work, troubleshoot and test the project systematically and be able to make any adjustments or corrections that are necessary and make the unit operative.

(11) Assemble the unit in final form for presentation, after confirming that the project performs according to specifications.

(12) Perform final tests on the project and evaluate its complete performance.

(13) Write a technical report that includes all drawings, results of tests performed, the technical specifications and other relevant material.

(14) As a final step, the student may present his work to the class and satisfactorily answer any questions that might come up during the discussion.

OUTLINE OF INSTRUCTION:

I. Selection of Individual Projects

  A. General information
    1. Requirements of advisor
    2. Time and cost limitations
  B. Individual student selection
  C. Advisor's approval

II. Project Development

  A. Research into background material
  B. Compiling preliminary data
  C. Submitting preliminary report to advisor
    1. Specifications
    2. Functional descriptions
    3. Block diagrams
  D. Construction of working model (if feasible)
  E. Compiling final data
  F. Submit project and final comprehensive report to advisor for evaluation

SUGGESTED REFERENCES:

- Handbooks
- Manuals
- Periodicals
- Manufacturers specification sheets

T-ELN 247

COURSE OUTLINE

T-ELN 247 ELECTRONIC SYSTEMS II: COMPUTERS

February, 1976

Developed by:

Stewart Reed, Forsyth Technical Institute

ELECTRONICS CURRICULUM COMMITTEE

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELN 247 ELECTRONIC SYSTEMS II: COMPUTERS

COURSE DESCRIPTION:

~~The course consists of a functional block diagram analysis of a number~~ of digital computer systems. Emphasis is placed on the mini/micro computer variety currently being used in industry. The lab will provide practice in manipulating the hardware and software associated with such computers.

COURSE HOURS PER WEEK: Class, 5; Laboratory, 4.

QUARTER HOURS CREDIT: 7.

PREREQUISITE: T-ELN 241.

COREQUISITE: T-ELN 217.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution, oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Explain the function of each instruction associated with a given computer.

(2) Explain the function and demonstrate the use of each operational control or switch associated with a given computer.

(3) Draw the block diagram and explain the function of each block or subsystem of a given computer.

(4) Explain the function and demonstrate the use of each piece of peripheral hardware for a given computer.

(5) Write a program using the instructions available for a given computer when given a flow chart of a program.

(6) Develop flow charts for computer programs.

(7) Write programs utilizing all instructions associated with a given computer.

(8) Store and run any program written for a given computer.

(9) Debug programs utilizing any special instructions and procedures available for a given computer.

CONDUCT OF COURSE:

The course is designed to provide instruction and practice in writing programs utilizing a computer's instructional repertoire and then inplementing the programs, through the full input/output capability of the machine. In addition the functional aspects of the various subsystem blocks of the computer will be covered to the extent that the student can understand how an instruction is executed. An investigation of other associated peripheral hardware may be included.

OUTLINE OF INSTRUCTION:

I. Introduction to the General Characteristics of the Computer.

A. Physical layout
B. Memory capability
C. Peripheral capability

II. Internal Organization

A. Displays and registers
B. Control section
C. Arithmetic section
D. Memory section
E. Input/output section

III. Operating Controls

A. Manual controls discussion
. Automatic controls

IV. Instruction Definition

. Operation code
. Operand address
. Format for programming sheet

V. Program Development

A. Flow charting basics
B. Menomic codes
C. Interpretation of an instruction description
D. Practice solving simple problems through flow charting

VI. Programming the Basic Arithmetic Instructions

A. Clear and add
B. Add
C. Subtract

VII. Operating Instructions for the Teletype-Print-Octal Function

A. Print answers to arithmetic problems
B. Print out contents in memory

VIII. Operating Instructions for the Paper Tape Punch Mechanism

~~A. Making octal format paper tapes~~
B. Making alpha format paper tapes

IX. Operating Instructions for the Paper Tape Reader

A. Reading an octal format tape
B. Reading an alpha format tape

X. Programming Alpha Format Instructions

A. ASC II code
B. Writing programs with alpha data

XI. Programming Advanced Arithmetic Instructions

A. Multiply
B. Shift right and left
C. Divide
D. Octal to alpha conversion/alpha to octal conversion

XII. Programming the Indexing Instructions

A. Index and add
B. Index and subtract

XIII. Programming Decision Making Instructions

A. Branch on zero
B. Branch on negative
C. Branch on overflow

XIV. Programming the Subroutine Instruction

A. Subroutine format
B. Kinds and examples of subroutines

XV. Methods to Debug a Program

A. One-step analysis
B. Display instruction
C. Break instruction

XVI. Analysis of Steps Within the Execution of an Instruction by the Machine

A. Phase counter

B. Function register
C. Fetch and exout parts of an instruction

XVII. Memory Section

A. Simplified core theory
   1. Half and full select currents, I and Y lines
   2. Inhibit and sense lines
~~B. Address register function~~
C. Memory register function

SUGGESTED TEXTS:

Manuals supplied with computer system.

SUGGESTED REFERENCES:

Baron, Robert C. and Piccirilli, Albert T. Digital Logic and Computer Operations. New York: McGraw-Hill Book Co., 1967.

Bartee, Thomas C. Digital Computer Fundamentals; Third Edition. New York: McGraw-Hill Book Co., 1972.

Deam, Nuchow and Zeppa. Digital Computers; Latest Edition. Reston VA: Reston Publishing Co.

Dickey, Larry W. Introduction to Computer Concepts: Hardware and Software. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1974.

Robinson, Vester. Basic Principles of Digital Computers. Reston VA: Reston Publishing Co., 1974.

SUGGESTED EQUIPMENT:

Training type computer of the minicomputer type with teletypewriter unit interfaced with the computer. The teletype unit should be complete with a paper tape punch and reader. (See Electronics equipment list for suggested computer trainers.)

Operators manuals for the above hardware.

Paper supplies for the teletype unit

COURSE OUTLINE

T-ELN 248 ELECTRONIC SYSTEMS III: COMPUTERS

February, 1976

Developed by:

Stewart Reed, Forsyth Technical Institute

ELECTRONICS CURRICULUM COMMITTEE

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELN 248 ELECTRONIC SYSTEMS III: COMPUTERS

COURSE DESCRIPTION:

This course deals with the detailed theory of the computer systems previously covered followed by troubleshooting and maintenance procedures. The lab consists of digital measurements in support of operation theory followed by actual troubleshooting practice, dealing with systems analysis and diagnostic procedures.

COURSE HOURS PER WEEK: Class, 5; Laboratory, 4.

QUARTER HOURS CREDIT: 7.

PREREQUISITE: T-ELN 247.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution, oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Trace logic signal paths on the schematic diagram of a given computer.

(2) Explain the operation of each section of the computer from a bit-by-bit logic analysis.

(3) Identify any logic signal on the schematic diagram and locate the actual test point in the computer.

(4) Establish a timing display on a multichannel oscilloscope for any dynamic operation of any subsystem within the computer.

(5) Proficiently use a multichannel triggered oscilloscope for establishing timing display measurements.

(6) Demonstrate the use of logic probes in determining logic levels at any circuit point in the computer.

(7) Extract, examine and replace circuit cards.

(8) Explain and demonstrate the use of diagnostic programs.

(9) Develop diagnostic programs peculiar to specific test routines.

(10) Given a problem in some specific part of the computer, he can by the use of diagnostic procedures, isolate

the probable cause to a defective gate, connection, or switch.

(11) As a means of analyzing the problem, write a detailed diagnostic report, which should include a diagnostic program which he has developed, a systematic testing procedure, and a speculation as to the probable cause of the malfunction.

(12) Demonstrate the operation and application of any specialized digital computer testing instruments available.

OUTLINE OF INSTRUCTION:

I. General System Schematic Diagrams

A. Coordinate system
B. Logic signal index

II. Access to Logic Test Points in the Computer

A. Cross-reference from schematic to the front panel
B. Rear panel connections

III. Logic Probe Operation

A. Static display
B. Pulse display

IV. Dual-trace Oscilloscope Operation

A. Synchronization to a reference signal
B. Pulse timing from one signal source to another

V. Analysis of the Control Section

A. Clock
B. Clock counter
C. Clock counter decodes
D. Phase counter
E. Phase counter decodes
F. Shift counter

VI. Analysis of the Memory Section

A. Coincident current
B. Clear/write cycle
C. Read/restore cycle
D. Sense and inhibit windings
E. X and Y selection matrices
F. Address register

G. Memory register
H. Memory cycle timing
I. Memory cycle logic and timing waveforms

VII. Analysis of the Arithmetic Section

A. Accumulator
B. B register
C. Adder
D. Adder control section
E. Adder timing
F. Adder timing waveforms

VIII. Analysis of the Input/Output Section

A. Computer keyboard
B. Programming controls
C. Teletype control section
D. Tape reader control section
E. Card reader control section
F. I/O timing waveforms

IX. Instruction Timing Analysis

Example instructions should be analyzed in detail as they are carried out step-by-step

X. Diagnostic Program Writing

A. Special diagnostic instructions
B. Diagnostic printout procedures

XI. Troubleshooting Control

A. Special halt conditions
B. Repeat instruction control

XII. Troubleshooting Practice

NOTE: If the computer is equipped with trouble switches, the student should list the symptoms of each problem, write an appropriate diagnostic program, determine a systematic step-by-step procedure, analyze the test data and speculate as to the probable cause of the problem.

SUGGESTED TEXTS:

Manuals supplied with computer system.

SUGGESTED REFERENCES:

Baron, Robert C. and Piccirilli, Albert T. Digital Logic and Computer Operations. New York: McGraw-Hill Book Co., 1967.

Bartee, Thomas C. Digital Computer Fundamentals; Third Edition. New York: McGraw-Hill Book Co., 1972.

Deam, Nuchow and Zeppa. Digital Computers; Latest Edition. Reston VA: Reston Publishing Co.

Dickey, Larry W. Introduction to Computer Concepts: Hardware and Software. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1974.

Robinson, Vester. Basic Principles of Digital Computers. Reston VA: Reston Publishing Co., 1974.

SUGGESTED EQUIPMENT:

Same computer as used for T-ELN 247
Theory and maintenance manuals for above computer
Dual-trace oscilloscope
Logic probe (see Electronic Equipment List)

T-ELN 249

COURSE OUTLINE

T-ELN 249 ELECTRONIC SYSTEMS II: AUTOMATIC CONTROL

February, 1976

Developed by:

Peter Resta, Nash Technical Institute

ELECTRONICS CURRICULUM COMMITTEE

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELN 249 ELECTRONIC SYSTEMS II: AUTOMATIC CONTROL

COURSE DESCRIPTION:

Automatic control concepts including calibration, measurement and standards are introduced. Laboratory exercises are provided on simulated or generalized measurement and control systems that include indicators, recorders, and controllers. Emphasis is placed on process or system stability using various types of controllers. Final control elements and their characteristics are studied. Graphical analyses and solutions of process control systems are included.
Prerequisite: T-ELN 241.

COURSE HOURS PER WEEK: Class, 5; Laboratory, 4.

QUARTER HOURS CREDIT: 7.

PREREQUISITES: T-ELN 241.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution, oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Define the technical meaning of:

   a. Terms peculiar to measurement of control variables, control agents, and controlling means
   b. Measuring parameters
   c. Process characteristics
   d. Terms peculiar to automatic control technology

(2) Analyze, evaluate, select, specify and recommend types of controllers based on open-loop and closed-loop system response.

(3) Know when and how to apply the following types of controllers for system stability and optimum control:

   a. On-off (two position)
   b. Proportional
   c. Proportional plus automatic reset
   d. Proportional plus automatic reset plus rate
   e. Cascade control
   f. Computer control

(4) Demonstrate a knowledge of controllers in the laboratory by adjusting and calibrating to specified accuracy, sensitivity, and response characteristics, electronic, pneumatic, and hydraulic controllers that modulate final control elements.

(5) Show that the need for operating procedures is to maintain the variable at a desired set point.

(6) Describe the characteristics of the various types of control valves and their selection for optimum systems response to maintain the variable at a set point.

(7) Analyze system characteristics by transient or frequency response and by graphical plots of system equations.

OUTLINE OF INSTRUCTION:

I. Measurement and Control

  A. Definition of terms
  B. Characteristics of measuring function
  C. System characteristics

II. Automatic Control

  A. Control elements
    1. Primary measuring element (the process variable)
    2. Measuring function (transmission methods)
    3. Controlling function (transmission methods)
    4. Final control elements
  B. Characteristics of automatic control
    1. Reset (on/off or floating)
      a. Manual reset
      b. Automatic reset (integral)
    2. Proportional (position and time)
      a. Proportional band (gain)
      b. Proportional plus reset
    3. Rate (derivative)
      a. Plus reset
      b. Plus proportional
    4. Proportional plus reset plus rate
  C. System control of process
    1. Types of automatic controllers
    2. Final control elements
    3. Cascade control
    4. Computer control

III. System Stability

  A. System characteristics reviewed
  B. Selection of the system controller

C. Adjustment of controller for optimum response and system stability
   1. Transient response due to step input
   2. Evaluate variable response of system

IV. Experiences with Types of Controllers

A. Electronic controllers
B. Pneumatic controllers
C. Hydraulic controllers
D. Final control elements

V. Characteristics of Final Control Elements

VI. System Analysis by Graphical Solutions

A. System characteristics reviewed
B. Transient response to step input (the time constant method)
C. Frequency response (the Bode plot)
D. Controller forms
E. Process and controller combined (the closed-loop system - feedback)
F. System disturbances
G. Control system design

SUGGESTED TEXT AND REFERENCES:

Kirk, Frankie W. and Rimboi, Nicholas R. Instrumentation; Second Edition. Chicago, Ill: American Technical Society, 1966.

Tyson, Forest C. Jr. Industrial Instrumentation. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1961.

Foss, L.M. and Delahooke, B.C. Theory and Applications of Industrial Process Control. Albany, NY: Delmar Publishers, Inc.

Nixon, Floyd E. Principles of Automatic Controls. Englewood Cliffs, NJ: Prentice-Hall Inc.

COURSE OUTLINE

T-ELN 250 ELECTRONIC SYSTEMS III: AUTOMATIC CONTROL

February, 1976

Developed by:

Peter Resta, Nash Technical Institute

ELECTRONICS CURRICULUM COMMITTEE

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELN 250 ELECTRONIC SYSTEMS III: AUTOMATIC CONTROL

COURSE DESCRIPTION:

A study of automatic control theory and processes including the characteristics and mathematical models of linear systems. Practice is provided in specifying and selecting process or automatic control parameters and equipment. Electronic and mechanical controls are introduced as well as the use of the minicomputer in the control loop. Practical analysis and evaluation on actual or simulated processes or systems is covered in the laboratory.

COURSE HOURS PER WEEK: Class, 5; Laboratory, 4.

QUARTER HOURS CREDIT: 7.

PREREQUISITES: T-ELN 249.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution, oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Describe examples of automatic control systems.

(2) Know the application of mathematics to control systems and the solutions of various linear differential equations.

(3) Know block diagram elements along with their mathematical transfer function and be able to approximate the transient response.

(4) Sketch block diagrams depicting the mathematical transfer function or equation for each block of various types of control systems including the on-off (two position) controller, the proportional controller, the proportional plus automatic reset controller, and the proportional plus automatic reset plus rate controller.

(5) Understand the Nyquist criterion and be able to apply it to automatic control problems to determine system characteristics.

(6) By plotting system equations on appropriate graph paper, correctly analyze the system and close the loop with specified system gain and frequency response (emphasis will be placed on first-order systems, second-order systems, Nyquist plots and

the Bode plot).

(7) Describe first-order and second-order systems and know how to apply cascaded lag or lead compensation or feedback compensation to obtain optimum system response.

(8) Know the effect of noise upon system performance and know the types and use of filters to minimize output disturbances.

(9) Correlate control functions to mathematic equations and graphically plot the functions in order to analyze, evaluate, and improve system performance by proper on-line adjustments of the controller for optimum response.

(10) Analyze systems by observing transient response data.

(11) Perform laboratory work with electronic controllers, pneumatic controllers, and electro-pneumatic controllers.

(12) Use the mini/micro computer in the control loop.

OUTLINE OF INSTRUCTION:

I. Automatic Control Systems

A. Type
B. Applications
C. Examples
D. Physical viewpoint
E. Analytical viewpoint

II. Applications of Mathematics to Control Systems

A. Mathematical applications
B. Characteristics of a linear continuous system
C. Classical solutions of RC, RL, and RLC networks
D. LaPlace transform solutions of RC, RL, and RLC networks
E. Block diagram transformations

III. Block Diagrams

A. Diagram elements (transfer function)
B. Single loop diagrams
C. Multiple loop diagrams
D. Block diagrams of control systems

IV. Analysis of System Response

A. Transient response (step input function)
B. Frequency response (sinusoidal input function)

V. Systems with Feedback

A. Characteristic equations
B. Nyquist criterion
C. Bode plots

VI. How to Analyze an Automatic Control System

A. Stability of open-loop systems
B. First-order system
C. Second-order system
D. Other methods
   1. Log
   2. Decibel
   3. Root locus plots

VII. Improving System Performance

A. Types of compensation
   1. Cascade lead and cascade lag
   2. Feedback
   3. Combine cascade and feedback
B. Noise and disturbances to output
   1. Filters
   2. Selection of filters
   3. Applications

VIII. Analysis and Evaluation of Electronic, Pneumatic, and Electro-Pneumatic Systems

A. Intuitive reasoning from data
B. Equation fitting of data
C. Least square method on data
D. Slope method

IX. Sample Data Acquisition System

A. Non-continuous systems
B. Application of computer in control of automatic systems

SUGGESTED TEXT AND REFERENCES:

Kirk, Frankie W. and Rimboi, Nicholas R. Instrumentation: Second Edition. Chicago, Ill: American Technical Society, 1966.

Tyson, Forest C. Jr. Industrial Instrumentation. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1961.

Foss, L.M. and Delahooke, B.C. Theory and Applications of Industrial Process Control. Albany, NY: Delmar Publishers, Inc.

Nixon, Floyd E. Principles of Automatic Controls. Englewood Cliffs, NJ: Prentice-Hall, Inc.

T-ELC 204

COURSE OUTLINE

T-ELC 204 ELECTRICAL CIRCUITS

December, 1976

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELC 204 ELECTRICAL CIRCUITS

COURSE DESCRIPTION:

Advanced alternating current circuit analysis, network equations and theorems, polyphase circuits, balanced and unbalanced three-phase circuits, polyphase rectifiers and measuring power in polyphase systems are covered.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 3.

QUARTER HOURS CREDIT: 4.

PREREQUISITE: T-ELC 114.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution, oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Determine series and parallel equivalent circuits using Kirchoff's law.

(2) Simplify electrical circuits to Thevenin's or Norton's equivalent.

(3) Determine maximum power transfer using graphical analysis.

(4) Calculate electrical properties of network circuits using superposition, mesh and nodal analysis.

(5) Perform delta-wye transformations.

(6) Discuss applications of resonant circuits.

(7) Determine the advantages of polyphase systems.

(8) Describe the characteristics of polyphase rectifiers.

(9) Measure power in a three phase system.

(10) Use laboratory equipment to experimentally prove mathematical analysis of circuit parameters.

COURSE OUTLINE

T-ELC 211 ELECTRICAL MACHINES I

December, 1976

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELC 211 ELECTRICAL MACHINES I

COURSE DESCRIPTION:

Principles, construction, characteristics, applications and control of direct current generators and motors. Advanced alternating current circuit analysis in polyphase systems is covered. Includes a survey of induction motors, transformers, alternators, and generators. Experience provided in specifying and wiring machines.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 3.

QUARTER HOURS CREDIT: 4.

PREREQUISITE: T-ELC 114.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution, oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Describe the relationships of flux, motion, torque, and voltages in DC generators and motors.

(2) Explain the construction of DC dynamos.

(3) Describe the types of armature windings.

(4) Draw wiring diagrams illustrating complete armature windings.

(5) Use formulas to calculate parallel circuits, slot, commutator pitch, dead elements and equalizing connections.

(6) Describe DC motor and generator characteristics.

(7) Calculate electrical and physical quantities for DC machines, transformers, alternators and induction motors.

(8) Determine efficiencies, ratings and applications of dynamos, generators, and motors.

(9) Analyze AC circuits used with motors and generators.

(10) Explain the principles and operation of transformers.

(11) Explain the principles and operation of induction motors.

(12) Explain the principles and operation of alternators and generators.

(13) Select and wire electrical machines in the laboratory.

T-ELC 212

COURSE OUTLINE

T-ELC 212 ELECTRICAL MACHINES II

December, 1976

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RLAEIGH, NROTH CAROLINA

COURSE OUTLINE

T-ELC 212 ELECTRICAL MACHINES II

COURSE DESCRIPTION:

Principles, construction, operation, application, and control of single-phase and polyphase power converters, and motors and generators, specialized motors. Single-phase and polyphase transformers, auto transformers and parallel operation of alternators are covered.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 3.

QUARTER HOURS CREDIT: 4.

PREREQUISITE: T-ELC 211.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution, oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Analyze phase relationships, vector diagrams, and loads in AC circuits.

(2) Use voltage and current relationships and the equivalent circuit of a transformer.

(3) Determine the regulation, efficiency, parallel operation and power applications of the transformer.

(4) Describe the principles, construction, frequency, field poles, winding, regulation, efficiency and parallel operation of alternators.

(5) Describe the operating principles and characteristics of polyphase induction motors.

(6) Describe the characteristics of wound-rotor and double squirrel polyphase induction motors.

(7) Explain dynamic braking and reversing methods.

(8) Identify types of starters and explain their use.

(9) Discuss the construction, principles, method of starting, efficiency, speed, torque, and applications of single phase motors.

(10) Discuss the types and applications of rectifiers and converters.

(11) Calculate electrical and physical quantities for synchronous motors, specialized transformers and motors, and three-phase motors and transformers.

(12) Select and wire electrical machines and control circuits in the laboratory.

T-ELC 214

COURSE OUTLINE

T-ELC 214 INDUSTRIAL ELECTRICAL CONTROL SYSTEMS

July, 1976

Developed by:

Jerry Thompson, Catawba Valley Technical Institute

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELC 214 INDUSTRIAL ELECTRICAL CONTROL SYSTEMS

COURSE DESCRIPTION:

A study of industrial electrical control systems. Emphasis is placed on practical circuit analysis as it pertains to starting, rapid stopping, reversing, speed control, and circuit protection for electrical motors. Travel limits for control of mechanical systems are investigated as is timing of multimotor drives. Control building blocks such as switches, relays, contractors, transformer, rectifiers, brakes, protective units and power amplifiers form an integral part of the course.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 4.

QUARTER HOURS CREDIT: 5.

PREREQUISITE: T-ELM 211.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution oral and/or written examonations covering the material in the outline of instruction. As a minimum a student shall:

(1) Determine, select and evaluate overload and short circuit protective devices for optimum motor protection.

(2) Design, select, compare performance and evaluate AC and DC motor control circuits including starting, reversing, jogging, plugging, speed control, regulating, braking, static and dynamic switching.

(3) Determine and evaluate voltage/current levels and waveforms in triggering the power circuits of solid state motor controllers.

(4) Describe the selection and application of solid state motor controller components.

(5) Assemble, wire, operationally test and evaluate the performance of motor control circuits.

(6) Describe the characteristics and uses of DC and AC motor controls and starters.

(7) Describe the operation and design of the common types of DC motor controls and starters.

(8) Calculate required parameters and draw circuit diagrams for DC control circuits.

(9) Test, evaluate, and maintain the common types of DC motor controls.

(10) Write lab reports on tests performed on DC motor controls and starters.

(11) Describe the operation and design of the common types of AC motor controls and starters.

(12) Calculate parameters and draw circuit diagrams for AC control circuits.

(13) Test, evaluate and maintain the commonly used types of AC motor starters and controls.

(14) Write reports on tests performed on AC motor starters and controls.

(15) Describe the operation and design of the commonly used types of regulators and regulating systems.

(16) Test, evaluate and maintain the commonly used types of regulators and regulating systems.

(17) Describe the operation and design of selected devices such as limit switches, pressure switches, brakes and special control circuits.

(18) Test, evaluate and maintain selected devices and special control circuits.

OUTLINE OF INSTRUCTION:

I. DC Motor Controls

A. Manual starters
B. Automatic starters
C. Control circuits
D. Speed control
E. Protective devices

II. AC Motor Controls

A. Manual starters
B. Automatic starters

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C. Control circuits
D. Speed control
E. Protective devices

III. Regulators and Regulating Systems

A. Current and voltage
B. Speed
C. Position
D. Operating systems

IV. Auxiliary Devices and Special Control Circuits

A. Limit switches
B. Pressure and float switches
C. Brakes

SUGGESTED TEXT:

Siskind, Charles S. Electrical Control Systems In Industry. New York: McGraw-Hill Book Co., 1963.

COURSE OUTLINE

T-ELC 221 ELECTROMAGNETIC CONTROLS

December, 1976

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELC 221 ELECTROMAGNETIC CONTROLS

COURSE DESCRIPTION:

A study of control components and schematic motor control wiring diagrams. Motor starters, master controllers, protective devices, rotating and magnetic amplifiers and regulators are introduced.

COURSE HOURS PER WEEK: Class, 2; Laboratory, 3.

QUARTER HOURS CREDIT: 3.

PREREQUISITE: T-ELC 114.

COURSE OUTLINE

T-ELC 222 SOLID STATE CONTROLS

December, 1976

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELC 222 SOLID STATE CONTROLS

COURSE DESCRIPTION:

Introduction to static switching circuits and controls, Boolean algebra, static switching applications involving logic components, and design of control circuits. Dynamic controls involving solid state devices such as the transistor, integrated circuit, and digital readout. Mini computers and their relationship to the control of machines and manufacturing processes will be studied.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 3.

QUARTER HOURS CREDIT: 4.

PREREQUISITE: T-ELC 211.

T-ELC 235

COURSE OUTLINE

T-ELC 235 PLANNING ELECTRICAL INSTALLATIONS

December, 1976

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELC 235 PLANNING ELECTRICAL INSTALLATIONS

COURSE DESCRIPTION:

A familiarization with the National Electrical Code; the power requirements and typical design of industrial and commercial installations. Design and calculation of illumination and electrical cooling and heating.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 6.

QUARTER HOURS CREDIT: 5.

PREREQUISITE: T-ELC 114.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution, oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Use the National Electrical Code to determine safe standards for planning electrical installations.

(2) Be familiar with requirements for grounding, installing fixed electrical conductors, and wiring methods and materials, for industrial and commercial installations.

(3) Be aware of special occupancy wiring situations and factors determining the methods and materials used.

(4) Calculate for and plan lighting installations.

(5) Select lighting systems and light sources.

(6) Calculate heat loss and gain for electrical heating and cooling systems.

(7) Prepare estimates for lighting, power, heating and cooling installations.

(8) Design electrical installation for a residence or small commercial building.

T-ELC 238

COURSE OUTLINE

T-ELC 238 POWER DISTRIBUTION

December, 1976

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELC 238 POWER DISTRIBUTION

COURSE DESCRIPTION:

Design of electrical distribution systems for power, lighting and heating, including services, switchboards, control and power panels, motor control centers, unit substations, low and high voltage switchgear and underground systems.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 3.

QUARTER HOURS CREDIT: 5.

PREREQUISITE: T-ELC 211, T-ELC 221.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution, oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Use basic wiring concepts and configurations to provide transfer of energy from source to the load.

(2) Discuss the considerations for safety, capacity, flexibility, accessibility and reliability in designing and installing electrical power systems.

(3) Identify factors to include in designing overhead and underground inter-plant distribution, high voltage ratings, ultimate plant capacity, locations for power switchgear, and motor control panels, and the routing of high voltage feeders.

(4) Design branch circuits for buildings to include light, heat and power loads.

(5) Design special circuits for relays, remote control lighting and panelboards.

(6) Determine power feeder size for motor ci:cuits.

(7) Describe factors involved in the selection of switchgear, switchboards, and panelboards.

(8) Discuss the advantages of load center substation design.

(9) Identify the uses of various standard circuits including radial, loop, and selective systems.

(10) Compare various raceways and conductors on factors such as costs, protection, flexibility, and life, and the features of busway, cable, and conduit systems.

(11) Determine circuit requirements for residential wiring.

(12) Calculate residential lighting, appliance, and conditioning loads.

(13) Design electric space heating systems.

(14) Describe the application, installation, wiring, and control of electric space heating.

(15) Use heat charts, tables and formulas for calculating heat loss, moisture, degree-days, R-numbers, and cost of electric heating systems.

(16) Identify the characteristics, class of power supply data and wiring for signal and communications systems.

(17) Identify factors which determine the wiring design of specialized signal systems.

T-ELM 211

COURSE OUTLINE

T-ELM 211 ELECTROMECHANICAL DEVICES

July, 1976

Developed by:

Jerry Thompson, Catawba Valley Technical Institute

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELM 211 ELECTROMECHANICAL DEVICES

COURSE DESCRIPTION:

A study of the fundamental devices used in electromechanical technology. Devices such as electrical motors, generators, transformers, relays, and transducers will be investigated. Concepts of work, energy, power, time constants, and efficiency as related to electromechanical devices will be stressed. Study of the instrumentation required to perform the investigation of electromechanical devices will form an integral part of the course.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 4.

QUARTER HOURS CREDIT: 5.

PREREQUISITES: T-ELC 114, T-PHY 101.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Demonstrate understanding of and the capability to perform analytical calculations concerning performance of electromechanical devices such as: direct current generators, direct current motors, alternating current generators, alternating current motors, transformers and regulators, relays, solenoids, and transducers.

(2) Demonstrate capability of setting up, conducting, evaluating, and reporting laboratory tests on electromechanical devices such as: direct current motors, alternating current motors, transformers, relays, and transducers.

(3) Be able to use technical library materials.

(4) Explain how simple AC and DC motors are constructed and how power losses and efficiency affect their operation.

(5) Describe the different types of motors and how the speed, torque, and construction differ for each type.

(6) Describe the relationships between the primary and secondary windings of a transformer, the different types of transformers and how losses affect their operation.

(7) Explain how work is computed for mechanical and electrical systems. Static, dynamic, kinetic, and potential energies are examined for various systems.

(8) Identify relay action and ratings, relay contact arrangements, operating time, contact materials, and relay classifications.

(9) Explain the parts of a generator and how energy can be produced and stored.

(10) Explain how relays work, contact arrangements, relay time constants and exponential curves.

(11) Describe basic motor action and learn what motor time constants are and their electrical counterpart.

(12) Illustrate how a motor operates with AC or DC input voltages and how inductive and capacitive reactance, impedance, and phase relationships are computed.

(13) Explain the construction and operation of transducers for control purposes.

OUTLINE OF INSTRUCTION:

I. Direct Current Generators

A. Principles of operation
1. Single coil generator
2. Field excitation
3. Generator voltage equation
4. Magnetization curve
5. Armature reaction
6. Commutation
7. Interpoles
8. Motor action

B. Types of DC generators
1. Separately excited
2. Self-excited
3. Series
4. Compound

C. Operation of DC generators
   1. Voltage regulation
   2. Efficiency and losses
   3. Parallel operation

II. Direct Current Motors

A. Principles of operation
   1. Motor principle
   2. Torque
   3. Generator action
   4. Equivalent circuit
   5. Power
   6. Armature reaction
   7. Speed
B. Types of DC motors
   1. Shunt
   2. Series
   3. Compound

III. Alternating Current Generators

A. Principles of operation
   1. Construction
   2. Voltage generation
B. Operation
   1. Regulation
   2. Parallel
   3. Hunting
   4. Rating
   5. Losses and efficiency

IV. Alternating Current Motors

A. Polyphase induction
   1. Principles of operation
   2. Construction
   3. Characterisitcs
B. Synchronous machinery
   1. Motors
   2. Inductors
   3. Power drives
C. Single phase
   1. Types
   2. Operation

V. Transformers and Regulators

A. Principles of operation
B. Types of transformers
C. Losses and efficiency

VI. Relays

A. Characteristics
   1. Ratings
   2. Switching
   3. Power requirements

B. Relay types
   1. Typical magnetic relays
   2. Special relay types

VII. Solenoids

A. Types

B. Operation

VIII. Transducers

A. Position

B. Temperature

C. Pressure

D. Flow rate, strain, humidity

SUGGESTED TEXT:

Robertson, Allan and Hunter. Electromechanisms/Devices. Albany, New York: Delmar Publishing Co., Latest Edition.

T-ELM 212

COURSE OUTLINE

T-ELM 212 CONTROL SYSTEM TECHNOLOGY I

October, 1976

Developed by:

Jerry Thompson, Catawba Valley Technical Institute

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELM 212 CONTROL SYSTEM TECHNOLOGY I

COURSE DESCRIPTION:

A study of control system technology. Basic concepts and terminology are investigated. Methods used to evaluate open-loop, closed-loop, regulator, follow-up, process, servomechanism, sequential, numerical, analog and digital control systems are introduced. Methods to describing control system components are investigated for electrical, liquid,gas, thermal and mechanical systems. Characteristics of processes, measuring means, and controllers are covered.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 4.

QUARTER HOURS CREDIT: 5.

PREREQUISITE: T-ELM 211.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution, oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Construct basic block diagram representation of control systems.

(2) Draw block diagrams and explain operating characteristicsin open-loop control systems. Breadboard open-loop system and demonstrate characteristics of system.

(3) Draw block diagrams and explain operating characteristics in closed-loop control systems. Breadboard closed-loop system and demonstrate normal system characteristics.

(4) Explain criteria used in analysis and evaluation of control systems. Vary system damping and measure response for over, under, and critically damped systems. Simulate process control characteristics.

(5) Draw block diagrams and explain function of different types of controllers such as: regulator and follow-up, process, servomechanism, sequential, numerical, analog, and digital.

(6) Perform analytical calculations for the basic elements of a control system given specific formulas.

(7) Define transfer functions for simple electrical and mechanical networks used in automatic control systems.

(8) Set up of simple control problems for solution by analog computer.

(9) Define and perform analytical calculations for basic process characteristics such as: integral, first-order lag, dead time, and second-order lag.

(10) Perform analytical calculations for basic measuring means characteristics such as: speed of response, accuracy, and dynamic characteristics.

OUTLINE OF INSTRUCTION:

I. Basic Concerts and Terminology

A. Introduction
B. Block diagrams and traveling signals
C. Open-loop control
D. Closed-loop control

II. Evaluation of Control Systems

A. Benefits of automatic control
B. Load changes
C. Objectives of a control system
D. Damping and stability
E. Criteria of good control

III. Types of Control

A. Introduction
B. Regulator and follow-up systems
C. Process control
D. Servomechanisms
E. Sequential control
F. Numerical control
G. Analog control
H. Digital control

IV. Basic Elements of a System

A. Introduction

B. Resistance
C. Capacitance
D. Inertia, inertance or inductance
E. Dead time

V. Introduction to Laplace Transforms

A. Input-output relationships
B. Laplace transforms
C. Transfer functions

VI. Introduction to Analog Computers

A. Use of operational amplifiers
B. Programming of selected problems

VII. Process Characteristics

A. Introduction
B. The integral process
C. The first-order lag process
D. The dead-time process
E. The second-order lag process
F. The first-order lag plus dead-time process

VIII. Measuring-Means Characteristics

A. Introduction
B. Speed of response
C. Accuracy
D. Dynamic characteristics

SUGGESTED TEXTS:

Bateson, Robert. Introduction to Control System Technology. Charles E. Merrill Publishing Co., 1973.

COURSE OUTLINE

T-ELM 213 CONTROL SYSTEM TECHNOLOGY II

October, 1976

Developed by:

Jerry Thompson, Catawba Valley Technical Institute

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELM 213 CONTROL SYSTEM TECHNOLOGY II

COURSE DESCRIPTION:

Control system transducers, final control elements, and performance are covered. Transducer topics include position, displacement, velocity, acceleration, force, temperature, flow rate, pressure, and liquid level measurement. Control element topics include control valves, armature controlled DC motors, two-phase AC motors, and amplifiers. Topics include frequency response analysis and testing, Bode diagrams, closed-loop response, stability, and controller adjustment.

COURSE HOURS PER WEEK: Class,3; Laboratory, 4.

QUARTER HOURS CREDIT: 5.

PREREQUISITE: T-ELM 212.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution, oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Perform analytical calculations for basic controller characteristics such as: two-position control, floating control, proportional control, integral control, proportional plus integral control, derivative control, proportional plus derivative control, and proportional plus derivative plus integral control.

(2) Perform analytical calculations for basic measuring means components such as: position and displacement measurement, velocity measurement, acceleration measurement, force measurement, temperature measurement, flow-rate measurement, pressure measurement, and liquid-level measurement.

(3) Verify measuring means characteristics, operation, and applications.

(4) Determine characteristics and use transfer functions for amplifers and control elements such as: control valves, AC/DC motors, amplifiers (AC/DC/SCR), fluid power motors, hydraulic servo valves.

(5) Conduct frequency response on a unit basis for operation and control elements.

(6) Determine frequency response and plot Bode diagrams for simple open-loop and closed-loop systems.

OUTLINE OF INSTRUCTION:

I. Controller Characteristics

A. Introduction
B. Two-position control
C. Floating control
D. Proportional control
E. Integral control
F. Proportional plus integral control
G. Derivative control mode
H. Proportional plus derivative control
I. Proportional plus integral plus derivative control

II. Measuring Means Components

A. Introduction
B. Transducers
C. Position and displacement measurement
D. Velocity measurement
E. Accerleration measurement
F. Force measurement
G. Temperature measurement
H. Flow rate measurement
I. Pressure measurement
J. Liquid level measurement

III. Amplifiers and Control Elements

A. Control valves
B. AC/DC motors
C. Amplifiers
D. Fluid power motors
E. Electrically controlled hydraulic servomechanism (valve)

IV. Analysis of Control Systems

A. Frequency response for various control systems
B. Construction of Bode, diagrams
C. Closed loop response and stability

SUGGESTED TEXTS:

Bateson, Robert. Introduction to Control System Technology. Charles E. Merrill Publishing Co., 1973.

COURSE OUTLINE

T-ELN 224 COMPUTER AND MICROPROCESSOR FUNDAMENTALS

October, 1976

Developed by:

Jerry Thompson, Catawba Valley Technical Institute
Richard Bley, Catawba Valley Technical Institute

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELN 224 COMPUTER AND MICROPROCESSOR FUNDAMENTALS

COURSE DESCRIPTION:

An in-depth study of computing principles. Subjects covered include analog and digital computers, memory devices, input-output devices, analog to digital converters, and digital to analog converters. Laboratory work using integrated circuits as computer building blocks will reinforce the classroom material.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 4.

QUARTER HOURS CREDIT: 5.

PREREQUISITE: T-ELN 219.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Classify computer and microprocessor systems.

(2) Execute computer programming and select instructions and assembly languages for specific applications.

(3) Select microprocessor systems for specific applications.

(4) Use the binary, octal and hexadecimal number systems.

(5) Use ASCII coding.

(6) Describe the construction and operation of computer memory elements to include core storage; semiconductor storage; tape, disk and drum storage.

(7) Describe the construction and operation of input-output devices to include tape and cards, CRT output, ADC's and DAC's intelligent terminals and other interfacing devices.

(8) Describe and use computer organization to include construction of instruction word, control section operation and minicomputer organization.

(9) Program and operate computer training systems.

(10) Explain and use elements of microprocessors and microprocessor systems.

OUTLINE OF INSTRUCTION:

I. Computers

A. Computer operations
B. Programming
C. Number systems
D. Boolean algebra and gate networks
E. Logic Design
F. Arithmetic element
G. Memory element
H. Input/output devices
I. Computer organization and control

II. Microprocessors

A. Classification
B. Application
C. Components
D. Organization and control
E. Operation

SUGGESTED TEXT:

Bartée, Thomas C. Digital Computer Fundamentals. McGraw-Hill Book Co.. New York: 1972 Third Edition, $11.50.

COURSE OUTLINE

T-MEC 100 MACHINE PRACTICES

December, 1976

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-MEC 100 MACHINE PRACTICES

COURSE DESCRIPTION:

A course designed to familiarize the student with the machine shop and machine processes. Although not an in-depth study of machine shop practice, it covers a wide variety of techniques, machines, and procedures while giving enough shop practice to enable the student to "get the feel" of most of the machines.

COURSE HOURS PER WEEK: Class, 2; Laboratory, 3.

QUARTER HOURS CREDIT: 3.

PREREQUISITE: None.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution, oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Identify, use and care for hand tools using proper safety practices.

(2) Use layout and measuring tools.

(3) Identify selected metals by external appearance.

(4) Use and care for portable power tools following proper safety practices.

(5) Operate machine tools following proper safety practices.

COURSE OUTLINE

T-MEC 107 APPLIED MECHANICS

July, 1976

Developed by:

Jerry Thompson, Catawba Valley Technical Institute

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-MEC 107 APPLIED MECHANICS

COURSE DESCRIPTION:

Concepts and applications of statics and dynamics. Force systems, moments and couples, equilibrium, trusses, friction, centroids, center of gravity, moments of inertia, motion, work, energy, momentum, and impulse are covered. Applications relating to the particular technology are introduced.

COURSE HOURS PER WEEK: Class, 5; Laboratory, 0.

QUARTER HOURS CREDIT: 5.

PREREQUISITES: T-MAT 102.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Demonstrate understanding and use of fundamental principles of mechanics as follows:

a. Be able to replace biaxial and triaxial force systems by a single force.

b. Be able to resolve a single force into its biaxial or triaxial components.

c. Be able to explain moments of a force and to use them correctly in quantitative calculations.

d. Be able to determine the amount and location of the resultant of a system of parallel forces in one plane.

e. Be able to determine the amount and location of the resultant of a system of parallel forces in space.

f. Be able to recognize couples and to use them correctly in quantitative calculations.

g. Be able to replace a force by a force and a couple.

(2) Demonstrate understanding of and perform quantitative calculations based upon a system of biaxial forces in equilibrium.

a. Be able to draw free body diagrams of a rigid body or series of connected rigid bodies acted upon by (1) biaxial force system in equilibrium and (2) parallel force system in equilibrium.

b. Be able to derive the static equations, $F_x=0$, $F_y=0$, from the free body diagrams and use these equations to calculate unknown forces acting on the systems.

(3) Demonstrate understanding of the functions performed by friction and perform quantitative calculations on systems in equilibrium taking into account the forces generated by friction.

a. Be able to solve force systems acting on bodies on inclined planes.

b. Be able to solve force systems acting on bodies in a biaxial plane.

(4) Demonstrate understanding of and perform quantitative calculations in determining the centroid of commonly shaped areas.

a. Be able to calculate the centroid of rectangles, triangles, circles, semi-circles, and quarter-circles.

b. Be able to calculate the centroid of areas composed of the geometric shapes listed above.

(5) Demonstrate understanding of and perform quantitative calculations in determining the moment of inertia for commonly shaped bodies.

a. Be able to calculate the rectangular moment of inertia of rectangular, triangular, circular, semi-circular, and quarter-circular bodies.

b. Be able to calculate the rectangular moment of inertia of bodies composed of the geometric shapes listed above.

c. Be able to calculate the polar moment of inertia for rotating cylindrical bodies.

(6) Demonstrate understanding of and perform quantitative calculations in determining the motion of a rigid body as defined by rectilinear and angular motion.

a. Be able to solve problems involving linear motion of machine members including displacement, velocity, and acceleration.

b. Be able to solve problems involving angular motion of machine members including displacement, velocity, and acceleration.

(7) Demonstrate understanding of and perform quantitative calculations in determining the motion of bodies when acted upon by a system of unbalanced forces taking into account the forces and masses of the system.

a. Be able to solve problems involving particle motion by constructing the free body diagram, writing the equations of motion, and solving the equations.

b. Be able to solve problems involving the motion of connected bodies by constructing the free body diagrams, writing the equations of motion, and solving the equations.

(8) Demonstrate understanding of and perform quantitative calculations in determining the work performed and the energy used in selected mechanical systems.

a. Be able to solve problems involving the basic concepts of work.

b. Be able to solve problems involving the basic concepts of kinetic and potential energy.

c. Be able to apply the work-energy method of analysis in solving for motion of bodies.

(9) Demonstrate understanding of and perform quantitative calculations in determining the motion of bodies using the impulse and momentum method of analysis.

a. Be able to apply the impulse/momentum method in solving for the motion of bodies.

b. Be able to apply the conservation of linear momentum principle in solving for the motion of bodies.

OUTLINE OF INSTRUCTION:

I. Fundamental Principles of Mechanics

A. Resolution of forces
B. Resultants of force systems
C. Moments of a force
D. Couples

II. Equilibrium of Biaxial Forces

A. Construction and use of free body diagrams
B. Derivation and solution of static equations

III. Friction

A. Free body diagram of systems involving friction
B. Derivation and solution of equation

IV. Centroids

A. Single geometric shapes
B. Composite geometric shapes

V. Moments of Inertia

A. Single geometric shapes
B. Composite geometric shapes
C. Polar moment of inertia

VI. Kinematics

A. Linear motion
B. Angular motion
C. Component motion

VII. Force, Mass, Acceleration

A. Particle motion
B. Connected bodies

VIII. Work and Energy

A. Basic concepts
B. Work-energy principles
C. Power

IX. Impulse and Momentum

A. Impulse-momentum principle
B. Conservation of momentum

SUGGESTED TEXT:

Breneman, John W. Mechanics. New York: McGraw-Hill Book Company., 1960.

COURSE OUTLINE

T-MEC 110 FUNDAMENTAL MECHANISMS

December 1971

OCCUPATIONAL EDUCATION DIVISION
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-MEC 110 FUNDAMENTAL MECHANISMS

COURSE DESCRIPTION:

A study of the purpose and action of cams, cables, gear trains, differentials, screws, belts, pulleys, shafts, levers, and other mechanical devices used to transmit or control signals.

OBJECTIVES: To present an overview of the purpose and actions of mechanisms and mechanical devices used to transmit or control signals.

COURSE HOURS PER WEEK: Class 2; Laboratory 4

QUARTER HOURS CREDIT: 4

PREREQUISITE: T-PHY 102

OUTLINE OF INSTRUCTION:

I. Introduction and basic concepts

   A. Terminology
      1. Mechanism
      2. Machine
      3. Complete pairs
      4. Incomplete pairs
      5. Links
      6. Constrained motion
      7. Point paths
   B. Coordinate systems
      1. Vectors
         a. Scalar quantities
         b. Vector quantities
         c. Addition and subtraction
   C. Classification of motion
      1. Plane motion
         a. Translation
         b. Rotation
      2. Helical motion
      3. Spherical motion
   D. Velocity and acceleration
      1. Linear
      2. Angular

II. Motion and velocities of linkages

A. Fundamental equations
1. Motion on a straight path
2. Motion on a circular path
3. Rotation about a fixed axis
4. Linear velocity
5. Angular velocity
6. Relationship between linear and angular velocities

B. Instantaneous centers of velocity
1. Introduction
2. Instantaneous centers of velocity
a. Permanent centers
b. Fixed centers
3. Kennedy's theorem
4. Poles and relatives velocities
5. Locating poles
6. Using poles
7. Force and torque ratios
8. Polodes
9. Center of curvature
a. Inflection circle
b. Hartmann's construction

C. Basic problems
1. Analytical solutions
2. Graphical solutions
3. Basic mechanisms
a. The rotating link
b. The yoke
(1) Motion curves
(2) Average velocity
(3) Inertia forces
c. The sliding block
d. Eccentric circular disc and follower
e. Slider-crank mechanism
f. Four-bar mechanism

III. Transmission of motion

A. Direct contact mechanisms
1. Introduction
a. Speed ratio
b. Velocities at point of contact
c. Sliding and slide-sweep ratio
d. Translating driven body
e. Pure rolling
f. Uniform speed ratio
g. Profile interchangeability
h. Cycloidal profiles
i. Involute profiles
j. Gear-tooth profiles
k. Equivalent mechanisms

2. Gears
    a. Types
        (1) Spur
        (2) Helical
        (3) Worm
        (4) Bevel
    b. Terminology
    c. Gear trains
        (1) Single-gear pairs
        (2) Single trains
        (3) Compound trains
        (4) Coaxial trains
        (5) Change-gear trains
3. Cams
    a. Introduction
    b. Types of cams and followers
        (1) Disc
        (2) Radial
        (3) Offset
        (4) Flat faced
        (5) Translational
        (6) Cylindrical
    c. Types of motion
        (1) Straight-line or uniform motion
        (2) Parabolic motion
        (3) Harmonic motion
        (4) Cyclodial motion

B. Flexible connectors
    1. Introduction
        a. Hoisting
        b. Conveyors
        c. Power transmissions
    2. Types of flexible connectors
        a. Flat belts
        b. V-belts
        c. Roller chains
        d. Inverted tooth chains
        e. Bead chains
        f. Differential chain hoist
        g. Variable speed drives

C. Couplings
    1. Types
        a. Sleeve
        b. Bellows
        c. Oldham
        d. Universal joints

D. Servo systems
    1. Breadboarding
    2. Electromechanical

SUGGESTED TEXTS:

Berg, Winfred M., Precision Mechanical Components, Theory and Application of, 2nd Edition. East Rockaway, N. Y.: Russell E. Sacken, 1965. Handbook to familiarize designers, engineers, and draftsmen with standardized precision, mechanical instrument components, provide basic design information which will help build better systems, and explain the design and engineering advantages and disadvantages of a wide variety of such precise components and equipment available in today's market.

SUGGESTED REFERENCES:

Chironis, Nicholas, Mechanisms, Linkages, and Mechanical Controls. New York: McGraw-Hill Book Company, Inc., 1965. Through coverage of classical and modern mechanisms and devices giving full descriptions of their motions and functions.

Lent, Deane, Analysis and Design of Mechanisms. Englewood Cliffs: Prentice Hall, 1961. This book is written for the first year student in any technical school. It does not presume a knowledge of physics, calculus, or kinematics. It starts at the beginning and builds a staunch foundation of basic principles and techniques. Graphical methods are used wherever calculations are complex or laborious.

Prageman, H. I., Mechanism. Scranton, Pennsylvania: International Textbook Company, 1947.

Tao, D. S., Fundamentals of Applied Kinematics. Reading, Mass.: Addison-Wesley, 1967. This text attempts to bridge the gap between theory and day-to-day problems on the job by relating fundamental principles to familiar machines.

Winston, S. E., Mechanism. Chicago: American Technical Society, 1961. Fundamental theory of mechanisms. Basic principles of the three ordinary modes of transmission of motion are developed.

T-MEC 235

COURSE OUTLINE

T-MEC 235 HYDRAULICS AND PNEUMATICS

January, 1973

Developed by:

Janet S. O'Brien
Guilford Technical Institute

Printed by:

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
STATE BOARD OF EDUCATION
RALEIGH, NORTH CAROLINA

COURSE DESCRIPTION

T-MEC 235 HYDRAULICS AND PNEUMATICS

The basic theories of hydraulic and pneumatic systems. Combinations of systems in various circuits. Basic designs and functions of circuits and motors, controls, electrohydraulic servomechanisms, plumbing, filtration, accumulators and reservoirs.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 3.

QUARTER HOURS CREDIT: 4.

PREREQUISITE: T-PHY 102.

OUTLINE OF INSTRUCTION:

I. An Introduction to Fluid Mechanics

<u>Objectives</u>

A. The student should be able to define fluid mechanics and fluids, and list the two basic classes of the latter.

B. The student should be able to list and define the following characteristics of fluids:

1. Volume
2. Weight
3. Mass
4. Specific weight (weight density)
5. Density (mass density)

C. The student should be able to define

1. Pressure
2. Specific gravity

I. An Introduction to Fluid Mechanics (continued)

Objectives (continued)

D. The student should be able to explain Pascal's law and pressure head.

E. The student should be able to work problems involving items listed in B through D above.

Topics

A. What Is Fluid Mechanics?

Fluid mechanics is the study of the physical behavior of fluids and fluid systems and the laws describing this behavior.

B. What Is a Fluid?

A fluid is a substance which has definite mass and volume but has no definite shape; a fluid cannot sustain a shear stress under equilibrium conditions.

1. Liquids (and concept of "ideal liquid")
2. Gases

C. Some Characteristics of Fluids

1. Volume
2. Weight
3. Mass
4. Specific weight (weight density)
5. Density (mass density)

D. What Is Pressure?

1. Definition of pressure
2. Definition of specific gravity

E. Pascal's Law

F. Pressure Head

II. Pressure, Head, Force

Objectives

A. The student should be able to define and use correctly the following important terms:

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II. Pressure, Head, Force (continued)

Objectives (continued)

1. Piezometer tube
2. Gage pressure
3. Absolute pressure
4. Vacuum
5. Manometer
6. Cylinder
7. Regenerative cylinder

B. The student should be able to work problems involving piezometer tubes, mercury manometers, differential manometers, devices whose function depends on the application of Pascal's Law, single-acting fluid power cylinders, and regenerative fluid power cylinders.

Topics

A. Pressure Head and the Piezometer Tube

B. Absolute and Gage Pressure

1. Absolute pressure
2. Gage pressure
3. Vacuum
4. Absolute zero pressure

C Pressure Head and the Manometer

1. Piezometer with a U-tube
2. Manometer (especially, the mercury manometer)

D. The Differential Manometer

E. Force Multiplication Via Pressure and Area

1. Review of Pascal's Law
2. Analogy between the fluid system using Pascal's Law and the mechanical lever system

F. The Fluid Power Cylinder

1. Use of the fluid power cylinder
2. Single-acting cylinder
3. Regenerative cylinder

III. Buoyancy, Force on Submerged Surfaces

Objectives

A. The student should be able to define and use correctly the following important terms:

1. Static pressure
2. Pressure action
3. Head
4. Pressure distribution
5. Total pressure force
6. Center of pressure
7. Buoyant force

B. The student should be able to work problems involving finding the pressure at various depths in bodies of water, finding the total force on submerged surfaces, and finding the volumes of submerged solid objects given their weights in air and in water.

Topics

A. Hydrostatic Pressure

B. Pressure Distribution with Changing Head

C. Forces on Submerged Surfaces

D. Buoyancy

IV. Displacement, Flow Rate, Continuity of Flow, Flow Velocity, Horsepower

Objectives

A. The student should be able to define and use correctly the following important terms:

1. Stroke
2. Displacement volume
3. Flow rate
4. Flow velocity
5. Continuity of flow
6. Work
7. Hydraulic horsepower

B. The student should be able to work problems involving the finding of cylinder dispacement volume, flow rate, flow velocity, work done, hydraulic horsepower, and pump efficiency.

IV. Displacement, Flow Rate, Continuity of Flow, Flow Velocity, Horsepower (continued)

Topics

A. Cylinder Characteristics

1. The pump
2. The compressor
3. Displacement volume (in cubic inches or cubic feet)
4. Stroke
5. Volume rate of flow (in gallons per minute)

B. Flow Velocity

1. Principle of continuity of flow
2. Continuity equation
3. Review of concept of "ideal liquid"

C. Mass Flow Rate

D. Work Done in Pumping a Fluid

E. Horsepower Required to Pump Fluids

V. Conservation of Energy, Bernoulli's Equation

Objectives

A. The student should be able to define and use correctly the following important terms:

1. Potential energy
2. Kinetic energy
3. Bernoulli's equation
4. Head loss
5. Head added

B. The student should be able to work problems requiring the use of Bernoulli's equation.

Topics

A. Energy Relationships in Fluid Systems

1. Potential energy
2. Kinetic energy
3. The principle of conservation of energy

V. Conservation of Energy, Bernoulli's Equation (continued)

Topics (continued)

B. Bernoulli's Equation

1. Derivation of Bernoulli's equation from the General Energy Equation
2. Elevation head or static head
3. Pressure head or static pressure head
4. Velocity head
5. Elevation head and pressure head related to potential energy of the flowing stream
6. Velocity head related to kinetic energy of the flowing stream

C. Ideal Flow Versus Actual Flow Conditions

1. For a constant flow rate Q, when the cross-sectional area of the conductor decreases from one point to another, the flow velocity increases, and vice versa.
2. The velocity head varies as the square of the flow velocity.
3. When the flow velocity increases, there is a corresponding decrease in pressure; conversely, when there is a decrease in velocity, there is an increase in pressure.
4. Head loss

D. Energy Diagram

VI. Flow of Fluid in Pipes

Objectives

A. The student should be able to define and use correctly the following important terms:

1. Laminar flow
2. Turbulent flow
3. Critical velocity
4. Reynolds number
5. Viscosity
6. Absolute viscosity
7. Relative viscosity
8. Kinematic viscosity
9. SSU, Saybolt Seconds Universal
10. Average velocity
11. Flow losses
12. Darcy-Weisbach equation
13. Absolute roughness
14. Relative roughness

VI. Flow of Fluid in Pipes (continued)

<u>Objectives</u> (continued)

B. The student should be able to work problems involving the conversion of kinematic viscosity to absolute viscosity and vice versa; problems involving the determination of velocity, flow rate, pressure drop or head loss, etc. of fluid flowing in pipes.

<u>Topics</u>

A. Types of Flow

1. Laminar flow
2. Turbulent flow

B. Critical Velocity

1. Upper critical velocity
2. Lower critical velocity

C. Reynolds Number

1. Definition of Reynolds number
2. Equation for determining the Reynolds number
3. Average Reynolds-number values of less than 2000 indicate laminar flow for pipe flow.
4. Average Reynolds-number values of more than 3000 indicate turbulent flow for pipe flow.

D. Viscosity and Absolute Viscosity

1. Definition of viscosity and absolute viscosity
2. Three basic assumptions made in developing a picture of the nature of viscosity.
3. Units of absolute viscosity

    a. In the foot-pound-second system ($lb \cdot sec/ft^2$)
    b. In the metric system (poise or centipoise)

4. Relative viscosity

E. Kinematic Viscosity

1. Definition of kinematic viscosity
2. Units of kinematic viscosity

    a. In the foot-pound-second system (ft^2/sec)
    b. In the metric system (stoke or centistoke)

F. Conversion from English to Metric Systems of Measure

G. Viscosity: Saybolt Seconds Universal

1. Relationship between viscosity and kinematic viscosity

   a. When (SSU) t less than 100 seconds
   b. When (SSU) t greater than 100 seconds

H. Average velocity

I. Flow Losses in Pipes

1. Major Loss

   a. Due to viscous-friction (shearing) effects associated with the flow of fluid through a pipe.

2. Minor Losses

   a. Due to the effects of a sudden contraction of cross section of the pipe.
   b. Due to a sudden expansion of cross section.
   c. Due to obstructions, such as pipe fittings, valves, etc.
   d. Due to curves and bends in pipe lines.

3. The Darcy-Weisbach equation

   a. Relative roughness of the surface of the conductor
   b. Absolute roughness of the surface of the conductor
   c. The friction factor for laminar flow
   d. The friction factor for turbulent flow

VII. Topics Dealing with Compressible Fluids

Objectives

A. The student should be able to define and/or explain, and use correctly the following important terms or laws:

1. Charles' Law
2. Boyle's Law
3. General Gas Law
4. Compressor
5. Pneumatic fluid power system
6. Harris formula
7. Compression ratio
8. Standard conditions
9. Pneumatic cylinder

VII. Topics Dealing with Compressible Fluids (continued)

Objectives (continued)

B. The student should be able to work problems utilizing Charles' Law, Boyle's Law, and the General Gas Law, and to calculate air flow losses in pipes.

Topics

A. Introduction to Compressible Flow

1. Definition of Fluid power

B. Gas Laws

1. Review of and expansion of the concept of absolute zero pressure
2. Absolute zero temperature

C. Charles' Law

D. Boyle's Law

E. General Gas Law

1. Definition of the universal gas constant

F. Compressors

G. Pneumatic Fluid Power Systems

1. Definition of a pneumatic fluid power system
2. Definition of a pressure regulator
3. Air at standard conditions

H. Air Flow Losses in Pipes

1. Harris formula
2. Compression ratio
3. Use of the N-factor from tabulated data.

SUGGESTED LABORATORY EXERCISES

1. Sight Gage
2. Visual Flow Box
3. Laminar and Turbulent Flow
4. Reynolds Number
5. Water Flow Nomograph
6. Pipe Fittings
7. Friction Factor
8. Static Head and Pressure Differences
9. Static Pressure and Back Pressure
10. Gate Valves
11. Frictional Losses

NOTE: Detailed descriptions of the above experiments can be found in <u>Scott Fluid Circuit System</u> published by Scott-Engineering Sciences, Pompano Beach, Florida, 1968. It is expected that they will be performed on the Scott Fluid Circuit System, Model 9009.

SUGGESTED TEXT

R. W. Henke, Introduction to Fluid Mechanics, 1st Edition: Addison-Wesley Publishing Co., Inc., Reading, Mass., 1966. (Excellent coverage of material. Well illustrated.)

SUGGESTED REFERENCES

K. Brenkert, Jr., Elementary Theoretical Fluid Mechanics, 1st Edition: John Wiley & Sons, Inc., New York, 1960.

G. N. Cox and F. J. Germano, Fluid Mechanics, 1st Edition, 8th printing, 1955: D. Van Nostrand Co., Inc., Princeton, N. J., 1941.

R. V. Giles, Fluid Mechanics and Hydraulics, 2nd Edition: Schaum's Outline Series, McGraw-Hill Book Co., Inc., New York, 1962.

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____________, Hydraulic Institute Pipe Friction Manual, 3rd Edition: Hydraulic Institute, New York, 1961.

COURSE OUTLINE

T-ELN 203 MEASUREMENT AND CONTROL I

July, 1976

Developed by:

William H. Coleman, Cape Fear Technical Institute
Arthur W. Stroman III, Cape Fear Technical Institute

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELN 203 MEASUREMENT AND CONTROL I

COURSE DESCRIPTION:

A study of the concepts of measurement and control, levels of accuracy, and traceability. Also covered are the theory and calibration of pressure gauges, vacuum gauges, and pressure switches using laboratory standards such as the dead weight tester, manometer, precision test gauges, and associated hardware. General shop practices are included.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 6.

QUARTER HOURS CREDIT: 5.

PREREQUISITE: T-MAT 101.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Know what to do in the event of electrical shock. Know the established industrial rules concerning injuries.

(2) Know how to recognize unsafe conditions that may exist within an industrial complex. Know the standard procedure for correcting unsafe conditions.

(3) Identify how materials act or react when heated, cooled, stretched, compressed, twisted or bent. Learn some of the electrical characteristics of materials when altered. Learn that materials change dimensions when heated or cooled.

(4) Identify basic pressure mechanisms and configurations. Learn the meaning and effects of hysteresis. Learn the applications of the common elements used in process measurement.

(5) Identify various types of measuring and controlling instruments in the lab.

(6) Introduce the student to the various characteristics of measuring and controlling instruments.

(7) Demonstrate the various general characteristics of instruments. By monitoring voltage across precision 100 ohm resistors on connectors cord terminal board, change in recorder input can be detected before any change in recorder pen takes place.

(8) Use a manometer to measure pressure. Observe and learn the effects of filling materials on the sensitivity and response of manometers - construct a "U" tube manometer. Learn the factors in manometer accuracy.

(9) Identify the basic principles of "Wall Manometers" their practical considerations and applications. Learn how to convert manometer from differential instrument to absolute pressure instrument. Learn relationship between "well" area and tube size.

(10) Identify the basic principles of the inclined tube manometer. Learn the pressure balance equation and be able to work with it. Learn the practical considerations and application of the Inclined Manometer.

(11) Identify the temperature scales, i.e. (Fahrenheit, Celcius, Kelvin and Rankine) and the various temperature measuring devices.

(12) Know how temperature changes are related to volume changes.

(13) Know how pressure changes are related to temperature changes.

(14) Identify the different classes of thermometer and the general temperature ranges of each class. Learn the non-electrical methods of temperature measurements.

(15) Study and demonstrate the conditions which alter thermal resistance and determine thermal time constants.

(16) Know the basic laws of thermoelectricity used in thermocouples. Learn the practical application of thermocouples - types of thermocouples, calibration of thermocouples, grades of thermocouples wire. Identify symbols and color coding for thermocouple wire. Use thermocouple calibration data. Describe advantages and disadvantages of thermocouples.

(17) Know the nomenclature of a dead-weight-tester. To learn why a dead-weight-tester is used as a laboratory standard for pressure gauge calibration. Learn how to maintain and care for a dead-weight-tester.

(18) Know how pressure measuring devices employ elastic membranes.

(19) Know the meaning of differential pressure - and how to set up manometers and gauges to measure differential pressure.

(20) Know how a pneumatic relay works.

(21) Know how pressures are transmitted by a pneumatic bridge- and study the distance-pressure relationships. Study baffle clearance vs. back-pressure. Study factors that affect sensitivity of pneumatic bridge.

(22) Know how a differential pressure transmitter operates. Learn how the piping must be arranged. Calibrate a differential pressure transmitter. Dissmantle and reassemble dp cell, calibrate and place in service.

(23) Know the theories and means by which liquid level measurements (non-electrical) are made.

OUTLINE OF INSTRUCTION:

I. Measurement Methods

A. Basic theory
1. Physical units
2. Pounds per square inch
3. Atmospheric pressure
4. Atmospheric equivalents
5. Density
6. Specific gravity
7. Static head
8. Absolute pressure

B. Liquid column manometers
1. Open U tube
2. Closed U tube
3. Inclined tube
4. Mercury manometer
5. Bell manometers

II. Basic Pressure Mechanisms

A. Bourdon C tube
1. Excursion standards
2. Scales, accuracy, linearity-hysteresis
3. Pressure ranges
4. Bourdon tube materials

B. Helical element
1. Principle of operation
2. Pressure ranges

C. Diaphram elements
1. Principle of operation
2. Pressure ranges

D. Bellows elements
   1. Principle of operation
      a. On conventional pressure ranges
      b. As receiver bellows
      c. Pressure ranges
      d. Absolute pressure bellows
   2. Applications
E. Pressure gauge calibration
   1. Dead weight testing machines
      a. Principle of operation
      b. Construction
      c. Testing procedure
      d. Friction
      e. Lost motion
   2. Other standards
F. Pressure gauge accessories
   1. Needle valve dampner
   2. Piston dampner
   3. Rubber bulb dampner
   4. Purge action
   5. Pigtails
   6. Isolation diaphragm

III. Liquid Flow Measurement

A. Primary devices
   1. Reynolds experiment
      a. Viscous flow
      b. Turbulent flow
   2. Analysis of effect of restriction in line
      a. Tap locations: Flange, vena contracta, corner, pipe, elbow
      b. Flow
B. Orfice plate
   1. Specifications, flatness, polish, sharp edge, accuracy of bore, counterbore, condensate drain hole
   2. Limitations and capabilities
C. Pilot tube
   1. Structure
   2. Applications
D. Venturi tube
   1. Structure
   2. Applications
E. Flow nozzle
   1. Structure
   2. Applications
F. Dall tube
   1. Structure
   2. Applications
G. Turbine flow meters
   1. Structure
   2. Applications
H. Positive displacement meters
   1. Structure
   2. Applications

I. Magnetic flow meters
   1. Structure
   2. Applications
J. Liquid flow calculations
   1. Formulas
   2. Calculations using Foxboro slide rule

IV. Liquid Level Measurement

A. Liquid level -- open tanks
   1. Bob and float
   2. Sight glass
   3. Air purge system
   4. Diaphragm box
   5. Differential pressure cell
   6. Equipment construction
B. Liquid level -- closed tanks
   1. Differential pressure manometer
      a. Principle of operation
      b. Gas purge
      c. Liquid purge
      d. Liquid seals
   2. Equipment consturction

V. Liquid Density Measurement

A. Air purge
B. Temperature difference
C. Conductivity of solution

VI. Temperature Measurements and Methods

A. Temperature scales
B. Bi-metallic thermometers
C. Mercurial thermometers
D. Pressure thermometers
E. Optical pyrometers
F. Thermocouples
G. Thermistors

VII. Thermal Systems

A. Liquid filled
   1. Capillary tubing
   2. Filling mediums
      a. Class I, liquid expansion
      b. Class II, vapor pressure
      c. Class III, gas pressure
      d. Class V, mercury expansion
B. Vapor pressure systems
   1. Evacuation and filling
   2. Ambient temperature compensations
   3. Nonlinear scales

4. Ranges
5. Normal and reversed systems
6. Capillary tubing

C. Gas filled thermal systems
1. Gas laws
2. System construction
3. Ambient temperature compensation
4. Scale ranges
5. Fully compensated
6. Case compensation
7. Possible errors
8. Bulb design
9. Capillary tubing

D. Liquid expansion systems
1. Evacuation and filling
2. Ambient temperature compensation
3. Bulb volume
4. Uniform scale ranges
5. Fully compensated
6. Case compensated
7. Differential temperature system
8. Bulb immersion
9. Tubing

SUGGESTED TEXTS:

Kirk, Franklin, W., and Rimboi, Nicholas R., Instrumentation; Second Edition. Chicago IL: American Technical Society., 1966.

O'Higgins, Patrick J. Basic Instrumentation, Industrial Measurement. New York: McGraw-Hill Book Co., 1966.

SUGGESTED REFERENCES:

Fribance, Austin. Industrial Instrumentation Fundamentals. New York: McGraw-Hill Book Co., 1962.

O'Higgins, Patrick J., Basic In.trumentation, Industrial Measurement. New York: McGraw-Hill Book Co., 1966.

Anderson, Norman. Industrial Process Control. Foxboro, MA: Foxboro Co. Latest Edition.

Warren, John. Control Instrument Mechanisms. Indianapolis, IN: The Bobbs-Merrill Co., 1967.

Zoss, L.M., and Delahozke, B.C., Industrial Process Control. Albany, New York: Delmar Publishers., Latest Edition.

Kirk, Franklin W. and Rimboi, Nicholas R. Instrumentation. Chicago, IL: American Technical Society., 1966.

Marcus, Abraham and Lenk, John D. Measurements for Technicians. Englewood Cliffs, NJ: Prentice-Hall Inc., 1971.

LaJoy, Millard H. Industrial Automatic Controls. Englewood Cliffs, NJ: Prentice-Hall Inc., 1955.

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COURSE OUTLINE

T-ELN 213 MEASUREMENT AND CONTROL II

July, 1976

Developed by:

William H. Coleman, Cape Fear Technical Institute
Arthur W. Stroman III, Cape Fear Technical Institute

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELN 213 MEASUREMENT AND CONTROL II

COURSE DESCRIPTION:

A study of control theory and applications with emphasis on electronic and electric controls and mechanisms. Control loops and configurations of electronic and pneumatics are constructed and placed in operation. Applications of interfacing are covered along with calibration and alignment of constructed systems.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 6.

QUARTER HOURS CREDIT: 5.

PREREQUISITES: T-ELN 203.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Know the effects of the sum of two forces with equal and unequal force levers on the resultant force.

(2) Know what is meant by ratio control or the difference between two input signal quantities.

(3) Know how a moment balance bridge can be used to average signals and some applications.

(4) Know the effects of on-off control in systems such as residential heating, air conditioning, ovens or any applications in which band spread between high and low limits is not critical.

(5) Know the effects of proportional control with respect to temperature control systems and level control.

(6) Know how proportional plus reset action works.

(7) Know the effects of proportional plus reset action in an actual operating system. (Flow Loop)

(8) Know the theory of operation of the Electronic Controller and Controller specifications, input circuit, amplifiers, proportional circuits, reset circuits, power supply.

(9) Know how a pneumatic controller functions. Also to know how a penumatic controller mechanism, sensitivity reduction mechanical and sensitivity reduction pneumatic works.

(10) Know how to set up pneumatic controllers in system and operate at optimum operating conditions.

OUTLINE OF INSTRUCTION:

I. Fundamentals of Control Theory

- A. Control response effects
    - 1. On-off response
    - 2. Proportional response
    - 3. Proportional plus reset response
    - 4. Proportional plus rate response
    - 5. Proportional plus reset plus rate response
- B. Offset
- C. Stabilization time

II. Basic Controller Mechanisms

- A. Nozzle baffle theory
- B. Controller relay
    - 1. Leakless type - nozzle closed
    - 2. Leakless type - nozzle open
    - 3. Overthrow mechanism - gravity type
    - 4. Overthrow mechanism - spring type

III. Proportional Controllers

- A. Pneumatic controller mechanisms
    - 1. Sensitivity reduction - mechanical
    - 2. Sensitivity reduction - pneumatic
    - 3. Proportional controller with reset
    - 4. Proportional controller with reset plus rate
- B. Electrical controllers
    - 1. Electrical characteristics
        - a. Supply voltages
        - b. Power supplies
            - (1) Controller input characteristics
            - (2) Controller output currents
- C. Controller circutry
    - 1. Proportional control
    - 2. Proportional plus reset
    - 3. Proportional plus reset plus rate response
- D. Specialized controllers, pneumatic and electronic
    - 1. Ratio controller

a. Direct
b. Inverse
2. Pneumatiset controller
3. Time schedule controllers

IV. Transmitter Theory, Pneumatic and Electronic

A. Liquid level transmitter
B. Temperature transmitters
C. Differential pressure transmitter
D. Absolute pressure transmitter
E. Flow transmitters

SUGGESTED TEXTS:

Kirk, Franklin, W., and Rimboi, Nicholas R., Instrumentation; Second Edition. Chicago, IL: American Technical Society., 1966.

O'Higgins, Patrick J. Basic Instrumentation, Industrial Measurement. New York: McGraw-Hill Book Co., 1966.

SUGGESTED REFERENCES:

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Harvey, Glenn F. Standards and Practices for Instrumentaiton. Pittsburgh, PA: Instruments Society of America., 1974.

Considine, Douglas M. Handbook of Applied Instrumentation. New York: McGraw-Hill Book Co., 1964.

T-ELN 223

COURSE OUTLINE

T-ELN 223 MEASUREMENT AND CONTROL III

July, 1976

Developed by:

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PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-ELN 223 MEASUREMENT AND CONTROL III

COURSE DESCRIPTION:

Troubleshooting techniques are studied and practiced using standard instrument maintenance test equipment. Actual loops and control systems are set up and tubing and piping layouts are studied. Instruments are dismantled, reassembled, calibrated, and placed in service.

COURSE HOURS PER WEEK: Class, 3; Laboratory, 9.

QUARTER HOURS CREDIT: 6.

PREREQUISITE: T-ELN 213.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Recognize and identify the various tools that are used in instrument maintenance, and know how these tools are used in calibration and repair of instruments.

(2) Know how to identify thermocouples (color code), how to check and calibrate thermocouples, and how to run lead wires.

(3) Know the proper lubricants to use on various key points, how to clean and check key points for wear, lubrication precautions, and how to keep maintenance records.

(4) Know air supply requirements for pneumatic systems, and the components and purpose of these components in instrument air supply systems.

(5) Know how to make electrical connections, how to recognize defects in electrical wiring, cable color-codes, and know various insulations for different applications.

(6) Know how to effectively troubleshoot a system to locate the defective component instrument.

(7) Know the theory of operation, how to use, and how to maintain the dead-weight tester.

(8) Know how to set up for calibration of all instruments available to us - to actually perform calibrations of instruments assigned.

(9) Know how to properly dismantle the 13A DP cell, reassemble, calibrate and place in service in flow loop.

(10) Know how to properly dismantle the 613 DM DP cell, reassemble, calibrate and place in service.

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(11) Know how to dismantle, reassemble and calibrate the model 69TA-1 transducer.

(12) Know how to dismantle, reassemble and calibrate the model 66FR-2 air-to-current transducer.

(13) Know how to troubleshoot the model 6400 recorder, what key points to check for wear or binds, and how to set up and calibrate the recorder.

(14) Know how to locate key voltage points in the model FR-316-C-2 frequency-to-current transducer, and how to properly set up and calibrate the FR-316.

(15) Know how to locate key voltage points, the various functions, and how to properly calibrate the Foxboro model 62H controller.

(16) Know the theory of operation of the motor control system, how to follow the wiring diagram and actually wire the system completely and operate, and how to properly dress wiring.

(17) Know how to calibrate the model 40 recorder, and how to check for wear and binds.

(18) Know how to dismantle, reassemble and calibrate the Foxboro control valve # 25.

OUTLINE OF INSTRUCTION:

I. Care and Use of Hand Tools

A. Instrument maintenance tools
B. Shop tools

II. Instrument Cleaning and Lubricating

A. Visual inspection
B. Types of lubricants

C. Points of lubrication to be considered

III. Instrument Cleaning and Lubricating

A. Visual inspection
B. Types of lubricants
C. Points of lubrication to be considered
D. Lubrication precautions
E. Maintenance records
F. Preventive maintenance

IV. Control Signal Transmission

A. Air supply requirements
B. Elements of air supply systems
C. Tubing
1. Material
2. Size
3. Connection
4. Tubing installation
D. Pipe
1. Material
2. Size
3. Connection
4. Pipe installation
E. Electrical wiring
1. Connection
2. Protection
3. Color coding
4. Cabler

V. Final Control Elements

A. Installation
B. Maintenance
C. Calibration

VI. Troubleshooting

A. Basic steps
B. Repairs

VII. Preinstallation Preparation of Instruments

A. Bench check
B. Operational checks

VIII. Instrument Mounting

A. Purpose
B. Procedure
C. Inter-connection

IX. Instrument Parts and Components

A. Frequency or inspection
B. Parts replacement
C. Methods of removal
D. Repairs to parts

X. Thermocouple Fabrication and Installation.

A. Fabrication
B. Insulation
C. Thermocouple
D. Extension wire installation
E. Calibration procedure

XI. Instrument Removal from System

A. Coordination with operation
B. Tag out

XII. Instrument Installation

A. Safety rules
B. Procedures
C. Final adjustments

XIII. Systems Troubleshooting

A. Discussion with operating persound.
B. Process familiarity
C. Past records

SUGGESTED TEXTS:

Kirk, Franklin, W., and Rimboi, Nicholas R., Instrumentation: Second Editio Chicago, IL: American Technical Society., 1966.

O'Higgins, Patrick J. Basic Instrumentation, Industrial Measurement. New York: McGraw-Hill Book Co., 1966.

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O'Higgins, Patrick J., Basic Instrumentation, Industrial Measurement. New York: McGraw-Hill Book Co., 1966.

Anderson, Norman. Industrial Process Control. Foxboro, MA: Foxboro Co. Latest Edition.

Warren, John. Control Instrument Mechanisms. Indianapolis, IN: The Bobbs-Merrill Co., 1967.

Zoss, L.M., and Delahozke, B.C., Industrial Process Control. Albany, New York: Delmar Publishers., Latest Edition.

Kirk, Franklin W. and Rimboi, Nicholas R. Instrumentation. Chicago, IL: American Technical Society., 1966.

Marcus, Abraham and Lenk, John D. Measurements for Technicians. Englewood Cliffs, NJ: Prentice-Hall Inc., 1971.

LaJoy, Millard H. Industrial Automatic Controls. Englewood Cliffs, NJ: Prentice-Hall Inc., 1955.

Elonka, Stephen, and Parson, Alonzo. Standard Instrumentation Questions and Answers Vol. I & II. New York: McGraw-Hill Book Co., 1962.

Harvey, Glenn F. Standards and Practices for Instrumentation. Pittsburgh, PA: Instruments Society of America., 1974.

Considine, Douglas M. Handbook of Applied Instrumentation. New York: McGraw-Hill Book Co., 1964.

T-CHM 117

COURSE OUTLINE

T-CHM 117 INSTRUMENTATION CHEMISTRY

July, 1976

Developed by:

William H. Coleman, Cape Fear Technical Institute
Arthur W. Stroman III, Cape Fear Technical Institute
Owen S. Eckhardt, Cape Fear Technical Institute

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

COURSE OUTLINE

T-CHM 117 INSTRUMENTATION CHEMISTRY

COURSE DESCRIPTION:

A chemistry course designed to acquaint the student with basic concepts applied to industrial chemical processes. In the laboratory these concepts will be put into practice using industrial type equipment to gather the necessary data and illustrate principles of chemical processes.

COURSE HOURS PER WEEK: Class, 5; Laboratory, 3.

QUARTER HOURS CREDIT: 6.

PREREQUISITE: None.

OBJECTIVES:

Either during or upon completion of this course, the student should pass with a proficiency determined by the institution oral and/or written examinations covering the material in the outline of instruction. As a minimum a student shall:

(1) Solve problems using dimensional analysis to convert data from the Metric System to the English System.

(2) List and give examples of the forms of matter, the classes of matter and the forms of energy.

(3) List ten of the more commonly used physical properties of elements and compounds.

(4) Identify various parts of the Periodic Chart and be able to name the various families of elements.

(5) Make simple sketches of the atoms of the first twenty elements and correctly identify the parts.

(6) Explain how atomic weight is obtained and how it is used.

(7) Define ions and molecules and to list and define five types of bonding.

(8) Write the formula for the compounds given.

(9) Write the equation and balance it for all of the examples given.

(10) Define and give examples of acids and bases and write equations for the preparation of three different acids and three different bases.

(11) List and give examples of the three classes of salts.

(12) Define pH and explain how pH is used.

(13) Work problems using the various gas law relationships.

(14) Explain why water is used as a standard for many physical property determinations.

(15) Demonstrate how to prepare solutions of the four standard strengths.

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(16) Differentiate between electrolytes and non-electrolytes and explain how each affects the colligative properties of solutions.

(17) List and give examples of the four basic types of recreations.

(18) List the factors that affect the rate of reaction.

(19) Demonstrate a comprehension of redox by solving simple redox equations.

(20) Demonstrate a comprehension of the Electromotive Series by solving galvanic cell problems.

(21) Explain electrolysis and electroplating.

(22) Explain the difference between a galvanic cell and a storage battery.

(23) List seven general classifications of organic compounds.

(24) Identify and give the use of the compounds given.

OUTLINE OF INSTRUCTION:

I. Conversion Units

   A. Using dimensional analysis
   B. Metric units
   C. English units
   D. Conversions

II. Matter and Energy

   A. Matter
      1. Three forms

a. Solids
b. Liquids
c. Cases
2. Three classes
a. Elements
b. Compounds
c. Mixtures
(1) Types
(2) Methods of separation
B. Energy
1. Forms
a. Mechanical
b. Heat
c. Light
d. Electrical
e. Nuclear
C. Law of conservation of matter and energy
D. Physical change
E. Chemical change

III. Physical Properties

A. Heat of fusion
B. Melting point
C. Specific heat
D. Heat of vaporization
E. Vapor pressure
F. Boiling point
G. Density
H. Viscosity
I. Conductivity
1. Thermal
2. Electrical
J. Hardness
K. Crystal form
L. Malleability and ductility

IV. General Discussion of the Elements

V. The Periodic Chart

A. Groups or families
B. Periods
C. Symbols
D. Atomic number
E. Atomic weight
F. Other data

VI. Atomic Structure

A. Protons
B. Neutrons
C. Electrons
D. Nucleus
E. Electron clouds

F. Shells
G. Subshells
H. Orbitals
I. Isotopes
J. Electron configurations
K. Valence

VII. Ions, Molecules, Bonding

A. Ions
   1. Cations
   2. Anions
   3. Ionic bonds
B. Molecules
   1. Like atoms
   2. Unlike atoms
   3. Bonds
      a. Covalent
      b. Coordinate covalent
      c. Hydrogen
      d. Van der Waal
      e. Metallic

VIII. Formulas and Equations

A. How to write a formula
   1. Symbols
   2. Valence
   3. Radicals
B. How to write an equation
   1. Symbols
   2. Balancing

IX. Acids, Bases, Salts

A. Acids
   1. Definition
   2. Preparation
   3. Types
      a. Mineral
      b. Organic
B. Bases
   1. Definition
   2. Preparation
C. pH
   1. Definition
   2. Measurement
D. Salts
   1. Types
   2. Preparation

C. Moles
D. $pV = nRT$
E. Partial pressure

XI. Water and Solutions

A. Water
B. Solutions
   1. The solution process
   2. Strength
      a. Molar
      b. Molal
      c. Normal
      d. Percent by weight

XII. Electrolytes and Non-Electrolytes

A. Electrolytes
B. Non-electrolytes
C. Colligative properties
   1. Vapor pressure depression
   2. Melting point lowering
   3. Boiling point elevation
   4. Osmosis

XIII. Reactions

A. Types
B. Collision theory
C. Rate
D. Equilibrium

XIV. Redox

A. What is a redox reaction
B. Half reaction
C. Oxidation numbers
D. Balancing

XV. Electrochemistry

A. The electromotive series
B. Electrode potentials
C. Galvanic cells
D. Electrolysis
E. Electroplating
F. Storage battery

XVI. Organic Chemistry

A. Introduction
B. Types of compounds
   1. Hydrocarbons
      a. Aliphatic
      b. Aromatic
   2. Alcohols
   3. Aldehydes and Ketones
   4. Acids
   5. Ethers
   6. Halides
   7. Esters
   8. Amides
C. Uses for above

SUGGESTED TEXTS:

Lewis. College Chemistry. 9th Edition. New York: Barnes and Noble publishers.

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EQUIPMENT LISTS

EQUIPMENT LIST: 61 ELECTRONICS

Code No. Name of List

See Last Page

Cost

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Supporting Base

THIS EQUIPMENT LIST SHOULD BE REVIEWED WITHIN TWO YEARS AFTER ITS EFFECTIVE DATE.

NEW LIST ☐

REVISED LIST ☐ Please destroy cover and pages_____dated___________.

Replace with cover and pages attached.

DEPARTMENT OF COMMUNITY COLLEGES

PROGRAM DEVELOPMENT

Date: January, 1977

COMMITTEE

Roy A. Gull	Catawba Valley Technical Institute
John S. Jamison, Jr.	Fayetteville Technical Institute
Foy Willson	Lenoir Community College
A. L. deBruyne	Durham Technical Institute
J. Edward Peeples	Technical Institute of Alamance
Erwin W. McCulloch	Rowan Technical Institute
Ronald Gyles	Central Piedmont Community College
Frank A. Gourley, Jr.	Department of Community Colleges

EQUIPMENT LIST: 61 ELECTRONICS

Code No. Name of List

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
		FIRST YEAR		
I. Teaching Systems				
1	10	Basic Electronic Teaching Systems	750.00	7,500.00
2	10	Basic Electricity Teaching System	340.00	3,400.00
II. Instruments				
*3	12	Multi Function Meter DC, AC volts, Ohms (HP) 427A, Hewlett Packard, or equivalent.	250.00	3,000.00
*4	12	Milliammeter Lab volt 442, or (12-0-10ma milliammeters) Parker SL35, (12-0-50ma milliammeters) Parker SL35, or equivalent.	65.00	780.00
5	1	Incircuit transistor tester Sencore TR139, or equivalent.	89.50	89.50
*6	12	Multimeter VOM Triplett 601 and/or Phillips PM 2400, or equivalent.	150.00	1,800.00

*Indicates the minimum items required for this list to furnish basic austere support.

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
		FIRST YEAR		
7	1	Tube Analyzer Triplett 3444-A, or equivalent.	470.00	470.00
*8	10	Oscilloscope (DC-450KHZ), Triggered X-Y (Balanced Amplifiers) TEK 503 or Phillips PM 3221, or equivalent.	695.00	6,950.00
9	1	Oscilloscope, Storage Dual Trace, Time Base, Sampling, Four Trace Plug ins, TEK 564B (3A3, 3B3, S-1, 3A74), or equivalent.	2,875.00	2,875.00
10	10	Radio Frequency Generator, 100 KHZ-50 MHZ	150.00	1,500.00
*11	20	Attenuator P[illegible]er for scopes	26.00	520.00
*12	10	Low Capacity probes for scopes	26.00	260.00
13	1	Current probe for scope	110.00	110.00
14	1	Scope cart with plug-in carrier, TEK 201-2, or equivalent.	140.00	140.00
*15	30	Resistance Decade Box	40.00	1,200.00
*16	10	Capacitance Decade Box	30.00	300.00
17	2	Wheatstone Bridge	200.00	400.00

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
		FIRST YEAR		
18	2	Volt-amp-watt meter (0-3KW), Simpson, or equivalent.	150.00	300.00
19	1	Potentiometer Leeds & Northup LN4258, or equivalent.	400.00	400.00
20	1	Standard Cell, for potentiometer	40.00	40.00
21	1	Volt Box, for potentiometer	180.00	180.00
III. Power Supplies				
*22	10	Audio Oscillator Sine and Square Wave HP209A or equivalent.	320.00	3,200.00
*23	10	Power Supply (Voltage regulated, current regulated) HP6209B or equivalent.	235.00	2,350.00
*24	10	Variable transformer GRW5LM or equivalent.	26.00	260.00
*25	10	Bench Power Supplies Voltage and Current Regulated. HP6214A or equivalent.	115.00	1,150.00
IV. Furniture				
26	10	Work Surface	38.00	380.00
27	10	Component Base	63.00	630.00

61 Code No. — ELECTRONICS Name of List — Page 4

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
		FIRST YEAR		
28	10	Instrument Storage Base	35.00	350.00
29		Assorted Storage Shelving and Storage Cabinet		831.00
30	1	Shop Desk w/Drawer	54.00	54.00
31	1	Stool, Masonite Seat w/Back	11.40	11.40
32	20	Stool, Masonite Seat, 24 in.	6.48	129.60
V.	Tools (may be purchased as supplies)			
33	1	Electric Drill, 1/4 in.	40.00	40.00
34	1	Circle Hole Cutter	3.24	3.24
35	1	Countersink	.54	.54
36	1	Steel Tape, 10 ft.	1.00	1.00
37	2	Hacksaw	3.15	6.30
38	1	Combination Square	2.52	2.52
39	1	Snips, 10 in. Aviation	2.88	2.88
40	2	Hammer, Plastic Head	1.95	3.90
41	2	Scratchawl, Scriber	.48	.96

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
		FIRST YEAR		
42	2	Hammer, Ball-Pein 8 oz.	1.50	3.00
43	2	Drill Set, High Speed 1/16 in. to 1/4 in.	3.75	7.50
44	2	Chisel and Punch Set	2.33	4.66
45	2	Wrench, Adjustable 6"	1.77	3.54
46	2	Wrench Set, Open End, 10 pcs.	7.70	15.40
47	2	Nutdriver Set	10.00	20.00
48	2	Electrician's Knife	1.85	3.70
49	6	Chassis Punch, Round		
		2 ea. - 5/8 in. dia.	2.30	4.60
		2 ea. - 3/4 in. dia.	2.30	4.60
		2 ea. - 1 in. dia.	2.55	5.10
50	2	Chassis Punch, Square		
		1 - 1/2 in. sq.	4.95	4.95
		1 - 1 in. sq.	7.10	7.10
51	30	Screwdriver, Standard		
		10 - 4 in.	.69	6.90
		10 - 6 in.	.91	9.10
		10 - 8 in.	1.10	11.00

ITEM NO.	QUANTITY	DESCRIPTION FIRST YEAR	UNIT PRICE	TOT PRI
52	25	Screwdriver, Phillips		
		10 - #1	.76	7.
		10 - #2	.84	8.
		5 - #3	1.05	5.
53	3	Screwdriver, Offset, Standard	1.16	3.
54	3	Screwdriver, Phillips, Offset	1.16	3.
55	4	Screwdriver, Clutch-Head	.77	3.
56	2	Hex-Key Wrench Set, 15 pcs.	1.17	2.
57	10	Long Nose, Needle Point Pliers w/cutter, 6 in.	3.61	36.
58	10	Needle Point, Diagonal Cutter, 6 in.	3.67	36.
59	3	Pliers, Tongue - N - Groove 10 in.	3.50	10.
60	3	Pliers, Lineman 8 1/2 in.	4.80	14.
61	5	Pliers, Slip joint	.87	4.
62	3	Lever Wrench Pliers, Vise Grip 8 in.	1.56	4.
63	10	Soldering Gun	7.15	71.

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
		FIRST YEAR		
64	5	Pencil Soldering Iron	4.70	23.50
65	1	Alignment Tool Kit	14.17	14.17
66	2	Tube Pin Straightener	1.27	2.54
67	1	File, Round, 10 in. Bastard Cut	5.97	5.97
68	1	File, Three Square, 6 in.	6.48	6.48
69	1	File, Flat, 8 in. Bastard Cut	6.52	6.52
70	1	Bench Vise	13.40	13.40
71	2	Tapered Reamer, 1/8 in. - 1/2 in.	1.26	2.52
72	1	Tap and Die Set	28.04	28.04
73	6	De-soldering tools with assorted tips Ungar 7800 Hot Vac, or equivalent.	10.00	60.00
~~74~~	~~2~~	~~De-solderettes miniature,~~ Ungar 6992, or equivalent.	~~15.00~~	~~30.00~~
75	2	Magnifier Lamps, for printed circuit work, Luxo LFM-1, or equivalent.	36.00	72.00

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
		FIRST YEAR		
VI. Shop Equipment				
76	1	Bending and forming brake (18") Little Giant or equivalent.	8.98	8.98
77	1	Punch-Press-Shear Little Giant or equivalent.	8.95	8.95
78	1	Drill Press with Vise	75.00	75.00
79	1	Bench Grinder	50.00	50.00
		SECOND YEAR		
I. Teaching Systems				
80	5	Industrial Electronics Teaching Systems	662.00	3,310.00
81	1	Transistor Lecture Demonstration Unit	1,100.00	1,100.00
82	1	Industrial Instrumentation Training Unit,	5,600.00	5,600.00
*83	10	Logic Trainer, Indiana Instrument, UOR-C, or equivalent.	295.00	2,950.00
84	1	Microwave Laboratory Kit	2,500.00	2,500.00
85	1	Instrumentation Training Unit, Philco 4003, or equivalent.	5,000.00	5,000.00

61 — Code No. ELECTRONICS — Name of List — Page 9

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
		SECOND YEAR		
II. Instruments				
*86	10	Oscilloscope, Dual Trace plug-in. TEK 546, 1A1 or equivalent.	2,375.00	23,750.00
87	1	Set of Oscilloscope plug-ins Four Trace, Operational, Strain gauge Sampling. Differential. TEK 1A4, 0, Q, 1A5, 1S1 or equivalent.	3,010.00	3,010.00
88	1	Oscilloscope - Dual Beam, 2 single trace plug-in TEK 551, K or equivalent.	2,470.00	2,470.00
89	1	Large screen oscilloscope dual trace and time base plug-in probes. HP 143A, 1405A, 1421A, 2X10001B or equivalent.	2,420.00	2,420.00
90	1	Scope cart with drawer HP 1117B, 10475A, or equivalent.	215.00	215.00
91	11	Scope cart with plug-in carrier. TEK 202-2 or equivalent.	140.00	1,540.00
*92	10	Digital voltmeter with plug-in. HP 3439A, 3444A, 3445A, or Phillips PM 2421 or equivalent.	1,550.00	15,500.00
*93	10	Multifunction meter. AC Volts, DC volts & Amp, OHMS. HP 410C. or Ballentine 300G or equivalent.	475.00	4,750.00

61	ELECTRONICS	Page 10
Code No.	Name of List	

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
		SECOND YEAR		
94	1	Trace recording Camera with projector and adapter for oscilloscopes, TEK C-12, 016-0204-00, 016-0243-00 or equivalent.	650.00	650.00
95	1	Electrometer and DC amplifier. General Radio GR1230A or equivalent.	595.00	595.00
96	1	Frequency Counter 0-50M H-Z time interval, frequency converter plug-in. HP 5245M, 5267A, 5253B or equivalent.	4,000.00	4,000.00
*97	2	Impedance Bridge GR 1650B or equivalent.	450.00	900.00
98	1	Vector impedance meter HP 4800A or equivalent.	1,650.00	1,650.00
99	1	Power Output meter GR1840-A or equivalent.	325.00	325.00
*100	1	Laboratory Standard Decade Resistor. GR 1434P or equivalent.	137.00	137.00
*101	1	Laboratory Standard Decade Capacitor GR 1419B or equivalent.	270.00	270.00
*102	1	Laboratory Standard Decade Inductor GR 1491-F or equivalent.	715.00	715.00

61	ELECTRONICS	Page 11
Code No.	Name of List	

ITEM NO.	QUANTITY	DESCRIPTION SECOND YEAR	UNIT PRICE	TOTAL PRICE
*103	1	X-Y Recorder 11" x 17" with time base GR 7005B, 17108A or equivalent.	1,370.00	1,370.00
104	1	Stroboscope, GR 1531-AB or equivalent.	310.00	310.00
*105	1	Radio Frequency Bridge. GR 1606B or equivalent.	1,150.00	1,150.00
106	1	Microwave Power Meter	500.00	500.00
107	1	Distortion Analyzer. HP 331A or equivalent.	650.00	650.00
*108	1	Transistor Curve Tracer. TEK 575 or equivalent.	1,200.00	1,200.00
109	1	Laboratory Standard. HP 6920B or equivalent.	695.00	695.00
110	5	Volt-ohm meters, low voltage for solid state work, Triplett 630L, or equivalent.	66.00	330.00
111	5	Volt-ohm meters, high sensitivity-low reading (200,000 ohms/v) Triplett 630 NS, 601, or equivalent.	125.00	625.00
112	1	Audio Frequency Microvolter, GR 546C, or equivalent.	250.00	250.00
113	1	Megohmmeter, with both 100V and 500V test voltages, GR 1862C, or equivalent.	385.00	385.00

61	ELECTRONICS	Page 12
Code No.	Name of List	

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
		SECOND YEAR		
III.	Power Supplies			
114	1	Time Mark Generator TEK 184 or equivalent.	760.00	760.00
*115	10	Pulse Generator HP 1217C or equivalent.	380.00	3,800.00
116	1	Sweep generator HP675A or GR1025A or equivalent.	3,950.00	3,950.00
*117	1	Radio Frequency Signal Generator HP606B or equivalent.	1,550.00	1,550.00
118	7	Dual Power Supplies, Hewlett-Packard Co. #6227B, or equivalent.	450.00	3,150.00
119	7	Dual Power Supplies, Hewlett-Packard Co., #6228B, or equivalent.	450.00	3,150.00
120	6	Function Generator, Hewlett-Packard Co., #3310A, or equivalent.	575.00	3,450.00
IV.	Auxiliary			
121	1	Calculator, basic programmable electronic. Desktop with options for peripheral equipment (printer, card reader, plotter, or special programmed functions) Hewlett Packard model 9810A, or equivalent.	3,000.00	3,000.00

ELECTRONIC EQUIPMENT COMPANIES
REPRESENTATIVE LISTING*

Hewlett-Packard Corporation
1501 Page Mill Road
Palo Alto, California 94304

Electrolab Corporation
8 Kiwi Path
Liverpool, New York 13088

Tektronix Inc.
Box 500
Beaverton, Oregon 97005

Sencore, Incorporated
426 Westgate Drive
Addison, Illinois 60101

Phillips Electronic Instruments
750 S. Fulton Avenue
Mount Vernon, New York 10550

Triplett Electrical Instruments Company
286 Harmon Road
Bluffton, Ohio 45817

General Radio Company
22 Baker Avenue
West Concord, Massachusetts 01781

Simpson Electric Company
5218 W. Kinzie Street
Chicago, Illinois 60644

Philco Ford Corporation
815 Connecticut Avenue, N.W.
Washington, D. C. 20026

LabVolt Educational Systems,
Division of Buck Engineering Company
P.O. Box 686
Farmingdale, New Jersey 07727

Parker Instruments
200 Harvard Avenue
Stanford, Connecticut 06902

Indiana Instruments
P.O. Box 8368
St. Petersburg, Florida 33738

*This is not a complete listing of all such companies; neither does inclusion imply special approval, nor does omission imply disapproval of a company.

ITEM NO.	QUANTITY	DESCRIPTION	COST OF ITEM	TOTAL
122	1	Printer, alpha-numeric, for calculator above.	675.00	675.00
123	1	Function Block, plug-in print complete alpha for above calculator.	485.00	485.00
124	1	Function Block, plug-in mathematics model for above calculator.	485.00	485.00
125	1	Function Block, plug-in statistics model for above calculator.	485.00	485.00
126	1	Reader, Card for above calculator.	850.00	850.00
127	1	Plotter, for above calculator. HP Model 9862A, or equivalent.	2,675.00	2,675.00
128	1	RF Field Strength Meter, Jerrold Model 720B, or equivalent.	425.00	425.00
129	2	Word Generator, Two Channel, 32 Bit, 2 to 16 Bit Words, Bit Rate 10 HZ to 10 M HZ. H-P8006A, or equivalent.	1,200.00	2,400.00
130	2	Pocket Calculator, engineering, logarithmic, trigonometric, math functions. 35 key, 10 decimal digits, 4 registers. Hewlett-Packard, 35 HP, or equiv.	395.00	790.00
131	2	Security Cradle for pocket calculator, HP Model 82007A, or equivalent.	25.00	50.00

ITEM NO.	QUANTITY	DESCRIPTION	COST OF ITEM	TOTAL
132	1	Battery(s), with Battery Pack, Model No. 82004A, or equivalent.	18.00	18.00
133	1	Logic Analyzer, HP5000A, or equivalent.	1,900.00	1,900.00
134	1	Logic State Analyzer, HP1601L, or equivalent.	2,650.00	2,650.00
135	4	Operational Amplifier, TEKAM501, or equivalent.	225.00	900.00
136	1	Cabinets-Storage Wood	356.00	356.00
137	1	Benches, Crafts, Wood	532.00	532.00
138	1	Mark -Sense/Punched Card Reader to be compatable with above calculator (#121)	5,000.00	5,000.00
139	1	VHF FM transceiver 144 to 148 megohertz, with a minimun of ten watts output power. Drake 72 or equivalent	320.00	320.00
140	1	MF Transceiver CW and SSB with a minimuninput power of [illegible] watts PEP. Drake TR-4C or equivalent	600.00	600.00
141	1	Digital computer trainer with accessible circuit boards and test points. Selectable circuit "troubles" for service training. Eight bit word. Single step or continuous operation capability. Digiac model 3060 or equivalent	6,895.00	6,895.00
142	1	Teletype unit for use with digital computer trainer above. typewriter or paper tape capability. Model ASR-33 (Digiac 3061) or equivalent.	1,600.00	1,600.00

*Indicates the minimum items required for the list to furnish basic austere support.

ELECTRONICS TECHNOLOGY

61	EQUIPMENT LIST - 61	Page 15
Code No.	Name of List	

ITEM NUMBER	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
143	1	AM-FM Stereo Generator and Analyzer	$ 595.00	$ 595.00
144	1	Power Monitor Meter AC Voltage, Current, Wattage Meter	$ 75.00	$ 75.00
145	1	Spectrum Analyzer 1500 MHZ with Variable Persistence Display	$6,200.00	$6,200.00
146	30	Transistor Breading Sockets to Accommodate Minimum 4 - 14 Pin DIP's	$ 9.50	$ 285.00
147	12	Linear Integrated Circuit Breadboarding System For OP-AMP's	$ 99.95	$1,199.40
148	1	Circuit Demonstrator Magnetic Chalkboard Breadboarding System	$3,995.00	$3,995.00
149	5	Logic Troubleshooting Kit Including (1) Logic Probe (2) Logic Pulser (3) Logic Clip	$ 250.00	$1,250.00
150	8	Digital Integrated Circuitry Breadboarding System To Handle TO-5 and DIP Package Configuration	$ 99.95	$ 799.60

$199,809.00

NEW TOTAL COST

APPROVED: February, 1976

ADDENDUM:

61 — Code No.

ELECTRONICS — Name of List

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ITEM NO.	QUANTITY	DESCRIPTION	COST OF ITEM	TOTAL
151.	1	High Grain Antenna Tower	$234.00	$234.00

$200,043.00
NEW TOTAL COST

APPROVED: August, 1976

EQUIPMENT LIST: 58 ELECTRICAL

Code No. Name of List

$120,576.45

Cost

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Supporting Base

THIS EQUIPMENT LIST SHOULD BE REVIEWED WITHIN TWO YEARS AFTER ITS EFFECTIVE DATE.

SUPERCEDES LIST(S)

Electrical Technology dated December, 1965 PLEASE DESTROY

dated PLEASE DESTROY

Date: December, 1969

DEPARTMENT OF COMMUNITY COLLEGES
DIVISION OF OCCUPATIONAL EDUCATION

COMMITTEE

Ronald C. Gyles	Central Piedmont Community College
Norman Lackey	Catawba Valley Technical Institute
Raymond A. Fuhrer	Gaston College
Donald E. Johnson	Davidson County Community College
Kincheon H. Bailey	W. W. Holding Technical Institute
Frank A. Gourley, Jr.	Department of Community Colleges

NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
		Fractional Horsepower Motors, and Generators, and Accessories including: Bases, Motor-Generator; Split Phase Motor, 1/3 h.p.; Capacitor Start Motor 1 Ø 1/3 h.p.; Induction Motor, 3 Ø; Wound Rotor Motor 3Ø; DC Motor, compound wound; DC Generator, compound wound; Syn. Alternator, 3 Ø; Synchronous Alternator 1 Ø; Resistance Load Unit; Resistance Reactance Load Unit; Speed Control Rectifier; and Prony Brake.		5,000.00
Instruments				
	2	Tachometer, Stewart Warner THT 757	8.50	17.00
	7	Multimeter, VOM, w/breaker, Simpson 260, or equivalent.	49.00	343.00
	7	Wattmeter, Simpson 390, or equivalent.	55.00	385.00
	7	AC Ammeter, LabVolt 461, .1 to 10 amp	62.70	438.90
	2	Low Range Ohmmeter, Simpson 363, or equivalent.	25.00	50.00
	4	DC Ammeter, Labvolt 442, or equivalent.	62.70	250.80
	2	Voltmeter, Ammeter, Snaparound, Amprobe RS-3, or equivalent.	53.00	106.00
	1	Wheatstone Bridge, Industrial Instruments RN-2, or equivalent.	193.00	193.00

Page 1

EQUIPMENT LIST: 58 ELECTRICAL
Code No. Name of List

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
I. Teaching Systems				
1	1	Electrical Phenomena, Crow 500 G	462.00	462.00
2	1	Variable Condenser, Crow 512	54.00	54.00
3	1	High Inductance Coil, Crow 515	51.00	51.00
4	1	Auto-Transformer Assembly, Crow 517	32.00	32.00
5	3	Meter, Lecture, Crow 507	39.00	117.00
6	7	Basic Electricity Teaching System	340.00	2,380.00
7	4	Industrial Electronic Teaching System	550.00	1,100.00
8	2	Educational Trainer, Thy-mo-trol; Motor Control Unit	1,000.00	2,000.00
9	1	Motor Control Trainer, Thy-mo-trol	1,000.00	1,000.00
10	1	Mobile Transformer Learning Center	3,925.00	3,925.00
11	1	Solid State Logic Learning Center complete with Mobile Bench	3,752.00	3,752.00

*Indicates the minimum items required for this list to furnish basic austere support.

58	ELECTRICAL	Page 3
Code No.	Name of List	

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
21	1	Wattmeter, Simpson 391, or equ' alent.	44.00	44.00
22	1	Wattmeter, Simpson 392, c equivalent.	44.00	44.00
23	1	Capacitor Analyzer, Cornell Dubilier BF 71A, or equivalent.	130.00	130.00
24	1	Armature Test Growler	45.00	45.00
25	8	Wheatstone Bridge, Slide Wire	11.00	88.00
26	8	Galvanometer Labvolt 451B, or equivalent.	57.00	456.00
27	2	Kilowatt-Hour Meter, 220V - 3 Wire	40.00	80.00
28	1	Kilowatt-Hour Meter, 2 1/2 Element 220V	55.00	55.00
29	1	Kilowatt-Hour Meter, 3 Element, 220V	72.00	72.00
30	1	Demand Meter w/KWH, Type H-W2	125.00	125.00
31	1	Megger, Insulation Tester, Biddle 7679	305.00	305.00
32	4	Vacuum Tube Voltmeters, FET Norelco PM 2400 or Triplette 601, or equivalent.	150.00	600.00
33a	4	Eagle Signal Timer	75.00	300.00
34	12	A-C Ammeters Ranges 0-5/10, 0-25/50, Type AP-9, General Electric, or equivalent.	55.25	663.00

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Code No.	Name of List	

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
35	9	A-C Voltmeters Ranges 0-15/75, 0-150/300, Type AP-9, General Electric, or equivalent.	53.00	477.00
36	9	Wattmeters Type AP-9, A-C, 1 1/2/3 KW, Double Current 10/20 Amps & Double Voltage 150/300 Volts, General Electric, or equivalent.	100.25	902.25
37	6	Ammeter, D-C, 3-Amp. G.E. Type DP-9, or equivalent.	54.00	324.00
38	3	Ammeter, D-C, 7.5-Amp. G.E. Type DP-9, or equivalent.	54.00	162.00
39	3	Ammeter, D-C, 30-Amp. G.E., Type DP-9, or equivalent.	54.00	162.00
40	3	Ammeter, D-C, 50-Amp. G.E., Type DP-9, or equivalent.	54.00	162.00
41	3	Voltmeter D-C, 15/75 Volt G.E. Type DP-9, or equivalent.	68.00	204.00
42	3	Voltmeter D-C, 150/300 Volt G.E., Type DP-9, or equivalent.	68.00	204.00
43	3	Strobotac, General Radio Type 631-BL, or equivalent.	400.00	1,200.00
44	1	Phase sequence meter G.E. Catalog #462X62	25.00	25.00
45	3	Ligatmeter with Filter, Footcandle Meter with case weston portable Multi-Purpose Cat. #614, or equivalent.	21.00	63.00

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
46	1	AC Clamp, Volt-Ammeter, Weston 633, or equivalent.	142.00	142.00
47	2	Oscilloscope, Tektronic 503, with Leads	900.00	1,800.00
48	1	Stroboscope, General Radio 1531A, or equivalent.	343.00	343.00
49	2	Industrial Circuit Tester, w/Steel Case and Test Leads, Weston 785, or equivalent.	177.00	354.00
50	1	Therm-o-meter; Complete w/One Probe, Simpson, 389-3L, or equivalent.	63.00	63.00
51	2	Thermistor Leads for Model 389-3L, Above, Simpson 0010, or equivalent.	5.00	10.00
52	1	X.Y. Recorder Hewlett-Packard, Model 135A, or equivalent.	1,800.00	1,800.00
53	4	Decade Resistance Boxes	40.00	160.00

III. Power Supplies and Auxiliary Equipment

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
54	1	Laboratory Distribution Board, 6 Section, w/following equipment:	22,000.00	22,000.00

1 - Grill Door
60 - #10 Cords
6 - #6 Cords - 4'
2 - Cord Rack
3 - Mobile Transformer Bench,
1 to 3 KVA each

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Code No.	Name of List	

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
		1 - Set Cords for Above 16 - H-1 Outlets -- 4 wire 1 - H-2 Outlet 1 - H-[illegible] Outlet 1 - H-3 Gang Box 1 - X-4 Outlet 4 - X-5 Emergency Station 1 - X-6 Outlet 54 - Cords #14-4' 32 - Cords #16-4' 5 - Cords #14-8' 2 - REM-1 M-G Sets 2 - H-TAD Panels 2 - Sets Cords: 22 ea. Set 2 - H-AS-1 AC Starter Panel 2 - H-SR-1 Slip Ring Panel 2 - H-DS-1 DC Starter Panel 2 - H-SP-1 Motor Panel 2 - H-SM-1 Motor Panel 2 - H-IR-1 Induction Reg. Panel 2 - H-SRC Rotary Converter Panel 2 - H-WW-1 Worm Wheel Assembly 2 - H-R1 Mobile Dollies 2 - Sets Panel Cords: 25/set 1 - Storage Rack 20 - Cells, Nickel Cadmium Battery 1 - Battery Rack 1 - 3 Unit M-G Set 1 - Switch and Magnetic Starter 1 - Dynamometer 1 - HD-34T Tachometer 10 - Sets Instruction Manuals 1 - Set, Drawings Hampden, or equivalent.		
55	2	Audio Generators, Hewlett-Packard, 204C.	270.00	540.00
56	10	Battery Eliminator Low voltage variable supply	50.00	150.00
57	2	Single Phase, Split Phase, 1/2 HP, 115 Volt AC Motor	42.50	95.00

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Code No. — Name of List

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
58	1	Repulsion Start. Induction Run, 1 HP, 115 Volt AC Motor	85.00	85.00
59	8	Magnetic Starter Size 1	32.00	32.00
60	1	Motor Starter Manual, Size 1	28.00	28.00
61	2	Split Phase, Induction Motor 1/2 HP, 120-240 Volt. AC	50.00	100.00
62	2	Capacitor Start, Induction Motors 1/2 HP, 120-240 Volt, AC	50.00	100.00
63	2	Current Transformers, 50/5 amps, Through Type	9.00	18.00
64	2	Current Transformers, 100/5 amps, Through Type	9.00	18.00
65	4	Powerstats, Single Phase, Manual, Superior 116, or equivalent.	24.00	96.00
66	1	Powerstat, Three Phase, Manual, Superior 116 V-3, or equivalent.	62.00	62.00
67	4	Timing Relays, Pneumatic, Square D Type AG, or equivalent.	60.00	240.00
68	2	Timing Relays, Electronic, Square D Type EG	78.00	156.00

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Code No.	Name of List	

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
69	1	AC Reversing Magnetic Starter, Square D, or equivalent.		
		1 ea. - Single Phase	80.00	80.00
		1 ea. - Three Phase	100.00	100.00
70	1	AC Combination Magnetic Starter, Square D	100.00	100.00
71	3	AC Magnetic Contactors, Single Phase, Square D, or equivalent.	33.00	99.00
72	2	AC Magnetic Contactors, Three Phase, Square D, or equivalent.	31.00	62.00
73	3	AC Manual Starters, Single Phase, Square D, or equivalent.		
		2 ea. - Non-reversing	25.00	50.00
		1 ea. - Reversing	75.00	75.00
74	1	AC Manual Starter, Lint Tight, Square D, or equivalent.	32.00	32.00
75	3	AC Manual, Drum Switches, Reversing, Square D, or equivalent.	11.00	33.00
76	2	DC Magnetic Relays, Square D, or equivalent.	25.00	50.00
77	1	DC Contactor and Starter, Square D, or equivalent.	75.00	75.00
78	8	AC Magnetic Relay, Square D, or equivalent.	30.00	240.00
79	12	Standard Duty Control Stations, Assorted, Square D, or equivalent.	7.50	90.00

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
80	6	Air-Circuit Breakers, with Red Pilot Light and Enclosure, 30/50 amp.-3 Pole, 250 Volt, 15,000 I.C. Moulded Case	110.0	660.00
81	1	A-C Motor Starter. Size #2, Reduced Voltage, 3-Phase, 60 Cycle, 220 Volt Auto-Transf. Magnetic Type. SQ "D" with Overloads for 5-H.P.	1,200.00	1,200.00
82	1	Motor Starter, Primary Resistance, Size #2 3-Phase, 220 Volt, Magnetic SQ "D" type DG-2 with Overloads for 5-H.P.	350.00	350.00
83	2	Motor Starter, Across-the-line type, Size #2 Motor, 3-Phase, 220 Volt, Magnetic, with Overloads for 5-H.P., for 3-Phase, 220-Volt. SQ "D" DG-1, or equivalent.	84.00	168.00
84	3	Motor Starter, Magnetic Across-the-line, Size #1 suitable for 220 volt 60 Cycle, 3-Phase, A-C Motor similar to SQ "D" Co. Cat. #CG-3, or equivalent.	44.00	132.00
85	9	Momentary Push Button Station in general purpose enclosures, start-stop similar to SQ "D" Cat. #B-30, or equivalent.	7.50	67.50

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
86	3	Pilot Lights & Enclosures for 220 Volts. Similar to SQ "D" Cat. #B-49	14.00	42.00
87	2	Zero Speed Switch Allen-Bradley Co., Cat. #808EI, or equivalent.	103.00	206.00
88	2	Motor-Generator Set, Driving A-C Motor 3-H.P., 220 Volt, A-C, 3-Phase, 1750 RPM. Generator 3 K.W., 120 Volts, D-C having both shunt and series fields, Mounted on common base, G.E. Co. Motor SK 213A6201 and Generator SCD216E124 and with suitable Plate-type Field Rheostat	1,150.00	2,300.00
89	2	Motor-Generator Set having a 3-H.P. 120 Volt D-C 1750 RPM Motor driving another 3-HP, 120 Volt D-C Motor mounted on a common base similar to G.E. Co. SCD 216E124 with two suitable Platetype Field Rheostats	1,300.00	2,600.00
90	2	Motor-Generator Set having a 5-KVA, 4-KW-1800 RPM, 3-Phase, 60 Cycle, 120/240 Volt A-C, Synchronous Alternator Model SJ256 and a Compound D-C Generator 4 1/2 KW., 1750 RPM, 125 Volt, D-C, 36 Amps. on a common base with two suitable field Rheostats. G.E. H2304A	1,850.00	3,7[illegible]0.00

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
		Instruction Book, Outline Drawing #627B467 & 894A95 Diagram of Connections, G. E. Company, or equivalent.		
91	1	Voltage Regulator 7 1/2 KVA, 3-Phase, 104 Amp. 120/208 Volt Circuit with 20% Raise and 20% Lower from Normal Incoming Line Voltage. Motor driven G.E. Co. Catalog #31D5180M, or equivalent.	3,500.00	3,500.00
92	2	Reversing Motor Starter, Size #1 Suitable for 5-H.P., 3 Phase, 220 Volt A-C Induction Motor similar to SQ "D" Co. type DG-1 with Overload Protection	96.00	192.00
93	2	Direct Current Magnetic Motor Starter with Push Button suitable for a 3-H.P., 120 Volt, D-C, 1750, 24 Amps Compound Motor. With enclosure similar to G.E. Co. Cat. # with Momentary Push Station	300.00	600.00
94	2	Direct Current Magnetic Motor Starter with Push Button suitable for a 5-H.P., 120 Volt, D-C, 1750, 24 Amps Compound Motor. With Enclosure similar to G.E. Cat # with momentary Push Station	450.00	900.00

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
95	3	Wire Control Panel, individual components as described in Electric Motor Control Lab Manual by Walter N. Alerich, Delmar.	155.20	465.60
96	3	Relay and Lighting Panel, as described in Electric Motor Control Lab Manual.	142.90	428.70
97	3	Jog Control Panel, as described in Electric Motor Control Lab Manual	111.20	333.60
98	3	Forward-Reversing Panel, as described in Electric Motor Control Lab Manual	163.40	490.20
99	2	Drum Switch Panel, as described in Electric Motor Control Lab Manual	145.05	290.30
100	2	Speed Control Panel, as described in Electric Motor Control Lab Manual	138.80	277.60
101	2	Mobile Power Consoles	6,065.00	12,130.00
102	1	AC Controller	2,002.00	2,002.00
103	1	AC Motor, 3 horsepower	78.00	78.00
104	1	AC Motor, 3 horsepower	406.00	406.00
105	1	DC Controller	2,277.00	2,277.00
106	1	DC Motor, compound wound	741.00	741.00
107	1	Resistance Load Bank, mobile	586.00	586.00
108	1	Capacitance Load Bank, complete	681.00	681.00

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
109	1	Inductance Load Bank, mobile	601.00	601.00
110	1	Lot of Service Outlets complete including Cords	1,500.00	1,500.00
111	1	Panel for Industrial Electricity Lab, 2-section Basic	4,900.00	4,900.00
112	1	Fractional Horsepower AC Controller	1,160.00	1,160.00
113	1	Fractional Horsepower DC Controller	1,085.00	1,085.00
114	1	Fractional Horsepower Dynamometer, complete with mobile bench and Tachometer	1,541.00	1,541.00
115	1	Toroidal Saturable Reactor	228.00	228.00
116	5	Transformer Reactor Choke Kits	228.00	1,140.00
117	1	Appliance Test Console Mobile	1,390.00	1,390.00
118	6	Power Panels	169.00	1,014.00
119	6	Tunnel Modules for Power Panel	22.00	132.00
IV.	Special Purpose Equipment for Solid State Motor Control Devices			
120	3	Power Supply, NEMA type 1 Enclosure 115 Volt, A-C, G.E. Co. #CR245P101B or equivalent.	125.00	375.00

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
121	12	Output Amplifier, 115 Volt, 1 amp., G.E. CR245L101A, or equivalent.	60.00	720.00
122	3	Input Device, Single Phase, Sine to square wave and unit reset, G.E. #CR245G103A, or equivalent.	35.00	105.00
123	15	Logic Functions Two-2 Input "AND" with Standard and Inverted Outputs	28.00	420.00
124	9	Logic Functions Two-3 Input "AND" with Standard Output	28.00	252.00
125	6	Logic Function One-6 Input "AND" with Standard Output G.E. Cat. #CR245A116A, or equivalent.	19.50	117.00
126	18	Logic Functions Two-3 Input "OR" with Standard Output G.E. Cat. #CR245B13A, or equivalent.	30.00	540.00
127	15	Logic Functions Two-1 Input "NOT" with Standard Output G.E. Cat. #CR245111A, or equivalent.	24.50	367.50
128	6	Logic Functions One-3 Input Sealed "AND" with Standard and Inverted Output, G.E. #CR245A213A, or equivalent.	22.00	132.00
129	6	Logic Functions Two-3 Input "AND-NOT" with Standard Output G.E. #CR245C103A, or equivalent.	17.50	105.00

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
130	6	Logic Function Two-3 Input "OR NOT" with Standard Output G.E. Cat. #CR245C113B, or equivalent.	28.00	168.00
131	9	Logic Functions One "Retentive Memory" with Standard and Inverted Output G.E. #CR245E112A, or equivalent.	50.00	450.00
132	9	Logic Functions One "OFF-RETURN MEMORY" with Standard and Inverted Output, G.E. #CR245E112A, or equivalent.	25.00	225.00
133	3	Logic Function "DELAY" (.006 - .03 sec.) with integral potentiometer, G.E. #CR245F110B, or equivalent.	44.00	132.00
134	9	Logic Functions "DELAY" (.04-12 sec.) with integral potentiometer, G.E. Cat. #CR245F111A, or equivalent.	44.00	396.00
135	3	Logic Functions "DELAY" (8-300 sec.) with integral potentiometer, G.E. Cat. #CR245F111B, or equivalent.	49.00	147.00
136	18	"Original Input" Devices, Two 115 Volt, A.C., G.E. Cat. CR245S102A, or equivalent.	37.00	666.00

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
137	3	Power Supply Incoming A-C Line Filter, G.E. #CR245X103A, or equivalent.	10.00	30.00
138	12	Base Assembly, 8 Unit Accessory Device, G.E. #CR245T108A, or equivalent.	16.00	192.00
139.	1	Wire Terminals, Package of 500, G.E. #55-163857P1, or equivalent.	32.00	32.00
140	3	Probe Test Light, G.E. Cat. #CR245X101A, or equivalent.	29.00	87.00
141	3	Multi-Unit Push Button Station, 16 Units, Allen-Bradley Catalog #800T-16TZ, or equivalent.	45.00	135.00
142	3	Control Relay Cabinet, Steel, 4'X2'X12', wall-mounted, Terminal blocks at bottom of cabinet for 120 #14 Wire connections, Panelette Co, or equivalent.	80.00	240.00
143	1	Custom Built Control Panel consisting of 11 rows of 18 terminals per row.	1,000.00	1,000.00
144	3	12 Alarm Point Cabinet Annunciator, with model S.F. Flasher, Pilot Lights, Audible Signal, Scram Instrument Co., or equivalent.	240.00	720.00

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ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
V. Shop Equipment				
145	1	Electric Drill, 3/8" variable speed, Black & Decker, or equivalent.	60.00	60.00
146	1	Machinist Vise, Stanley 3993 A, or equivalent.	11.00	11.00
147	8	Soldering Gun, Weller D-550, or equivalent.	6.90	55.20
148	1	Pencil Soldering Iron, Hexacon 25 S35, or equivalent.	5.10	5.10
VI. Furniture				
149	8	Work Surfaces, Lab-Volt. ET, 3' x 6', or equivalent.	38.00	304.00
150	8	Component Bases, for above, Lab-Volt. DB, or equivalent.	63.00	504.00
151	8	Instrument Storage Base, for above, Lab-Volt. CB, or equivalent.	35.00	280.00
152	1	Shelving and Steel Cabinets for Storage		600.00
153	1	Shop Desk w/Drawers, Penco 33110, or equivalent.	54.00	54.00
154	1	Stool, Masonite Seat w/Back, Bay MB1-2732, or equivalent.	11.40	11.40
155	15	Stool, Masonite Seat, 24", Bay M1-24, or equivalent.	6.40	96.00

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Code No.	Name of List	

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
VII.	Tools (May be purchased as supplies)			
156	16	Magnetic Compass	3.00	48.00
157	2	Flashlight, Everready 2251, or equivalent.	3.00	6.00
158	1	Circle Hole Cutter, Stanley 419, or equivalent.	3.24	3.24
159	1	Countersink, Stanley 137, or equivalent.	.54	.54
160	1	Steel Tape, 10 ft., Stanley CA 010W, or equivalent.	1.00	1.00
161	2	Hacksaw, Boney 2623, or equivalent.	3.15	6.30
162	1	Combination Square, Stanley 225, or equivalent.	2.52	2.52
163	1	Snips, 10" Aviation, Stanley 15435, or equivalent.	2.88	2.88
164	2	Hammer, Plastic Head, Stanley 594, or equivalent.	1.95	3.90
165	2	Scratch-Awl, Scriber, Stanley H 1202	.48	.96
166	2	Hammer, Ball Pein 8 oz., Stanley 308 B	1.80	3.60
167	2	Drill Set, High Speed, Jobber Size #60 to 1/2", Hanson S-113	10.00	20.00

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
168	2	Chisel and Punch Set, Cincinnati Tool 160	2.33	4.66
169	2	Wrench, Adjustable 6" Williams, Superadt 6	1.77	3.54
170	2	Wrench Set, Open End, 10 pcs., Thorsen PC-10	7.70	15.40
171	2	Nutdriver Set, Xcelite 127	5.76	11.52
172	6	Electricians Knife, Klein "XELA" 1550-2	1.85	3.70
173	6	Chassis Punches, Round, Greenlee Type 730		
		2 ea. - 5/8 in. dia.	2.30	4.60
		2 ea. - 3/4 in. dia.	2.30	4.60
		2 ea. - 1 in. dia.	2.55	5.10
174	2	Chassis Punch, Square, Greenlee Type 731		
		1 - 1/2 in. sq.	4.95	4.95
		1 - 1 in. sq.	7.10	7.10
175	1	Knockout Punch Set, 1/2" - 1 1/4" Greenlee 735	11.00	11.00
176	24	Screwdrivers, Standard Proto, or equivalent.		
		8 - 4" 9304	.69	5.52
		8 - 6" 9806	.91	7.28
		8 - 8" 9808	1.10	8.80
177	27	Screwdriver, Phillips Proto, or equivalent.		
		8 - #1 9682	.76	6.08
		8 - #2 9684	.84	6.72
		3 - #3 9686	1.05	3.15

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
178	3	Screwdriver, Offset, Standard, Stanley 3800, or equivalent.	1.16	3.48
179	3	Screwdriver, Phillips, Offset, Stanley 3423, or equivalent.	1.16	3.48
180	4	Screwdriver, Clutch-Head, Xcelite, or equivalent.		
		2 - G 183	.72	1.44
		2 - G 5324	.81	1.62
181	2	Hex Key Wrench Set, 15 pcs., Boney N 6R	1.17	2.34
182	8	Long Nose, Needle Point Pliers w/Cutter, 6", Kraueter CG 826, or equivalent.	3.61	28.88
183	8	Needle Point, Diagonal Cutter, 6", Kraueter CG 5601, or equivalent.	3.67	29.36
184	3	Pliers, Tongue - N - Grove 10", Kraueter CG 710, or equivalent.	3.50	10.50
185	3	Pliers, Lineman 8 1/2" Kraueter CG 1801, or equivalent.	4.80	14.40
186	8	Pliers, Slip Joint, Proto 201, or equivalent.	.87	6.96
187	3	Lever Wrench Pliers, Vise Grip 8" Proto 291, or equivalent.	1.56	4.68

*Indicates the minimum items required for this list to furnish basic austere support.

ELECTRICAL EQUIPMENT COMPANIES
REPRESENTATIVE LISTING*

Hampden Engineering Corporation
East Longmeadow, Massachusetts

Stewart-Warner Micracircuits, Inc.
730 E. Evelyn Avenue
Sunnyvale, California 94086

Simpson Electric Company
Division of American Gage &
Machine Company
5200 W. Kinzie Street
Chicago, Illinois 60644

Amprobe Instruments
Division of Soss Manufacturing Company
630 Merrick Road
Lynbrook, New York 11563

Industrial Instruments Corporation
8400 Research Road
Austin, Texas 78758

Cornell-Dubilier Electronics
Newark, New Jersey

Crow/Universal Scientific Company
1102 Shelby Street
Vincennes, Indiana

Hickok Teaching Systems, Inc.
Wheeling Avenue
Woburn, Massachusetts 01801

General Electric Company
570 Lexington Avenue
New York, New York 10022

Biddle Company
Twp Line & Jolly Road
Plymouth Meeting, Pennsylvania 19462

Superior Electric Company
383 Middle Street
Bristol, Connecticut 06010

Triplette Electric Instrument
Company
500 Harmon Road
Bluffton, Ohio

Square D Company
Executive Plaza
Park Ridge, Illinois 60068

Weston Electrical Instruments
Company
(Division of Daystrom Inc.)
450 Mountain Avenue
Murray Hill, New Jersey

General Radio Company
30 Baker Avenue
West Concord, Massachusetts

Allen-Bradley Company
1201 S. Second Street
Milwaukee, Wisconsin 53204

Tektronix Incorporated
Box 500
Beaverton, Oregon 97005

Electrolab Corporation
P.O. Box 326
Liverpool, New York 13088

*This is not a complete listing of all such companies; neither does inclusion imply special approval, nor does omission imply disapproval of a company.

EQUIPMENT LIST: 190 ELECTROMECHANICAL

Code No. Name of List

$122,731.00

Cost

20

Supporting Base

THIS EQUIPMENT LIST SHOULD BE REVIEWED WITHIN TWO YEARS AFTER ITS EFFECTIVE DATE.

NEW LIST [ ]

REVISED LIST [X] Please destroy cover ages_____ dated___________.

Replace with cover and pages attached.

DEPARTMENT OF COMMUNITY COLLEGES

PROGRAM DEVELOPMENT

Date: June, 1976

COMMITTEE

Thomas B. Hardison	Catawba Valley Technical Institute
Foy Willson	Lenoir Community College
Kincheon H. Bailey	Wake Technical Institute
James Gaudreault	Central Piedmont Community College
Frank A. Gourley, Jr.	Department of Community Colleges
Otto Blumenstine	Catawba Valley Technical Institute

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Code No.	Name of List	

ITEM NO.	QUANTITY	DESCRIPTION	COST OF ITEM	TOTAL
A. Servomechanisms				
1.	1	Mechanical Kit, Type 1000 Automat or PIC, or equivalent.	785.00	785.00
2.	2	Motor Kit, Type 4-12 Automat, or PIC, or equivalent.	95.00	190.00
3.	1	Servomechanism Kit Servomotors (AC/DC) Synchros - central Transformer Potentiometer (multiturn) Tachometer generator, or equivalent.	1000.00	1000.00
B. Computer Teaching Systems				
4.	2	Dataflow Wall Charts IBM, List #42 for 1401, or equivalent.	95.00	190.00
5.	1	Dynamic Timer, IBM, List #14 for 1401, or equivalent.	100.00	100.00
6.	1	Computer (IBM 1401), or equivalent.		
7.	1	Fludic Logic Trainer Eastman - Fludic Circuit Panel, or equivalent.	700.00	700.00
8.	1	Analog Computer Trainer EAITR-20 or equivalent	4500.00	4500.00
C. Mechanical				
9. Surplus:	--	Input Output Devices Coffee/Coin Machines Automatic Washers Desk Calaulators Juke Box, Record Changers Cash Registers Automative Sub-systems Gun Directors	(as required)	1000.00

ITEM NO.	QUANTITY	DESCRIPTION	COST OF ITEM	TOTAL
Instruments				
10.	1	Strip-Chart Recorder Hewlett Packard 7000 series, or equivalent.	3,000.00	3,000.00
11.	1	Cart for Oscilloscope, or equivalent.	150.00	150.00
12.	1	Polaroid Camera w/scope attachment, or equivalent.	250.00	250.00
13.	1	Microscope-Stereoptic w/zoom attachment, B & L, or equivalent.	450.00	450.00
14.	1	Micrometer X-Y table for microscope, or equivalent.	125.00	125.00
15.		Transducers: a. Pressure b. Force c. Motion	(as required)	1,000.00
16.		Force Gauges, Torque Gauges, etc., or equivalent.	(as required)	1,000.00

17. Commercial Equipment 5,000.00

A. Systems

1. Industrial Controllers
2. Conveyor
3. Pneumatic
4. Cleaning

B. Components

1. Relays
2. Solenoid - valves
3. Regulators
4. Actuators - Hydraulic/Pneumatic
5. Clutches
6. Cams
7. Storage Devices/Counters
8. Switches, steppers
9. Amplyfiers: Differential, Operational

NOTE: Each school should select systems and components based upon the local industrial needs.

ITEM NO.	QUANTITY	DESCRIPTION	COST OF ITEM	TOTAL
Tools, etc.				
18.		Miscellaneous Hand Tools	500.00	500.00
19.		Measuring Tools a. Micrometer b. Calipers c. Feeler Gages d. etc.	750.00	750.00
20.		Special Hand Tools a. Power screw drivers b. Pneumatic wire wrap	750.00	750.00
Mockups				
21.	1	1402 Punch Unit	225.00	225.00
22.	1	1403 Print Chain Circular Slide Rule	200.00	200.00
23.	1	1403 Printer Slide Rule	175.00	175.00
Shop Equipment				
Metal				
24.	1	Brake - 3'	100.00	100.00
25.	1	Shear - 3'	100.00	100.00
26.	1	Drill Press	125.00	125.00
27.	1	Vise - 6"	45.00	45.00
28.	1	Bench Grinder	50.00	50.00
29.	10	Vise Portable	15.00	150.00
30.	1	Tap and Die Set (Pipe & Screw Sets)	700.00	700.00
31.	1	8" Maximat Lathe	850.00	850.00
32.	1	Greenlee Punch Set (Round & Square)	100.00	100.00
33.	1	Nibler	25.00	25.00

ITEM NO.	QUANTITY	DESCRIPTION	COST OF ITEM	TOTAL
34.	1	Copper Tube Tools	25.00	25.00
35.	1	Band Saw, small	400.00	400.00
36.	1	Acetylene Torch	125.00	125.00
Wood and Plastic				
37.	1	Radial Table Saw w/attachments	400.00	400.00
38.	1	Belt Sander	200.00	200.00
39.		Power Sources	3,000.00	3,000.00
		a. Special AC (as required)		
		b. DC (as required)		
		1. Rotating (High Current)		
		2. Electronic		
		c. Pneumatic Compressor w/Air Cleaners, Filters and Oilers		
		d. Hydraulic		
Special Purpose Equipment				
40.	1	Computer Service Equipment	1,500.00	1,500.00
41.	1	Vacuum Technology Equipment roughing and diffusion pumps, gauges, peripheral equipment.	2,000.00	2,000.00
42.	1	Sound level measurement equipment.	5,000.00	5,000.00
43.	1	Servomechanism Kits	15,000.00	15,000.00
44.	1	Desk calculator, programmable	2,000.00	2,000.00

ITEM NO.	QUANTITY	DESCRIPTION	COST OF ITEM	TOTAL
Furniture				
45.	1	Desk, Workbenches, Storage Cabinets and Stools (See appropriate catalogs)		5,000.00
46.	1	Hydraulic/Pneumatic Set-up Tables (See Hydraulics and Pneumatics, Equipment List No. 98)		6,000.00
47.	2	Electromechanical Training Console	6,850.00	13,700.00
48.	2	Compressor Kit (price included in console)	--	--
49.	2	Electro-Hydraulic Servo Valve	650.00	1,300.00
50.	2	Basic Hydraulic Package	1,200.00	2,400.00
51.	2	Rotary Motor	965.00	1,930.00
52.	2	Rotary Loading Package	325.00	650.00
53.	2	Pressure Transducer Assembly	860.00	1,720.00
54.	2	Force Transducer Assembly	1,130.00	2,260.00
55.	2	Flow Transducer Assembly	1,250.00	2,500.00
56.	2	Instrumentation Amplifier	320.00	640.00
57.	4	Linear Actuator Assembly	655.00	2,620.00
58.	4	Linear Loading Package	400.00	1,600.00
59.	2	Transducer Readout Panel	350.00	700.00
60.	2	Fluidic Logic Trainer	1,095.00	2,190.00
61.	2	Pneumatic Trainer	980.00	1,960.00

ITEM NO.	QUANTITY	DESCRIPTION	COST OF ITEM	TOTAL
62.	2	Electric to Pneumatic Interface Package	150.00	300.00
63.	4	DC Servo Controller	635.00	2,540.00
64.	4	Gear Train with Digital Encoder	500.00	2,000.00
65.	2	Digital Logic Trainer	1,195.00	2,390.00
66.	2	Electrical Control Package	350.00	700.00
67.	2	Digital to Analog Converter	195.00	390.00
68.	3	Process Control Simulator	1,595.00	4,785.00
69.	1	Programmable read only memory (PROM) Programmer Featuring: Program, list, duplicate, and verify operation modes. Program capacity of 4096 and 8-bit words Hexadecimal Keyboard (0-9, A-F) Hexadecimal address and data display. Quick-load, zero insertion force, PROM sockets. Packaged in high-impact plastic carrying case. 117 VAC 60 Hz. power requirements. Ultraviolet lamp erase capability. Computer interface (8-bit parallel data transfer capability). Teletype interface for ASR 33 teletypewriter. PROM Programming Modules for Intel. 1702A, 9702, 2704, 2708, 3604.	2,000.00	2,000.00
70.	7	Microprocessor Design System Containing the Following: Front panel with provision for control and	500.00	3,500.00

ITEM NO.	QUANTITY	DESCRIPTION	COST OF ITEM	TOTAL
		monitoring of microprocessor functions, data switch input and display, display of status and interrupt signals, and single-step execution of programs. Asynchronous control card allowing microprocessor operation with teletype terminals and modems using ELA RS 232C standard interface 20 MA. current loops. Central processing card using Intel 8080 microprocessor integrated circuit containing all necessary signal buffering, gating, and clocking control. Interface board providing signal and power buses and two solderless breadboarding sockets for interface circuitry. Memory card containing up to 4K of static read/write memory and 1K of ultraviolet-erasable prom memory.		
71.	7	Microprocessor Outboard Circuits consisting of one each of the following: Power outboard Logic switch outboard 7-segment display with decoder/driver Clock outboard Led lamp monitor outboard, Dual lamp monitor outboard Programmable timer/counter outboard Universal outboard Driver/inverter/NOR (DIN) Outboard Pulse generator	315.00	2,205.00

ITEM NO.	QUANTITY	DESCRIPTION	COST OF ITEM	TOTAL
		Variable power supply (3-14v) outboard Monstable outboard Kluge card outboard Line driver/receiver and TTL/RS232C interface outboard TTL/20MA current loop inter-face outboard BCD decode counter/4 bit binary counter Latch outboard Decoder outboard Multiplexer outboard Universal asynchronous receiver/transmitter UART outboard		
		Microprocessor Accessories consisting of one each of the following items:		
72.	7	Tools and I.C. Sockets Xcelite 72CG 5-inch chain nose pliers Xcelite R184 screwdriver (4-inch blade; 1/8" lip width.) Xcelite 101-S wire stripper/cutter No. 22 gauge insulated wire (100 ft., red; 100 ft. black) 14-pin I.C. Sockets 16-pin I. C. Sockets 24-pin I. C. sockets	27.50	192.50
73.	7	Components - Electrical: Resistors (1/2 watt, 5% carbon film) 20 each 1000 ohms 8 each 100, 150, 220, 330, and 470 ohms 3 each 1500, 2200, 3300, 4700, 10K, 22K, 33K, 47K, 100K, 220K, 470K, 1M and 10M ohms. Capacitors 2 each 100 PF, 220 PF 470PF, 0.001UF 0.002UF, 0.005UF, 0.10UF, and	23.00	161.00

ITEM NO.	QUANTITY	DESCRIPTION	COST OF ITEM	TOTAL
		0.33UF ceramic disc. 2 each 1.0UF, 4.7UF 10UF, and 47UF, electrolytic Light-Emitting diodes (LEDS), with specification sheets 6 each red National NSL-5023 One seven-segment LED display Opcoa SLA-1 One Litronix Data Lit 704 display		
74.	7	Components - Integrated Circuits IS-AP3	155.00	1085.00
75.	7	Integrated Circuit Labels, approximately 500 individual adhesive-backed; for series 7400 TTL Integrated Circuits. (IS-SW3).	6.50	45.50

EQUIPMENT LIST: 101 INSTRUMENTATION

Code No. Name of List

See Last Page

Cost

20

Supporting Base

THIS EQUIPMENT LIST SHOULD BE REVIEWED WITHIN TWO YEARS AFTER ITS EFFECTIVE DATE.

NEW LIST ☐

REVISED LIST ☐ Please destroy cover and pages_____ dated__________.

Replace with cover and pages attached.

DEPARTMENT OF COMMUNITY COLLEGES

PROGRAM DEVELOPMENT

Date: January, 1977

COMMITTEE

R. L. Pearson	Riegel Paper Company
W. N. Allen	Hercules, Inc.
Barney Melton	Carolina Nitrogen Corp.
Franham Caney	E. I. DuPont de Nemours,
Karl Cleveland	General Electric Co.
William H. Coleman	Cape Fear Technical Institute
Foy Willson	Lenoir Community College
Frank A. Gourley, Jr.	Department of Community Colleges

EQUIPMENT LIST: 101 INSTRUMENTATION

Code No. Name of List

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
1	2	Calibrator, Electronic Consotrol 0-24 ma. to 0-60 ma. Foxboro Model 8121 N-118-FP, or equivalent.	445.00	890.00
2	2	Pneumatic to current converter input 3-15 psi, output 10-50 ma. Foxboro Model 66FR-2, or equivalent.	215.00	430.00
3	2	Voltage to current converter input 0-5 V.D.C., output 10-50 ma. Foxboro Model 66 GR-OW, or equivalent.	265.00	530.00
4	2	Receiver Recorder, Electronic consotrol, Foxboro Model 6410HF, or equivalent.	290.00	580.00
5	2	Case Recorder, Model 40 R-31C, Foxboro, or equivalent.	110.00	220.00
6	2	Receiving Element for Model 40R. PC 3-15 Foxboro, or equivalent.	85.00	170.00
7	2	Bellows for Model 40R 0-100 in. W.C., Foxboro Model PB-CC, or equivalent.	85.00	170.00

*Indicates the minimum items required for this list to furnish basic austere support.

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
8	2	Indicating Receiver Controller 0-100 scale, 3-15 psi input, Foxboro Model 52A SP4, or equivalent.	410.00	820.00
9	2	Current to Air Transducer 50 ma. to 3-15 psi, Foxboro Model 69 TA-1, or equivalent.	130.00	260.00
10	1	Electronic Differential Pressure Cell. Input 20-205 in. range, 10-50 ma. signal 100 diff., Foxboro Model 6[illegible]3 DM, or equivalent.	485.00	485.00
11	1	Pneumatic Differential Pressure Cell, input 20-205", Foxboro Model 13 A 1, or equivalent.	280.00	280.00
12	6	Combination Filter-Regulator 5-35 psi, 1/4" pipe. Fisher 67 FR, or equivalent.	17.00	102.00
13	2	Dial Thermometer, 50-500° F Weston No. 19385-3, or equivalent.	8.50	17.00
14	1	Pneumatic Temperature Transmitter. Bulb diam. 3/8", sensitive length 6", 3-15 psi output, 100°F span, 3 1/2' tubing Foxboro Model 12 A, or equivalent.	255.00	255.00
15	1	Oil bath "Magni-Whirl" Model MW-1145 A Blue M. Electric Co., or equivalent.	450.00	450.00

101	INSTRUMENTATION	Page 3
Code No.	Name of List	

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
16	1	Tech Trainer D-1 Master Demonstrator or equivalent. Tech Trainer Corp., Chattanoga, Tenn.	636.00	636.00
17	10	Student panel Racks Tech Trainer Model D2, or equivalent.	219.00	2,190.00
18	10	Complete experiment module for student panel Rack. Tech-Trainer "M" series.	4,000.00	44,000.00
19	4	Pneumatic Hand Calibrator, 0-18 psi, Taylor 44 S 390, or equivalent.	50.00	200.00
20	4	Pneumatic Hand Calibrator, 0-160" of water column, Taylor 44 S 369, or equivalent.	50.00	200.00
21	2	Dead weight tester, 0-1000 psi Ashcroft, or equivalent.	260.00	520.00
22	10	Pressure test gauge, 3" diam., 0-30 psi, 0.5% accuracy. U.S. Gauge Figure 1408, or equivalent.	37.00	370.00
23	1	Pressure test gauge 8 1/2" dial. 0-30 psi, 1/4" bottom connector, 0.25% accuracy, U.S. Gauge Figure 1400T, or equivalent.	115.00	115.00

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
24	2	Portable Potentiometer Indicator, Dual range, 0-30 mv. and 0-60 mv. Foxboro, or equivalent.	250.00	500.00
25	1	Foxboro Pneumatic Temperature Transmitter Model: 45, or equivalent.	243.00	243.00
26	1	Foxboro EMF to Current Converter Model: 693AT-0 Input Signal: 2 to 60 mv. Output Signal: 10 to 50 ma d-c into 100 to 700 ohms	420.00	420.00
27	1	Foxboro Frequency to Current Converter Model: FR-316-2 Calibration: To Foxboro 1-81F5C2 Turbine Meter Flow Range: 3.50 to 50.0 GPM Output: 10 to 50 ma d-c into 100 to 600 ohms	470.00	470.00
28	2	Foxboro Consotrol Controller Model: 62H-4E (Proportional and reset) Instrument Connection: 10 Conductor Cable (Reference H-11-A3), or equivalent.	510.00	1,020.00
29	1	Foxboro Electronic Consotrol Alarm Model: 63R-0A High Alarm Part No.: No-152-KA, or equivalent.	50.00	50.00

101	INSTRUMENTATION	Page 5
Code No.	Name of List	

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
30	1	Foxboro Square Root Extractor, Model: 557, or equivalent.	170.00	170.00
31	2	Foxboro Control Valve Type: Single seat, top and bottom guided End Connections: Wide range V-port, C.I. body, S.S. trim Actuator: P-25 Size: 1-inch, CV equals 10.1, or equivalent.	160.00 ea.	320.00
32	1	Foxboro Power Supply for Force Balance Transmitter Model: 610-AT-0, or equivalent.	70.00	70.00
33	2	Foxboro Receiver Elements for Recorder Receiver: Model: 4 OR Serial No. 1923662 Type: PC 3-15, or equivalent.	85.00	170.00
34	5	Pressure test Gauge, 4 1/2" Dial 0-100 psi, 1/4" bottom connector U.S. Gauge, Figure 5000, or equivalent.	75.00	375.00
35	2	Pressure switch United Electric, or equivalent.	25.00	50.00
36	2	Turbine Flow Meter 1" Foxboro Model 81F Series or equivalent.	405.00	810.00
37	1	Multi function, voltage current and resistance meter, Hewlett Packard Model 427A, or equivalent.	275.00	275.00

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
38	1	Air Dryer and Separator Van-Air Model D8, or equivalent.	260.00	260.00
39	1	Fluid Manometer Mariam Model 33KA35-2 0-100" or equivalent.	200.00	200.00
40	5	Mercury Manometer Meriam Model 33KB35-2, or equivalent.	150.00	750.00
41	2	Industrial Electronics Motor Control Demonstrator Hickok Model HM-5, or equivalent.	1,200.00	2,400.00
42	10	Vaccum Tube Voltmeter Heath Kit Model 1M-13W or equivalent.	40.00	400.00
43	10	Power supplies Hickok Model PS505, or equivalent.	250.00	2,500.00
44	5	Oscilloscope, Tektronic 561, or equivalent.	450.00	2,250.00
45	8	Plug in units for above Scopes, or equivalent.	200.00	1,600.00
46	2	Foxboro Electronic Consotrol Resistance-to-Current Converter Model: 694A Curve: NR 226, or equivalent.	387.00	774.00
47	2	Dynatherm Resistance Bulb Foxboro Model DB-13N-26W, or equivalent.	52.50	105.00

101	INSTRUMENTATION	Page 7
Code No.	Name of List	

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
48	1	Mechanics chest proto #9965, or equivalent.	17.62	17.62
49	2	Vaccum Pump Kinney Model KC-2, or equivalent.	200.00	400.00
50	2	Digital Volt meter Simpson Model 2700-A, or equivalent.	625.00	1,250.00
51	2	Centrifugal Pumps, or equivalent.	500.00	1,000.00
52		Pipe and fittings, surplus, or equivalent.	250.00	250.00
53	10	Transistor Circuit Analyzer, Hickok Model H-3C, or equivalent.	200.00	2,000.00
54	2	Consotrol Alarm Foxboro Model 63S, or equivalent.	175.00	250.00
55	2	Alarm Foxboro Model 63R, or equivalent.	80.00	160.00
56	2	Dynalog-Controller Foxboro Model 40 with M/40 pneumatic controller Assembly, or equivalent.	200.00	400.00
57	2	Electronic Power Supply Taylor 799NW00035 24V - 6 amps., or equivalent.	280.00	560.00
58	2	Computing Relay Taylor 106NF1151, or equivalent.	200.00	400.00
59	10	Audio Oscillators Hewlett-Packard 200 AB, or equivalent.	225.00	2,250.00

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
60	2	Pneumatic Analog Computer Foxboro Model 556-8-30, or equivalent.	245.00	490.00
61	2	Electrical Insulation Tester Biddle No. 2120, or equivalent.	250.00	500.00
62	1	Indicating Process Controller, solid state, 3 mode Barber Coleman Model 541C, or equiv-alent.	435.00	435.00
63	10	Instrument Set, Foxboro F-101AA, or equivalent.	16.00	160.00
64	10	Pressure Gage Tool Set Aircraft, or equivalent.	17.00	170.00

*Indicates the minimum items required for this list to furnish basic austere support.

ADDENDUM

101 INSTRUMENTATION Page 9

Code No. Name of List

ITEM NO.	QUANTITY	DESCRIPTION	COST OF ITEM	TOTAL
65	5	Work Bench Cabinet Type	376.00	1504.00
66	1	Drill, 1/4" Universal, all insulated.	47.50	47.50
67	1	Drill 3/8" Heavy-duty variable speed.	70.00	70.00
68	1	Grinder, 7" 1/2Hp. 115-230 V.	98.00	98.00
69	1	Drill Press Variable speed, Bench Model 3/4 Hp., single phase with tilting table.	364.00	364.00
70	1	Drill Press Vise Jaw size: 3" x 3/4" Open jaws, 3"	27.50	27.50
71	1	Hardware Storage Cabinet.	257.00	257.00
72	2	High Speed Drill Sets 1/16 thru 1/2" by 1/64	52.10	104.20
73	1	Resistance to Voltage Converter (platinum) (dual)	440.00	440.00
74	1	Thermocouple to Voltage Converter, Dual Chomel- Alumel, Iron-Constantan	440.00	440.00
75	2	Current to Voltage Converter	200.00	400.00
76	2	Contact Input Isolator	72.00	144.00
77	2	Pulse Rate to Voltage Converter 0-50, 0-12, 800 PPS	620.00	1240.00

101	INSTRUMENTATION	Page 10
Code No.	Name of List	

ITEM NO.	QUANTITY	DESCRIPTION	COST OF ITEM	TOTAL
78	1	Current to Voltage Converter	200.00	200.00
79	1	Control Card & Module	44.00 345.00	44.00 345.00
80	1	Batch Control Card & Module	464.00	464.00
81	2	Dual Absolute Alarm with Module (Relay Type) 100 MA @ 28VDC	233.00	466.00
82	2	Deviation Alarm with Module 100 MA @28VDC	228.00	456.00
83	2	Sq. Rt. Extractor with Module	318.00	636.00
84	2	Integrator (Linear)	288.00	576.00
85	1	Multiplier-Divider	448.00	448.00
86	1	Summer	398.00	398.00
87	1	Signal Selectro	193.00	193.00
88	2	Realy Output CPCD with Module	110.00	220.00
89	1	Intergrator Power Driver Relay Type, with Module	66.00	66.00
90	2	Voltage to Current Converter (4-20MA)	230.00	460.00
91	1	Voltage to Current Converter (10-50MA)	230.00	230.00
92	2	Rack, Module	110.00	220.00
93	5	Nest	154.00	770.00
94	1	Power Supply	770.00	770.00
95	2	Cable	33.00	66.00

ADDENDUM

101 — Code No. | INSTRUMENTATION — Name of List | Page 11

ITEM NO.	QUANTITY	DESCRIPTION	COST OF ITEM	TOTAL
96	1	Card Extender	55.00	55.00
97	1	System Calibrator	2,200.00	2,200.00
98	1	Card Test Module	220.00	220.00
99	1	Control Station Simulator	220.00	220.00
100	1	Calibration Module (TC)	16.50	16.50
101	1	Voltage Divider 50 mv-5.5 Volt Span	16.50	16.50
102	1	Voltage Divider 5-400 Volt Span	16.50	16.50
103	1	Totalizing Impulse Counter.	55.00	55.00
104	1	Recorder	655.00	655.00
105	1	Display, Remote	420.00	420.00
106	1	Shelf	122.00	122.00
107	1	Temperature Bath	1,000.00	1,000.00
108	1	Trainer Module	555.00	555.00
109	1	Refrigerated Bath	650.00	650.00
110	1	Battery Pack	200.00	200.00
111	1	RLC Bridge	800.00	800.00
112	1	Thermocouple Readout Meter	350.00	350.00
113	1	Reference Junction	475.00	475.00
114	1	Instrument Rack	900.00	900.00
115	1	Pyrometer	150.00	150.00

$102,005.00
NEW TOTAL COST

APPROVED: May, 1975

CURRICULUM GUIDELINES

STATE BOARD OF EDUCATION

DEPARTMENT OF COMMUNITY COLLEGES

CURRICULUM GUIDELINES

FOR

CURRICULUM T-045 (Code) Electronics (Title)

DATE SUBMITTED January, 1977

STATE PRESIDENT ______________________ ____________ Date

STATE BOARD CHAIRMAN ______________________ ____________ Date

AWARD APPROVALS:

Technical Curriculum	AAS Degree	(x)
Technical Specialty	Diploma	( )
Technical Specialty	Certificate	( )
Vocational	Diploma	( )
Vocational Specialty	Certificate	( )

PROPOSED EMPLOYMENT JOB OPPORTUNITIES - D.O.T.

Electronics

Entry Level Positions:

Title	D.O.T. No.
Electronic Technician	003.181
Electronic Engineering Aide	003.181
Communications Technician	003.181
Electronic Maintenance Supervisor	003.168
Electronic Engineering Technician	003.181

Advanced Level Positions:

Field Engineer	829.281
Technical Sales Representative	828.251
Technical Writer	139.288
Customer-Engineering Specialist	828.281
Research-Test Technician	003.281

CURRICULUM REQUIREMENTS

ELECTRONICS

Subject Area	Technical	Technical Specialty	Vocational	Vocational Specialty	
	Range of Hours				
	Credit	Credit	Credit	Credit	Contact
Technical	54-69				
Electrical Fundamentals	12-16				
Electronic Fundamentals	14-17				
Specialized Electronic Circuits	5-12				
Digital Electronics	0-5				
Electronic Systems	7-19				
Electronics Design	2-3				
Electives	4-6				
Related	31-36				
Drafting	4				
Technical Math	15-20				
Technical Physics	12				
General Education	18				
English	12				
Social Science	6				
Total	108-118				
Cooperative Education/Internship	0-12				

STATE BOARD OF EDUCATION

DEPARTMENT OF COMMUNITY COLLEGES

CURRICULUM GUIDELINES

FOR

CURRICULUM T-044 (Code) Electrical (Title)

DATE SUBMITTED January, 1977

STATE PRESIDENT ______________________ ________ Date

STATE BOARD CHAIRMAN ______________________ ________ Date

AWARD APPROVALS:

Technical Curriculum	AAS Degree	(x)
Technical Specialty	Diploma	( )
Technical Specialty	Certificate	( )
Vocational	Diploma	( )
Vocational Specialty	Certificate	( )

PROPOSED EMPLOYMENT JOB OPPORTUNITIES - D.O.T.
Electrical

Entry Level Positions:

Title	D.O.T. No.
Electrical Technician	003.181
Communications Technican	003.181
Electrical Draftsman	003.281
Illumination Technician	003.187

Advanced Level Positions:

Electrical Contractor	182.168
Electrical Estimator	003.281
Manufacturers' Service Representative	638.281
Powerhouse Load Dispatcher ,	003.187
Technical Writer	139.288

CURRICULUM REQUIREMENTS
ELECTRICAL

Subject Area	Technical	Technical Specialty	Vocational	Vocational Specialty	
	Range of Hours				
	Credit	Credit	Credit	Credit	Contact
Technical	54-70				
Electrical Fundamentals	12-16				
Electronic Fundamentals	10-17				
Electrical Machines	6-8				
Electrical Controls and Circuits	4-11				
Electrical Systems	4-11				
Electrical Design	3-6				
Electives	6-8				
Related	31-36				
Drafting	4				
Technical Math (including concepts of analytical geometry and calculus)	15-20				
Technical Physics (including mechanics, light and sound)	12				
General Education	18				
English	12				
Social Science	6				
Total	108-118				
Cooperative Education/Internship	0-12				

STATE BOARD OF EDUCATION

DEPARTMENT OF COMMUNITY COLLEGES

CURRICULUM GUIDELINES

FOR

CURRICULUM T-039 (Code) Electromechanical (Title)

DATE SUBMITTED January, 1977

STATE PRESIDENT ______________________ ______________ Date

STATE BOARD CHAIRMAN ______________________ ______________ Date

AWARD APPROVALS:

Technical Curriculum	AAS Degree	(x)
Technical Specialty	Diploma	( )
Technical Specialty	Certificate	( )
Vocational	Diploma	( )
Vocational Specialty	Certificate	( )

PROPOSED EMPLOYMENT JOB OPPORTUNITIES - D.O.T.

Entry Level Positions: Electromechanical

Title	D.O.T. No.
Electronic Mechanic	828.281
Electromechanical Technician	710.281
Automated Process Electronics Technician	728.281
Electromechanical Inspector	710.381
Electromechanisms Design Draftsman	017.281

Advanced Level Positions:

Test Equipment Development Technician	003.181
Customer-Engineering Specialist	828.281
Field Engineer	829.281

CURRICULUM REQUIREMENTS
Electromechanical

Subject Area	Technical	Technical Specialty	Vocational	Vocational Specialty	
	Range of Hours				
	Credit	Credit	Credit	Credit	Contact
Technical	61-77				
Electrical Fundamentals	12-16				
Electronic Fundamentals	10-17				
Specialized Electronic Circuits	0-3				
Digital Electronics	3-10				
Specialized Electronic Systems	0-5				
Electromechanical	10-20				
Mechanical	10-12				
Electives	3-8				
Related	31				
Drafting	4				
Technical Math	15				
Technical Physics	12				
General Education	18				
English	12				
Social Science	6				
Total	108-118				
Cooperative Education/Internship	0-12				

STATE BOARD OF EDUCATION

DEPARTMENT OF COMMUNITY COLLEGES

CURRICULUM GUIDELINES

FOR

CURRICULUM T-048 (Code) Instrumentation (Title)

DATE SUBMITTED January, 1977

STATE PRESIDENT ______________________ ____________ Date

STATE BOARD CHAIRMAN ______________________ ____________ Date

AWARD APPROVALS:

Technical Curriculum	AAS Degree	(x)
Technical Specialty	Diploma	( )
Technical Specialty	Certificate	( )
Vocational	Diploma	( )
Vocational Specialty	Certificate	( )

PROPOSED EMPLOYMENT JOB OPPORTUNITIES - D.O.T.

Instrumentation

Entry Level Positions:

Title	D.O.T. No.
Electronic Mechanic	828.281
Instrument Mechanic	710.281
Instrumentation Technician	003.281

Advanced Level Positions:

Development - Instrumentation Technician	003.181
Systems - Testing - Laboratory Technician	003.181

CURRICULUM REQUIREMENTS
Instrumentation

Subject Area	Technical	Technical Specialty	Vocational	Vocational Specialty
	Range of Hours			
	Credit	Credit	Credit	Credit	Contact
<u>Technical</u>	59-69				
Electrical Fundamentals	12-16				
Electronic Fundamentals	10-17				
Specialized Electronic Circuits	0-5				
Digital Electronics	0-5				
Instrumentation	16-20				
Chemistry	6-8				
Electives	4-9				
<u>Related</u>	31-36				
Drafting	4				
Technical Math	15-20				
Technical Physics	12				
<u>General Education</u>	18				
English	12				
Social Science	6				
Total	108-120				
Cooperative Education/Internship	0-12				