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ABSTRACT

The purpose of the Laser/Electro-Optics Technology (LEOT) Project was to establish a pilot educational program, develop a flexible curriculum, prepare and test instructional materials, transport the curriculum and instructional materials into other educational institutions by establishing relevant LEOT programs wherever they are needed, and to assure that faculties in these schools provide students with requisite knowledge and skills to prepare technicians for useful employment in this field. The curriculum which was developed is intended for use by two-year postsecondary technical institutions. The educational philosophy which was adopted focused on laboratory learning, i.e., teaching principles by doing things with your hands (as opposed to theory lectures or training in simple manipulations or procedures). The report begins by describing the project objectives and detailing the degree and manner in which these objectives were accomplished. All end products of the project are briefly described (curriculum outlines, instructional materials, support documents, and career counseling guides). There is discussion of the roles of the Industrial Advisory Committee, the Evaluation Team, and the Institutional Pilot Program. Following this is a short description of dissemination activities. (Author)

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FINAL REPORT

Project No. 8-0491
Grant No. OEG-8-080491-4701 (085)

DEVELOPMENT OF GENERALIZABLE EDUCATIONAL PROGRAMS IN LASER/ELECTRO-OPTICS TECHNOLOGY

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U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

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FOREWORD

In response to the needs of the laser and electro-optics industries, a curriculum has been designed and instructional materials have been developed which are being used by two-year post-secondary technical institutions throughout the nation to prepare men and women to work in these emerging technologies. The instructional materials are also being used in industries, institutions and government agencies for retraining existing employees who are entering this field.

The adaptability of these materials to a wide variety of educational environments (at postsecondary institutions as well as employer plants), is due to the curriculum learning objectives being performance based and the instructional materials being prepared in relatively independent, modular units.

This project effort was directed at a completely new educational field. Prior to the initiation of this project, no organized educational programs existed for preparing laser/electro-optical technicians. The program procedures, the modular format and the dissemination activities for this highly successful research activity can serve as a model for future curriculum development programs intended to serve a national need.

Roy W. Dugger
Principal Investigator

ACKNOWLEDGEMENTS

The Laser/Electro Optics Technology Project has involved many people, institutions, industries, and organizations over a five year period. Any attempt to classify their contributions as major or minor would be inappropriate.

In terms of continued support and encouragement for the project, credit must be given to Dr. Walter J. Brooking and others of the U. S. Office of Education staff who provided valuable assistance at many points. Key TERC personnel who contributed to the project were Mr. C. B. Doss, former Project Manager, and Dr. Anthony V. DaMommio, Program Specialist. President Maurice W. Roney of Texas State Technical Institute and the chairman of its Laser Department, Dr. John D. Pierson provided the facilities for the Pilot Program and the technical expertise for the development of curriculum and instructional materials.

Program guidance and content were provided by the Evaluation Team and the Industrial Advisory Committee. Among these groups were three gentlemen to whom this program owes much:

Dr. Arthur H. Guenther, Chief Scientist, Air Force Weapons Laboratory
Dr. Leno S. Pedrotti, Chairman, Physics Department, Air Force Institute of Technology
Mr. John Ready, Honeywell Research Laboratories

Daniel M. Hull
Project Manager

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I. INTRODUCTION

A very rapid growth of the Laser/Electro-Optics industry has been experienced within the past decade. Since the discovery of the first laser in 1960, teams of scientists and engineers throughout the country have emerged to develop new and better lasers and have found useful applications for lasers and electro-optical devices. Today, lasers are used extensively in medicine, construction, materials processing, testing and measurements, in military and space systems, and in laboratories to aid in sophisticated research activities such as inducing controlled nuclear fusion.

Although an abundant supply of scientists and engineers is available to predict new laser materials, techniques and applications, there is a shortage of trained manpower to test these ideas. For over a decade, industry has had increasing need for laboratory and field technicians that can implement experimental setups, understand safety precautions as they relate to eye and skin hazards, procure and maintain components, and operate and troubleshoot laser and electro-optical systems. During this period, industry has had to select electronic engineers and technicians and provide "on the job training" to develop laser and electro-optical technicians. For the most part. this approach has met with only limited success -- these "converted techs" usually do not have the fundamentals in lasers and optics and they require years to become familiar with the wide variety of materials, components and special techniques used in the field. This problem is compounded by the lack of instructional materials in lasers and electro-optics that are of a practical nature rather than theoretical treatise.

The purpose of the Laser/Electro-Optics Technology (LEOT) Project was to establish a pilot educational program, develop a flexible curriculum, prepare and test instructional materials, transport the curriculum and instructional materials into other educational institutions by establishing relevant LEOT programs wherever they are needed throughout the nation, and to assure that faculties in these schools provide students with requisite knowledge and skills to prepare technicians for useful employment in this field. Occupational surveys, task analyses, course outlines, instructional materials, equipment lists, laboratory designs, and faculty and administrative support materials have all been completed. The curriculum which was developed is intended for use by two year post secondary technical institutions. The education philosophy which was adopted focussed upon "laboratory learning", i.e., teaching principles by doing things with your hands (as opposed to theory lectures or training in simple manipulations or procedures).

The pilot program established at Texas State Technical Institute, (TSTI) in Waco has been in operation over five years, with 69 students currently enrolled and 44 graduates, all employed with starting annual salaries ranging from $6,144 to $15,999. Laser/Electro-Optics educational programs using project materials are being conducted at six educational institutions throughout the country, and seven other institutions are planning to initiate programs in the near future. This includes a Spanish/Bilingual program at the TSTI campus in Harlingen, Texas. In addition, three industries and one professional society are using the instructional materials developed on this project for retraining and updating existing employees.

This report will begin by describing the project objectives and detailing the degree and manner in which these objectives were accomplished. All end products of the project will be described (curriculum, instructional materials, support documents, and counseling guides). The discussion will then be directed toward the roles of the Advisory Committee, the Evaluation Team and the Institutional Pilot Program. Following this will be a description of dissemination activities and results.

The purpose of this report is to provide an account of the project activities to the granting agency and to other organizations involved in similar technical education research. A more appropriate document for the LEOT faculty and administrative planners is the LEOT Curriculum Guide which was developed on this project and is available from the Technical Education Research Centers. Other program support documents and the instructional modules can also be obtained from TERC.

II. PROGRAM OBJECTIVES

The specific program objectives as outlined in the grant proposal and the progress reports are listed below:

A. Perform an Occupational Analysis to quantitatively determine the major types and characteristics of employers of Electro-Optics Technicians and the job types and levels for technicians which are needed.

B. Perform a Task Analysis, determining from employers the knowledge and skill requirements and behavioral characteristics required for the different types or levels of Laser/Electro-Optics Technicians.

C. Curriculum Planning -- Utilizing the results of the Occupational Analysis and the Task Analysis, design the structure or outline of a generalizable educational program (probably two year, Associate Degree level) which will prepare technicians who will be broadly employable within the fields of Laser/Electro-Optics Technology.

D. Curriculum Development, Pilot Testing and Evaluation

1. Acquire facilities and equipment for Laser/Electro-Optis Laboratories to be used in the Pilot Instructional Program; provide teacher orientation for the instructional staff.

2. Develop, test, and evaluate instructional materials for a generalizable LEOT program. Translate the materials into Spanish for bilingual instructional programs.

3. Establish a pilot instructional program. Identify, select and test students.

4. Establish a system for continuous evaluation, throughout the development-program of procedures and end products.

5. Prepare documents to assist administrators, faculty and staff in program planning, curriculum identification, staff selection, implementation, facilities design and equipment selection.

6. Develop unified physics instructional materials for use in pre-technology programs.

E. Dissemination of Adapted LEOT Programs to Schools other than the Pilot Program.

1. Develop and implement a dissemination plan for transporting to other institutions the curriculum and instructional materials in Laser/Electro Optics Technology.

2. Produce a 10-12 minute motion picture film for recruiting high school students into Laser/Electro-Optics programs which are offered by their local institutions.

3. Develop, test and evaluate five Career Counseling Guides to enhance the effectiveness of communicating employment and training opportunities in new and emerging occupations such as Laser/Electro-Optics Technology.

4. Conduct training workshops for faculty and administrators who are interested in implementing an instructional program using some or all of the LEOT curriculum and instructional materials.

5. Provide instructional materials and consultant services in program planning and implementation for schools who are considering programs using LEOT materials.

III. PROGRAM ACCOMPLISHMENTS

The program was originally conceived as Electro-Optics Technology. In the Occupational Analysis a survey was attempted of over seven hundred employers of electro-optics technicians in thirteen major cities, to determine the job categories, applications, level of employee and projected numbers of job openings over a decade. The results of this survey were extremely difficult to analyze and generalize because of the low percentage of responses and wide diversity of jobs. However, based upon the experience gained in this activity, several conclusions were reached:

1. The emphasis in the technology should be in the rapidly emerging area of Lasers; hence the transformation to Laser/ Electro-Optics Technology (LEOT).

2. The specifics of a Task Analysis leading to the evolvement of behavioral learning objectives should be obtained from a working Advisory Committee of industrial/institutional employers of LEO technicians.

The membership of the national LEOT Industrial Advisory Committee (IAC) was carefully selected to be broadly representative of the entire field, from component manufacturers, equipment manufacturers, research laboratories, defense and space establishments, applications oriented industries, and AEC laboratories. Priorities for selection were based on information obtained in the Occupational Analysis. The membership of the IAC and its very significant role in the entire research activity is described in Section VIII. This committee met in working sessions twice a year in 1971, 72, and 73, and was singularly the most important resource on the project. The only cost of this committee to the project was the member's travel expenses, and the employers of several members voluntarily paid this expense in addition to their regular salary -- thus, an example of the excellent industrial support for this project.

The first two meetings of the IAC were primarily concerned with the development of a generalized task analysis and the identification of the depth to which technical information was required of technicians. The IAC emphatically stated on many occasions that calculus and theoretical concepts in physics were neither required nor desired in preparation for technicians they hired. Initially, each IAC member provided a listing of the "ten most desirable skills of an effective Laser/Electro-Optic Technician". The composite list included the fifteen skills which follow:

1. Troubleshoots and repairs laser systems.

2. Performs tests and measurements using electronic devices.

3. Performs alignment procedures on optical systems, especially those which involve lasers and laser-related optics.

4. Prepares and reads shop drawings and schematics.

5. Maintains a laboratory notebook, performs data reduction, and prepares reports.

6. Operates interferometers, spectrometers, monochromators and spectrophotometers.

7. Operates laser systems, including intra-cavity modulation and Q-switching devices.

8. Utilizes basic laser and electrical safety practices in the laboratory.

9. Performs optical inspections and cleaning of optical components.

10. Operates and calibrates photodetectors, photomultipliers, optical power meters and calorimeters.

11. Processes photographic film and plates.

12. Produces and reconstructs holograms.

13. Selects laser and optical components based on optical, electronic and mechanical properties using manufacturers' catalogues and other trade publications.

14. Troubleshoots and repairs electro-optic devices.

15. Fabricates and assembles components for laser/electro-optic devices and systems.

The IAC further delineated this list into 156 tasks necessary for a technician to perform as a Laser Electro-Optics Technician. These 156 tasks were then rated by the IAC in relation to the importance of each task. Tasks with average ratings or higher were utilized in the formation of instructional courses. Because so many tasks received high ratings from the IAC a decision was made that certain groups of items should be taught within the core program. Otherwise, the number of tasks included within the LEOT program would have become too large. Specifically, the items related to shop practice and to electronics and instrumentation were included in the core.

The remaining tasks with high ratings were separated into groups of related items. These groups formed the basis for the development of courses in the LEOT Model Curriculum. This structuring led to the identification of ten courses for the LEOT program. When the content of courses had been identified, the learning objectives for each course were divided into a series of instructional modules. As a check, the original list of 156 tasks was compared with the behavioral objectives in the instructional modules to verify that the course content was valid.

At the onset of curriculum definition and development a six member Evaluation Team was established to provide continuous, unbiased evaluation of all aspects of program development. In addition to the Team Chief, the various members had specific responsibilities for the following areas: Industrial Employment, Curriculum Development, Technical Instruction, Tests/Measurement, and Counseling. The Team met quarterly for two years during the critical curriculum development period and contributed significantly to the structure and accountability of the development process and the use of behavioral learning objectives, explicitly stated at the beginning of each instructional module. The role of the Evaluation Team is described in detail in Section IX.

As the definition of content for the instructional modules began to evolve from the task analysis, the TERC staff designed the module format and wrote several instructional units for critique by the IAC, the Evaluation Team and the faculty in the pilot program at TSTI. Based upon the comments from these groups the module format was revised, and the content was changed in terms of depth of understanding, technical complexity and reading level.

Because of the large number of LEOT modules which were identified (99) and the technical complexity of the material was so specialized, the TERC Project Manager made a decision to maintain a minimal writing and editing staff and to contract the writing of module drafts to consultants who are "experts in the field". Prior to a writing agreement, the author was provided the list of measurable objectives for the module and an "Aid to Writers of Instructional Modules". This mode of operation proved to be much more efficient and yielded instructional materials which were relevant and extremely practical.

A flow chart, of the development procedure used for LEOT instructional modules is shown in Figure III-1. This type of record with an accompanying schedule was maintained on each module throughout the development phase. The following edits or tests were performed on each module.

- TERC Clerical Staff checks for typographical errors, grammar, and format.
- IAC members edit for job relevance and technical content.
- TERC staff works with Pilot Program faculty to verify the experimental procedure and equipment requirements.
- The Evaluation Team members review to determine reading level, prerequisites and whether behavioral objectives can be met with information in the discussion.
- Technical Edit Team edits for technical accuracy and consistency of symbols and units.
- Revised materials were Service Tested with students in the Pilot Program using pre and post tests to determine the effectiveness of the materials in conveying the learning objectives to the students. These results were reviewed by a member of the Evaluation Team. Language changes for better readability resulted from student criticism.

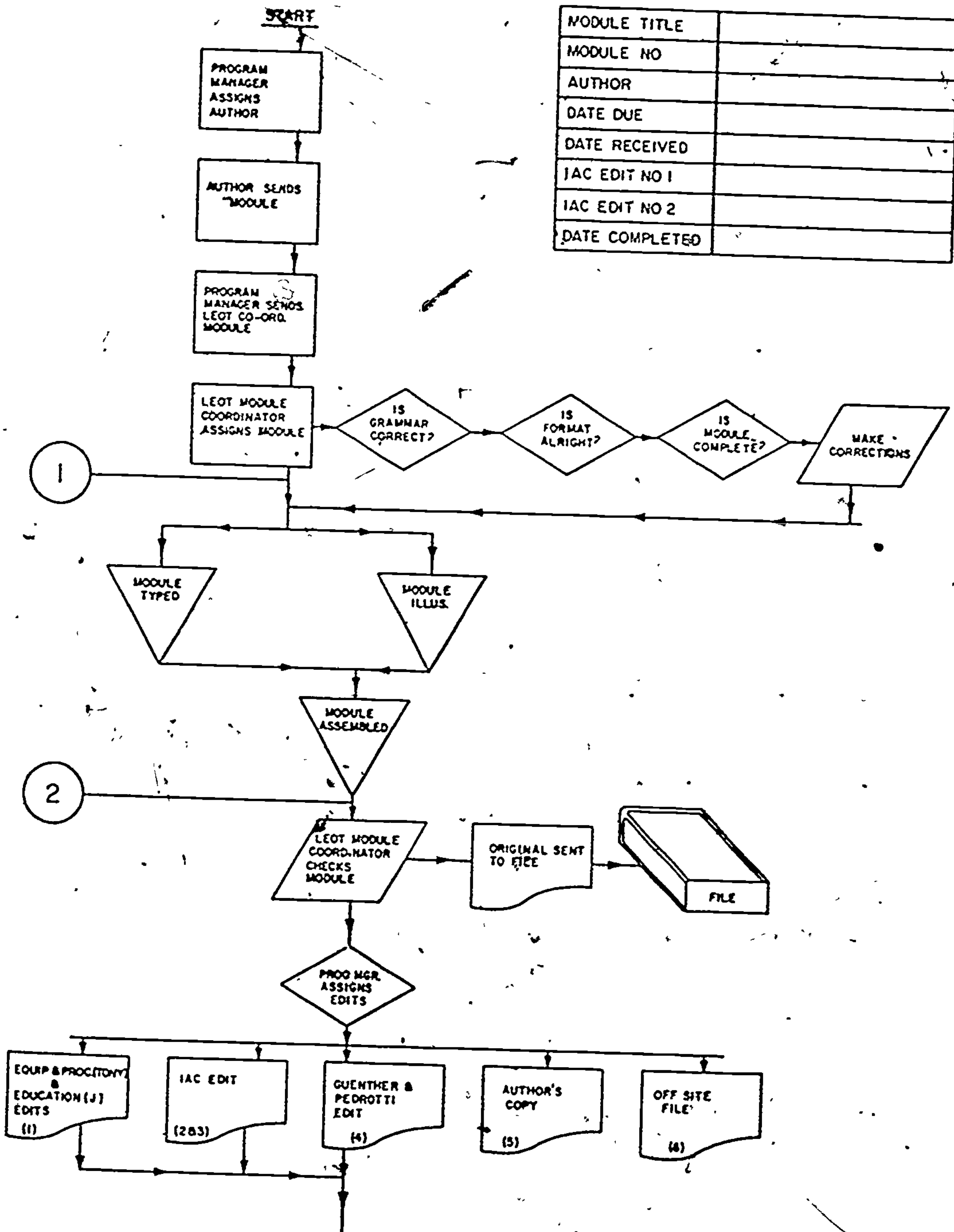
After careful examination of the LEOT course content, a decision was made to integrate the content of the physics instructional materials (for use in pre technology programs) into the LEOT modules, particularly those dealing with Introduction to Lasers, Geometrical Optics and Wave Optics. A copy of the Model Curriculum and a complete list of the Instructional Modules are presented in Sections IV and V. All instructional modules have been completed, edited, revised and tested.

Figure III-1

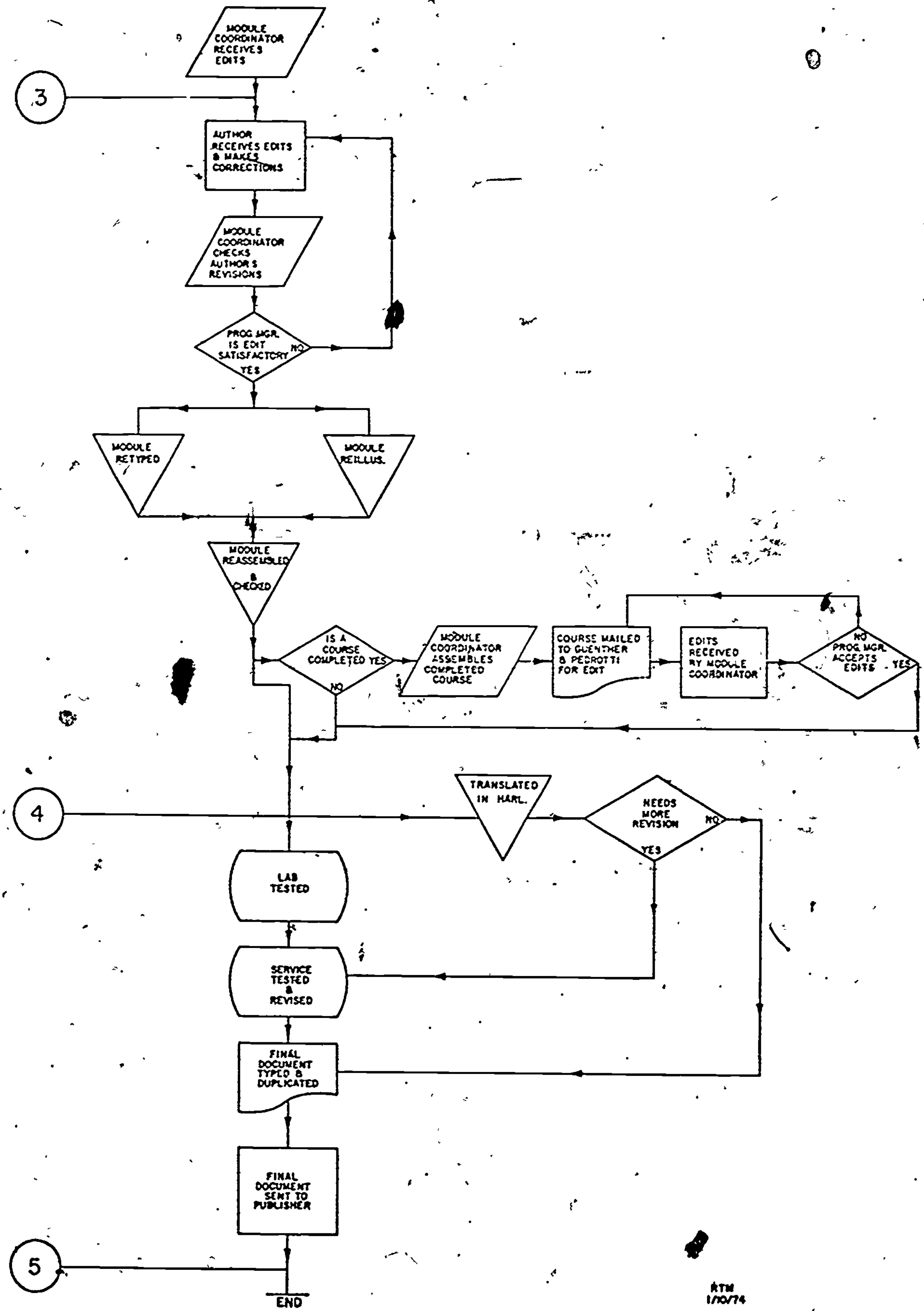
Flow Chart for

DEVELOPMENT PROCEDURE OF LEOT MODULES

MODULE TITLE	
MODULE NO	
AUTHOR	
DATE DUE	
DATE RECEIVED	
IAC EDIT NO 1	
IAC EDIT NO 2	
DATE COMPLETED	



15


MODULE COORDINATOR RECEIVES EDITS
3
AUTHOR RECEIVES EDITS & MAKES CORRECTIONS
MODULE COORDINATOR CHECKS AUTHOR'S REVISIONS
PROG MGR. IS EDIT SATISFACTORY
NO
YES
MODULE RETYPED
MODULE REILLUS.
MODULE REASSEMBLED & CHECKED
IS A COURSE COMPLETED
YES
NO
MODULE COORDINATOR ASSEMBLES COMPLETED COURSE
COURSE MAILED TO GUENTHER & PEDROTTI FOR EDIT
EDITS RECEIVED BY MODULE COORDINATOR
PROG MGR. ACCEPTS EDITS
NO
YES
4
TRANSLATED IN HARL.
NEEDS MORE REVISION
NO
YES
LAB TESTED
SERVICE TESTED & REVISED
FINAL DOCUMENT TYPED & DUPLICATED
FINAL DOCUMENT SENT TO PUBLISHER
5
END
RTM 1/10/74

Translation of completed modules into Spanish/Bilingual versions by specialists at the TSTI, Harlingen Campus began in 1973. The modules are translated as they are needed in the TSTI instructional program; to date, all modules in Courses #1, and 2, and most of the modules in Courses #3, 6 and 7, have been translated. By the end of 1975, all modules are expected to be translated.

To assist the administrators, faculty and staff of other institutions contemplating the implementation of LEOT programs, Program Planning Guides were prepared. These guides include:

1. LEOT Curriculum Guide

2. Career Opportunities in Lasers

3. LEOT Educational Equipment and Supplies

These documents are completed and have been used extensively to provide information in program planning, local employer needs survey, curriculum identification, staff selection, implementation, facilities design, safety considerations, and equipment selection. A more complete description of the Program Support Documents is provided in Section VI.

Five Career Counseling Guides were developed to enhance the effectiveness of communicating employment and training opportunities in new and emerging occupations such as Lasers/Electro-Optics Technology. Two of the guides are intended for use by high school counselors, two for students and one for parents of students who plan to enter a program in technical education. The titles of the guides are:

1. Counseling for Careers

2. Preparing for a Career

3. A Parents Guide to Technical Education

4. A Student Guide to Securing a Job

5. Career Counseling the Disadvantaged

All five guides have been written, tested, revised and evaluated. They are all extremely well received by high school counselors.

An effort was made to produce a 10-12 minute motion picture film for recruiting high school students into Laser/ Electro-Optics programs which are offered by their local institutions. After working on this film for over a year the company which was selected to prepare the film declared bankruptcy and ceased to operate. They returned unedited portions of the film to TERC, but since the contract called for payment upon receipt of a satisfactory version, no funds were disbursed for their effort.

Grant funds to complete the LEOT project were severely impacted due to inflated costs of materials and services. It was unlikely that sufficient funds or time were available to initiate another contract for a training film. Furthermore, upon being notified of the aforementioned circumstances, the Industrial Advisory Committee recommended that the recruiting film be given low priority compared to the instructional module development and the dissemination activities. Based on these circumstances and discussions with the USOE Project Officer the task to develop a recruiting film was dropped and funds were diverted to the dissemination activity.

Extensive dissemination efforts were active during the last eighteen months of the project. Interest in the program by schools was five times greater than had been anticipated, and Industry has become involved in using the instructional materials for retraining and updating existing employees. Details and results of the dissemination activity are included in Section XI.

IV. CURRICULUM

The Laser/Electro-Optics Technology (LEOT) instructional materials were developed to support an intensive two-year, full-time curriculum of post-secondary study. The model curriculum and adaptations which use it, are designed for maximum flexibility and the greatest possible use of existing classroom and laboratory-oriented courses in physics (optics) electronics, mechanics, drafting instrumentation, fabrication, communications, English, mathematics, lasers and safety.

The curriculum sequence for a quarter system on the following page is designed to concentrate on the primary skill requirements for laser and electro-optical technicians. It fully satisfies training requirements for the fifteen LEOT duties previously described. The content of the technical-specialty courses is suggested, but should be left flexible to allow for the course sequencing which best fits a specific institution's needs.

Course descriptions have been developed which match the course titles on the model curriculum. Although the topics listed under course title headings are not all-inclusive, their depth of coverage makes them suitable for use in school catalogs. LEOT program planning should be based on a study of the topics listed in each of the supportive instructional modules, and from other material selected by LEOT planners at each particular insitution. This procedure will yield the depth of classroom and laboratory planning and sequencing necessary to assure the success of the program.

FIRST QUARTER

<u>Mathematics I</u>

Types of numbers, basic arithmetic operations, powers of 10 and scientific notation, basic algebraic expressions and operations, exponents, powers, roots, basic laws of exponents, concept of the function, linear algebraic functions, quadratic algebraic functions, graphical representation of functions, rectangular coordinate system, equation of a

MODEL CURRICULUM FOR

LASER/ELECTRO-OPTICS TECHNOLOGY

QUARTER PLAN

Course	Hours Per Week Class	Lab	Study	Total
First Quarter				
Mathematics I	4	0	8	12
DC Circuits	3	3	6	12
Physics	3	3	6	12
Introduction to Lasers	3	3	6	12
	13	9	26	48
Second Quarter				
Mathematics II	4	0	8	12
Drafting	2	3	4	9
AC Circuits	3	3	6	12
Electronic and Mechanical Fabrication	1	3	2	6
Geometrical Optics	3	3	6	12
	13	12	26	51
Third Quarter				
Wave Optics	3	3	6	12
Laser/Electro-Optics Components	3	3	6	12
Electronic Instrumentation and Calibrations	3	3	6	12
Semiconductor and Vacuum Tube Fundamentals	3	3	6	12
	12	12	24	48
Fourth Quarter				
Laser Technology	3	3	6	12
Experimental Optical Methods	3	3	6	12
Technical Communications	3	0	6	9
Industrial Safety	2	0	4	6
Solid State Circuit Analysis	3	3	6	12
	14	9	28	51
Fifth Quarter				
Laser/Electro-Optic Devices	3	3	6	12
Laser/Electro-Optic Measurement	3	3	6	12
Digital Circuits I	3	3	6	12
Machine Tool and Shop Practics	3	3	6	12
	12	12	24	48
Sixth Quarter				
Laser Applications	3	3	6	12
Laser Projects	3	3	6	12
Digital Circuits II	3	3	6	12
Introduction to Computer Hardware	3	3	6	12
	12	12	24	48

straight line, distance between 2 points, slope of a line, intercepts, simultaneous linear equations, 2 x 2 and 3 x 3 determinants, use of slide rule and electronic calculator for multiplication, division, powers, roots.

DC Circuits

Simple model of the atom, charge, electric field, potential difference, current, resistance, Ohm's Law, power law; Kirchhoff's equations (series circuits, parallel circuits, series-parallel circuits), resistor color code, potentiometers, rheostats and voltage dividers, Thevenin's and Norton's equivalent circuit theorems, types and properties of batteries, electrical symbols and schematic diagrams, measuring direct current and voltage with a VOM, conversion of heat, light and pressure into electricity, the ohmmeter, simple switches, the voltmeter, the ammeter, resistive input transducers (thermistors, platinum resistance thermometer, strain gauge), magnetism, magnetic fields, induction, DC motors.

Physics

International System (SI) of units, dimensional analysis, conversion from one set of units to another, fundamental and derived quantities, measuring instruments, significant figures, vectors and scales, static forces, kinematics, simple harmonic motion, laws of motion, work, energy, power, mechanics of fluids, temperature, thermal expansion, gas laws, kinetic theory of an ideal gas, heat exchangers, specific heat, phases of matter, longitudinal and transverse waves, wave fronts, phase, amplitude, wavelength, wave speed, reflection and standing waves, sound waves, interference and beats.

Introduction to Lasers

Elements of a laser, operation of a helium-neon gas laser, laser physics, optical cavities, properties of laser light, survey of laser systems.

SECOND QUARTER

Mathematics II

Review of formulas from plane and solid geometry, radian measure, angular motion three-dimensional coordinate systems (rectangular, cylindrical, spherical), trigonometric functions and identities, small angle approximations, plane polar coordinates, graphs of trig functions, inverse trig functions, exponential functions, ~~Logarithms,~~ use of log tables, logarithmic functions, semilog and log-log graphical plots, addition and subtraction of vectors, vector components, unit vectors, vector and scalor products, use of slide rule and electronic calculator for trig functions, logarithms, and exponential functions, experimental error and significant figures (absolute and relative error, addition, subtraction, multiplication and division of experimental numbers), probable error, standard deviation.

Drafting

Basic exercises in lettering, use of drawing instruments, fabrication sketches, geometrical construction, pictorials and dimensioning.

AC Circuits

Electromagnetism, alternating current, a simple a-c motor, sine waves and their properties, capacitance, dielectric strength, types of capacitors, RC circuits, capacitive reactance, impedance, phase angles, vector representation of instantaneous voltages, capacitors in series and in parallel, time constants, inductance, Lenz's law, Faraday's law, RL circuits, inductive reactance, transformers, RLC series and parallel circuits, AC generators, 3-phase circuits, 3-phase induction motors, 3-phase synchronous motors, capacitive input and inductive input transducers.

Electronic and Mechanical Fabrication

Shop safety, use of handtools, measuring instruments, bench work, use of jigs, assembly of machined parts, use of hand drill and drill press and bender, soldering and desoldering techniques, circuit component layout, circuit board fabrication, cabling, color codes and wire sizes.

Geometrical Optics

Reflection and refraction of light, graphical ray tracing techniques, f-stops and apertures, imaging with a single lens, types of lenses, primary and secondary focal points, thin lens equation, imaging with multiple lenses, simple optical systems (microscopes, telescopes, collimators).

THIRD QUARTER

Wave Optics

Light as an electromagnetic wave, light sources, radiometric units, absorption, scattering, interference, diffraction, holography and polarization.

Laser and Electro-Optic Components

Optical tables and benches, component support, properties and uses of filters, optical windows, beamsplitters, etalons, mirrors, lenses, polarizers, gratings, photographic supplies and non-linear materials.

Electronic Instrumentation and Calibrations

Meter movements, calibration of ohmmeters, voltmeters, ammeters, use of shunts, potentiometer circuits, Wheatston bridge, AC bridges (Wien, Owens, Hay, Capacitance, Inductance), use of function generator, VTVM, recording potentiometer (strip chart recorder), use of thermocouples, wattmeters, emphasis on use of the oscilloscope for voltage, phase and frequency measurements and troubleshooting, familiarization with various types of scopes (vectorscopes, dual-trace with triggered sweep, sampling scopes).

Semiconductor and Vacuum Tube Fundamentals

Physical model for semiconductors, the p-n junction and diode action, vacuum diodes, rectification, half-wave and full-wave rectifiers, bridge rectifier, voltage doubler and tripler circuits, filtering (RC, RC π-section and LC section), voltage regulation and Zener generator, junction transistor, hybrid transistor parameters, load line analysis and biasing, transistor characteristic curves, single-stage transistor amplifiers (common base, common emitter, and common collector), silicon-controlled rectifiers, silicon controlled switches, unijunction transistors, field effect transistors, use of a curve tracer, vacuum tube characteristics (triodes, pentodes, beam power tubes, load lines, common amplifier circuits).

FOURTH QUARTER

Laser Technology

Laser power and energy measurements, characteristics of flashlamps, discharge circuits, and pulse forming networks for optically pumped solid lasers, CW arc lamps and power supplies for CW lasers, cooling systems for CW-pumped solid lasers, safe operation and measurements with argon, CO_2, ruby, Nd:YAG, dye and semiconductor lasers, study of laser Q-switching with a ruby laser.

Experimental Optical Methods

Types and properties of optical materials, cleaning optical components, types of glass and glassworking equipment, glassforming operations, glass seals, vacuum systems, thermocouple and ion gauges and gauge controllers, vacuum valves, cold traps, mechanical and oil diffusion pumps, evacuation and charging of vessels, vacuum deposition of thin films.

Technical Communications

Techniques of collecting data and organizing, writing, and editing technical reports, use of lab notebooks, preparation of equipment and component specifications.

Industrial Safety

General laboratory safety practices, chemical and electric hazards, and control measures, safe electrical wiring practices, toxic fumes, noise hazards, and personnel protection.

Solid State Circuit Analysis

Multi-stage transistor amplifier circuits, cascade amplifiers, decoupling, frequency response, transformer coupling push-pull amplifiers, complementary symmetry, DC amplifiers, chopper amplifiers, Darlington configuration, phase inversion, feedback fundamentals (negative feedback, current feedback, voltage feedback), feedback regulation for power supplies, series and shunt regulator circuits, positive feedback waveform generators, negative resistance waveform generators, tunnel diodes and circuits, UFT relaxation oscillator and staircase generator, characteristics of ideal operational amplifiers and common configurations, characteristics of real op-amps, practical circuits for voltage and current reference sources using op-amps waveform generator circuits using op-amps, integrated circuit op-amps.

FIFTH QUARTER

Laser/Electro-Optic Devices

Photodetectors, calorimeters and laser power meters, holographic equipment and supplies, techniques and setups for making holograms, photographic instrumentation including oscilloscope, SLR, and streak cameras and special purpose imaging devices, laser modulation and Q-switching devices including electro-optic, rotating prism, acousto-optic and bleachable dye methods, use of laser collimators and auto-collimators, spatial filters, beam expanders and Faraday isolators.

Laser/Electro-Optic Measurements

Wavelength, dispersion and refractive index measurements with divided-circle prism/grating spectrometer, use of monochromators and spectrophotometers, use of scanning Fabry-Perot interferometer for observation of longitudinal modes in a laser output, use of fixed spacing Fabry-Perot etalon, Michelson interferometer, use of Twyman-Green interferometer in optical testing, use of Mach-Zehnder interferometer for measuring refractive index of a gas, spatial resolution, concept of the modulation transfer function (MTF), use of USAF 1951 resolution target to measure MTF of a lens.

Digital Circuits I

Introduction to digital measurements, biasing conditions, of npn and pnp transistor switches, relays as switching elements, gating circuits, diode gate and coincidence circuits, AND gate, anticoincidence circuits using diodes, OR gate, transistor driven gate, NAND gate, classification of gates, digital IC's diode logic, resistor-transistor logic, diode-transistor logic, direct coupled transistor logic, transistor-transistor logic, emitter coupled logic, flip-flops, bistable multivibrator circuit, gates, JK flip-flops, master-slave JKFF, monostable multivibrator, Schmitt trigger circuits and their applications.

Machine Tools and Shop Practice

Operation of engine lathe, milling machine, drill press, grinder, sheet metal cutter and bender, hole punch and band saw. Preparation of shop drawings, use of dimensional tolerances, familiarization of different fabrication materials, mechanical and chemical finishes.

SIXTH QUARTER

Laser Applications

Cutting, drilling and welding with a laser, air pollution monitoring with lasers, data processing and data display, optical memories, holographic non-destructive testing, medical applications of lasers, ranging and angle tracking, optical communications systems.

Laser Projects

Construction and testing of a laser, optical or electro-optic device such as a helium-neon laser, CW-pumped Nd:YAG laser, CO_2 laser, optical power meter, autocollimator, LED communications link or photomultiplier power supply. Maintaining a laboratory notebook.

Digital Circuits II

Numbering systems, binary, conversion codes including binary-coded decimal (BCD) system, octal, digital logic, Boolean algebra-symbols and properties, NOR gate and NAND gate, half-adder and full-adder circuit configurations, digital symbols, counters and registers, modulo N counters, analog to digital (A/D) and digital to analog (D/A) conversions, binary ladder resistor networks, multiplexing integrating op-amp as a D/A converter, digital readout devices, digital instruments including digital voltmeter (DVM), frequency synthesizer, phase frequency detector.

Introduction to Computer Hardware

Study and use of input/output (I/O) devices used with digital computers; interfacing and troubleshooting techniques, data acquisition and computer graphics.

CURRICULUM OPTIONS

It should be emphasized that a full LEOT program is not necessary to develop graduates trained with skills to enable them to be useful in the world of work. The Industrial Advisory Committee has verified that the five courses listed on the next page, when included as an LEO option to a compatible electronics program produce technicians who are highly useful to industry; particularly in those companies or institutions where the laser or electro-optical device is incorporated as a component to a larger instrument or system (i.e., a radar system).

Course 1. Introduction to Lasers
(11 modules)

Course 2. Geometrical Optics
(11 modules)

Course 5. Wave Optics
(9 modules)

Course 6. Laser Electro-Optics Components
(11 modules)

Course 9. Laser Projects
(7 modules - student selects only one)

These courses have been integrated into existing six-quarter programs in technological fields allied to laser technology. An example Model Curriculum for a two year Electronics Program with a Laser/Electro-Optics Option is shown on the next page.

A second suggested option would involve the inclusion of several LEOT courses into an existing program in Technical Physics or Electro-Mechanical Technology (EMT). A graduate from one of these programs with a specialty in Laser/Electro-Optics would most easily find employment in applied research activities such as exist at several government and non-profit research institutions. The LEOT instructional modules which would integrate into these programs easily would be found in courses 1, 2, 4, 5 and 10 (see listing, Section V.)

Other programs and courses to which the supportive instructional modules apply are known to include:

Chemistry
Civil Technology
Construction Technology
Industrial Technology
Optical Technology
Vacuum Technology
Glassworking Technology

In addition, LEOT modules are being integrated into existing 4-year bachelor's degree programs in laser technology, electrical engineering and applied physics.

MODEL CURRICULUM FOR AN ELECTRONIC TECHNOLOGY PROGRAM

WITH A

LASER/ELECTRO-OPTICS TECHNOLOGY OPTION
QUARTER PLAN

Course	Hours Per Week Class	Lab	Study	Total
First Quarter				
Mathematics I	4	0	8	12
DC Circuits	3	3	6	12
Electronic and Mechanical Fabrication	1	3	2	6
Physics	3	3	6	12
Drafting	2	3	4	9
	13	12	26	51
Second Quarter				
Mathematics II	4	0	8	12
AC Circuits	3	3	6	12
Electro-Mechanical Controls	3	3	6	12
Industrial Safety	2	0	4	6
Introduction to Lasers	3	3	6	12
	15	9	30	54
Third Quarter				
Electronic Instrumentation & Calibrations	3	3	6	12
Semiconductor & Vacuum Tube Fundamentals	3	3	6	12
Machine Tools & Shop Practices	3	3	6	12
Geometrical Optics	3	3	6	12
	12	12	24	48
Fourth Quarter				
Solid State Circuit Analysis	3	3	6	12
Microwaves	3	3	6	12
Conversational Computer Languages	3	3	6	12
Laser/Electro-Optic Components	3	3	6	12
	12	12	24	48
Fifth Quarter				
Digital Circuits I	3	3	6	12
Communications I	3	3	6	12
Wave Optics	3	3	6	12
Technical Communications	3	3	6	12
	12	12	24	48
Sixth Quarter				
Digital Circuits II	3	3	6	12
Communications II	3	3	6	12
Laser Projects	3	3	6	12
Introduction to Computer Hardware	3	3	6	12
	12	12	24	48

V. INSTRUCTIONAL MATERIALS

A series of laboratory oriented Laser/Electro-Optics Instructional Modules have been developed, each module representing approximately one independent learning experience. The major divisions of these Laser/Electro-Optics Instructional Modules are as follows:

<u>Introduction</u>, which identifies the topic and often includes a rationale for doing exercises.

<u>Objectives</u>, which are stated in terms of action-oriented behaviors and which include such action words as operates, measures, calculates, identifies, and defines, instead of words with many interpretations such as know, understand, learn and appreciate.

<u>Discussion</u>, which presents the background theory and techniques supportive to the objectives of the lesson. This material must be well organized and free of extraneous and irrelevant material. Sentences are written clearly and concisely. Diagrams and illustrations are used to assist in supporting ideas and concepts.

<u>Materials</u>, which identifies the equipment required to complete the exercise.

<u>Procedures</u>, which is the experiment section or "hands-on" portion of the module. It includes step-by-step instructions. The experiments are designed to reinforce student learning, and data sheets for each experiment are provided in each module

<u>Problems</u>, which are included for the purpose of reviewing and reinforcing the points covered in the exercise.

<u>Reference Materials</u>, which are included as supplementary reading/viewing for the student.

The modular materials are adaptable to school semester and quarter systems and are arranged for easy adaptation to local, state and regional accreditation requirements. Some educational institutions have implemented the full program and others have integrated select groups of modules into existing electronics and vacuum programs. Also, a number of the 99 supportive instructional modules are being used to enrich existing courses in physics (optics).

The average length of a module is approximately forty pages. A list of titles of instructional modules follows, grouped by courses within the LEOT Model Curriculum. Two modules are not included in the laser courses but the subjects were identified by the IAC as being extremely valuable to the LEO technician. These Modules are:

a. Module A-1. Measurement and Errors

b. Module A-2. Maintenance of a Laboratory Notebook

COURSE 1. INTRODUCTION TO LASERS

UNIT I — LASER FUNDAMENTALS

- MODULE 1- 1 ELEMENTS AND OPERATION OF A LASER
- MODULE 1- 2 OPERATION OF AN OPTICAL POWER METER
- MODULE 1- 3 WAVE PROPERTIES OF LIGHT
- MODULE 1- 4 INTRODUCTION TO LASER SAFETY

UNIT II — LASER PHYSICS

- MODULE 1- 5 ENERGY LEVELS IN ATOMS
- MODULE 1- 6 LASING ACTION
- MODULE 1- 7 OPTICAL CAVITIES AND MODES OF OSCILLATION

UNIT III — PROPERTIES OF LASER LIGHT

- MODULE 1- 8 COHERENCE
- MODULE 1- 9 POWER AND DIRECTIONALITY

UNIT IV — LASER SYSTEMS

- MODULE 1-10 HELIUM-NEON GAS LASERS - A CASE STUDY
- MODULE 1-11 LASER CLASSIFICATIONS AND OPERATING MODES

"INTRODUCTION TO LASERS" CONSISTS OF ELEVEN MODULES. THE FIRST TEN MODULES ARE DESIGNED TO INTRODUCE THE NEW STUDENT TO THE OPERATION OF A LASER, THE PRINCIPLES OF A LASER, ITS OUTPUT CHARACTERISTICS, AND SAFE OPERATING PRACTICES. THESE MODULES ARE ALL TAUGHT USING LOW POWER, HELIUM-NEON LASERS. THE LAST MODULE SURVEYS THE VARIOUS TYPES OF LASERS ACCORDING TO THE ACTIVE MATERIALS, OUTPUT CHARACTERISTICS, AND APPLICATIONS.

COURSE 2. GEOMETRICAL OPTICS

UNIT I. — INTRODUCTION TO GEOMETRICAL OPTICS

- MODULE 2- 1 LIGHT RAYS
- MODULE 2- 2 PRINCIPLES OF REFLECTION
- MODULE 2- 3 REFLECTION OF LIGHT AT A PLANE BOUNDARY
- MODULE 2- 4 REFLECTION OF LIGHT AT A SPHERICAL SURFACE
- MODULE 2- 5 PRINCIPLES OF REFRACTION
- MODULE 2- 6 REFRACTION OF LIGHT AT A PLANE BOUNDARY
- MODULE 2- 7 REFRACTION OF LIGHT AT A CURVED BOUNDARY

UNIT II. — OPTICAL COMPONENTS AND SYSTEMS

- MODULE 2- 8 IMAGING WITH A SINGLE LENS
- MODULE 2- 9 IMAGING WITH A MULTIPLE LENS
- MODULE 2-10 F-STOPS AND APERTURES
- MODULE 2-11 OPTICAL SYSTEMS

THERE ARE THREE DIFFERENT METHODS FOR DETERMINING WHAT HAPPENS TO LIGHT AS IT IMPINGES ON A SURFACE OR BOUNDARY SEPARATING TWO OPTICAL MEDIA. THE FIRST METHOD INVOLVES AN APPLICATION OF THE LAWS OF REFLECTION AND REFRACTION WHICH ENABLE THE STUDENT TO TRACE MATHEMATICALLY A RAY OF LIGHT REFLECTED FROM AND TRANSMITTING THROUGH A SURFACE. THE SECOND METHOD OF DETERMINING HOW A RAY OF LIGHT WILL BE REFLECTED AND REFRACTED IS A RELATIVELY SIMPLE AND ELEGANT TECHNIQUE KNOWN AS GRAPHICAL RAY TRACING. THIS TECHNIQUE REQUIRES NO MATHEMATICAL OR ANALYTICAL SOLUTIONS AND CAN BE EXTENDED TO MORE COMPLICATED SYSTEMS. IT WILL IN MANY CASES PROVIDE AN INSIGHT INTO HOW LIGHT PROPAGATES THROUGH COMPLICATED OPTICAL SYSTEMS. THE THIRD METHOD IS THE EXPERIMENTAL TECHNIQUE IN WHICH THE STUDENT WILL TAKE AN EXPERIMENTAL SET UP AND ACTUALLY TRACE A RAY OF LIGHT THROUGH AN OPTICAL SYSTEM.

IT IS THE INTENT OF THIS COURSE TO PROVIDE THE STUDENT WITH MATHEMATICAL ABILITY, THE KNOWLEDGE TO EMPLOY THE GRAPHICAL-RAY TRACING TECHNIQUE, AND THE EXPERIMENTAL EXPERTISE TO TRACE A RAY OF LIGHT THROUGH A SYSTEM USING ANY ONE OF THESE TECHNIQUES FOR A LARGE VARIETY OF OPTICAL COMPONENTS SYSTEMS.

COURSE 3. LASER TECHNOLOGY

UNIT I. LASER COMPONENTS AND MEASUREMENTS

- MODULE 3- 1 PULSED LASER FLASHLAMPS AND POWER SUPPLIES
- MODULE 3- 2 POWER SOURCES FOR CW LASERS
- MODULE 3- 3 CW SOLID LASERS - EFFICIENCY AND COOLING
- MODULE 3- 4 LASER POWER AND ENERGY MEASUREMENTS

UNIT II. LASER SYSTEMS

- MODULE 3- 5 ION GAS LASERS
- MODULE 3- 6 MOLECULAR GAS LASERS
- MODULE 3- 7 OPTICALLY PUMPED CW SOLID LASERS
- MODULE 3- 8 OPTICALLY PUMPED, PULSED SOLID LASERS
- MODULE 3- 9 LASER Q-SWITCHING - GIANT PULSES
- MODULE 3-10 ORGANIC DYE LASERS
- MODULE 3-11 SEMICONDUCTOR LASERS

THE LASER TECHNOLOGY COURSE EXPLORES IN DEPTH SIX SPECIALIZED GROUPINGS OF LASERS, WHICH INCLUDE ION GAS LASERS, MOLECULAR GAS LASERS, OPTICALLY PUMPED CW SOLID LASERS, OPTICALLY PUMPED PULSED SOLID LASERS, ORGANIC DYE LASERS AND SEMICONDUCTOR LASERS. THESE SIX MODULES ARE INDEPENDENT OF EACH OTHER AND A SELECTION OF ANY ONE OR A GROUP OF THEM CAN BE TAUGHT FOR A MORE SPECIALIZED COURSE. AN UNDERSTANDING OF THESE MODULES PRESUPPOSES KNOWLEDGE OF LASER FUNDAMENTALS, OUTPUT PARAMETERS AND SAFETY, AS COVERED IN COURSE 1, INTRODUCTION TO LASERS.

COURSE 4. EXPERIMENTAL OPTICAL METHODS

UNIT I. OPTICAL MATERIALS

- MODULE 4- 1 TYPES AND PROPERTIES OF OPTICAL MATERIALS
- MODULE 4- 2 LIMITATIONS AND TESTING OF OPTICAL MATERIALS
- MODULE 4- 3 CLEANING OPTICAL COMPONENTS

UNIT II. GLASS FABRICATION

- MODULE 4- 4 GLASSES AND GLASS WORKING EQUIPMENT
- MODULE 4- 5 GLASS FORMING OPERATIONS
- MODULE 4- 6 GLASS SEALS

UNIT III. VACUUM TECHNOLOGY

- MODULE 4- 7 VACUUM SYSTEMS
- MODULE 4- 8 EVACUATION AND CHARGING OF LOW-PRESSURE DEVICES
- MODULE 4- 9 VACUUM DEPOSITION OF THIN FILMS

COURSE # 4 IS DESIGNED TO PROVIDE THE STUDENT WITH SKILLS AND KNOWLEDGE ON THE FUNDAMENTALS OF OPTICAL MATERIALS, GLASSWORKING AND VACUUM SYSTEMS. THE LABORATORY EXPERIMENTS IN THE MODULES WERE DEVELOPED TO BE USED WITH SIMPLE, INEXPENSIVE EQUIPMENT.

MODULES 1, 2, AND 3 DESCRIBE THE VARIOUS TYPES OF OPTICAL MATERIALS (GLASS, CRYSTAL, AND PLASTICS) THEIR PROPERTIES, PROPER CARE AND CLEANING TECHNIQUES. THESE MODULES CAN BE TAUGHT INDEPENDENTLY OR AS A UNIT. MODULES 4, 5, & 6 SHOULD BE TAUGHT SERIALLY AS A UNIT. COMPLETION OF THIS UNIT WILL ENABLE THE STUDENT TO PRODUCE USEABLE GLASS FORMS, TUBING BENDS, SEALS AND REPAIRS AS WELL AS A FAMILIARIZATION OF WHAT TYPES OF SERVICE HE CAN EXPECT FROM A SCIENTIFIC GLASS SHOP.

MODULES 7, 8, & 9 SHOULD ALSO BE TAUGHT SERIALLY AS A UNIT. THIS SERIES IS DESIGNED TO EXPOSE THE STUDENT TO THE PRACTICAL LABORATORY TECHNIQUES OF VACUUM SYSTEMS AND THIN FILM DEPOSITION.

COURSE 5. LIGHT SOURCES AND WAVE OPTICS

UNIT I. GENERATION AND MEASUREMENT OF LIGHT

- MODULE 5- 1 SOURCES AND THEIR CHARACTERISTICS
- MODULE 5- 2 RADIOMETRY AND PHOTOMETRY

UNIT II. WAVE OPTICS

- MODULE 5- 3 WAVE NATURE OF LIGHT
- MODULE 5- 4 REFLECTION AND REFRACTION
- MODULE 5- 5 PROPAGATION
- MODULE 5- 6 INTERFERENCE
- MODULE 5- 7 DIFFRACTION
- MODULE 5- 8 POLARIZATION

UNIT III. SPECIAL APPLICATIONS OF WAVE OPTICS

- MODULE 5- 9 HOLOGRAPHY

COURSE # 5 CONSISTS OF NINE MODULES. THE FIRST TWO MODULES CONSIDER THE GENERATION AND MEASUREMENT OF LIGHT, INCLUDING THE FUNDAMENTAL ORIGIN OF LIGHT, DIFFERENT TYPES OF LIGHT SOURCES, SPECTRAL CHARACTERISTICS OF LIGHT SOURCES, RADIOMETRY AND PHOTOMETRY. THE NEXT SIX MODULES ARE CONCERNED WITH THE WAVE NATURE OF LIGHT, WHICH IS IN SHARP CONTRAST TO THE GEOMETRICAL RAY NATURE OF LIGHT TREATED IN COURSE # 2. THESE MODULES CONSIDER REFLECTION, REFRACTION, AND PROPAGATION OF LIGHT FROM THE VIEW-POINT OF WAVE OPTICS. THEY TREAT THE ESSENTIAL PRINCIPLES OF INTERFERENCE, DIFFRACTION AND POLARIZATION OF LIGHT, ALL WAVE PHENOMENA AND ARE IMPORTANT TO A SOUND UNDERSTANDING OF LASER/ELECTRO-OPTICS TECHNOLOGY. THE FINAL MODULE IN THIS COURSE APPLIES THE PRINCIPLES OF WAVE OPTICS TO THE SCIENCE OF HOLOGRAPHY, ONE OF THE CURRENTLY IMPORTANT AREAS OF LASER TECHNOLOGY MADE POSSIBLE BY THE LASER.

COURSE 6. LASER AND ELECTRO-OPTIC COMPONENTS

UNIT I. SUPPORT HARDWARE FOR OPTICAL COMPONENTS

- MODULE 6- 1 OPTICAL TABLES AND BENCHES
- MODULE 6- 2 COMPONENT SUPPORTS

UNIT II. LASER AND ELECTRO-OPTIC COMPONENTS

- MODULE 6- 3 PHOTOGRAPHIC COMPONENTS & SUPPLIES
- MODULE 6- 4 WINDOWS
- MODULE 6- 5 MIRRORS, FLATS AND ETALONS
- MODULE 6- 6 FILTERS AND BEAM SPLITTERS
- MODULE 6- 7 PRISMS
- MODULE 6- 8 LENSES
- MODULE 6- 9 GRATINGS
- MODULE 6-10 POLARIZERS
- MODULE 6-11 NON-LINEAR MATERIALS

COURSE # 6, LASER AND ELECTRO OPTICAL COMPONENTS DEALS WITH THE "TOOLS OF THE TECHNOLOGY". THE MODULES IN THIS COURSE DO NOT ATTEMPT TO EXPLAIN THEORIES OR PRINCIPLES, BUT INSTEAD DESCRIBE THE HARDWARE THAT IS AVAILABLE, HOW TO DETERMINE THE QUALITY OF A COMPONENT THAT IS REQUIRED, AND HOW TO ACQUIRE IT. AS AN EXAMPLE: THE MODULE ON LENSES ONLY BRIEFLY REVIEWS THE PRINCIPLES OF REFRACTION WITH CURVED SURFACES (SO THAT THE MODULE IS NOT DEPENDENT UPON PREREQUISITE MODULES), THEN GOES INTO A DETAIL OF THE VARIOUS ABERRATIONS THAT CAN BE CAUSED IN LENSES, THE VARIETY OF LENSES THAT ARE AVAILABLE AND WHEN THEY SHOULD BE USED. IN THE MODULE ON FILTERS, THE EMPHASIS IS UPON PERFORMANCE AND COST, SO THAT THE TECHNICIAN WILL KNOW WHEN HE CAN USE A 50¢ FILTER AND WHEN HE NEEDS ONE THAT COSTS $500.00. THE IDEAS WHICH ARE CONVEYED ARE INTENDED TO PROVIDE THE STUDENT THE BENEFITS HE WOULD ORDINARILY DERIVE ONLY FROM YEARS OF PRACTICE IN THE LABORATORY.

EACH MODULE IN THE COURSE IS INDEPENDENT OF THE OTHERS, AND CAN BE TAUGHT SEPARATELY OR IN ANY SEQUENCE.

COURSE 7. LASER/ELECTRO-OPTIC DEVICES

UNIT I. OPTICAL DETECTION DEVICES

- MODULE 7- 1 PHOTODETECTORS
- MODULE 7- 2 LASER POWER & ENERGY DETECTORS

UNIT II. PHOTOGRAPHIC TECHNIQUES

- MODULE 7- 3 PHOTO INSTRUMENTATION EQUIPMENT
- MODULE 7- 4 HOLOGRAPHIC TECHNIQUES AND EQUIPMENT

UNIT III. LASER BEAM MANIPULATORS

- MODULE 7- 5 COLLIMATORS AND AUTOCOLLIMATORS
- MODULE 7- 6 BEAM EXPANDERS AND SPATIAL FILTERS
- MODULE 7- 7 ISOLATORS

UNIT IV. MODULATION DEVICES AND Q-SWITCHING

- MODULE 7- 8 MECHANICAL AND BLEACHABLE DYE METHODS
- MODULE 7- 9 ELECTRO-OPTIC MODULATORS
- MODULE 7-10 ACOUSTO-OPTIC DEVICES

THESE MODULES COVER THE THEORY AND OPERATION OF SPECIAL PURPOSE DEVICES TO MEASURE LASER OUTPUT PARAMETERS, TO MANIPULATE LASER BEAMS, AND TO MODULATE OR Q-SWITCH LASERS. ALSO INCLUDED ARE SPECIAL TECHNIQUES IN PHOTOGRAPHY AND HOLOGRAPHY.

MODULE 7-2 IS UNDERSTOOD MUCH BETTER IF IT IS PRECEDED BY MODULE 7-1. WITH THIS EXCEPTION ALL THE MODULES IN COURSE SEVEN ARE RELATIVELY INDEPENDENT OF EACH OTHER, WHICH PROVIDES THE FLEXIBILITY OF SELECTING ISOLATED MODULES FROM COURSE 7 TO DEVELOP A COURSE FOR SPECIAL NEEDS AND INTERESTS.

COURSE 8. LASER APPLICATIONS

UNIT I. MATERIALS PROCESSING

- MODULE 8- 1 WELDING
- MODULE 8- 2 DYNAMIC CUTTING AND DRILLING

UNIT II. DATA PROCESSING

- MODULE 8- 3 DATA RECORDING AND MANIPULATING
- MODULE 8- 4 DATA DISPLAY

UNIT III. TESTING AND MONITORING

- MODULE 8- 5 ENVIRONMENTAL TESTING & MONITORING
- MODULE 8- 6 NONDESTRUCTIVE TESTING

UNIT IV. RANGING AND ANGLE TRACKING

- MODULE 8- 7 RANGEFINDING
- MODULE 8- 8 ALIGNMENT AND ANGLE TRACKING

UNIT V. MEDICAL APPLICATIONS

- MODULE 8- 9 LASERS IN MEDICINE, SURGERY AND DENTISTRY

UNIT VI. COMMUNICATIONS

- MODULE 8-10 LASER COMMUNICATION SYSTEMS

COURSE # 8 CONSISTS OF TEN MODULES, ARRANGED IN SIX UNITS OF RELATED MODULES. THE PURPOSE OF COURSE # 8 IS TO DESCRIBE SOME OF THE LASER APPLICATIONS THAT ARE EMERGING FROM THE LABORATORY AND COMING INTO PRACTICAL USE IN INDUSTRY. THE COURSE WILL ALSO PROVIDE TRAINING FOR THE STUDENT IN THESE APPLICATIONS. THE COURSE BEGINS WITH LASER MATERIALS PROCESSING, WHICH INCLUDES WELDING, CUTTING AND DRILLING. THE SECOND UNIT DESCRIBES THE USE OF LASERS FOR DATA PROCESSING, INCLUDING RECORDING, DATA MANIPULATING, AND DISPLAY. A UNIT ON TESTING AND MONITORING SURVEYS APPLICATIONS IN ENVIRONMENTAL TESTING AND IN NONDESTRUCTIVE TESTING, PARTICULARLY HOLOGRAPHIC NONDESTRUCTIVE TESTING. THE GROWING USES OF LASERS FOR MEASUREMENT OF RANGE, ANGLE TRACKING, AND ALIGNMENT ARE DISCUSSED IN THE NEXT UNIT. LASER APPLICATIONS IN SURGERY AND DENTISTRY ARE COVERED IN A UNIT ON MEDICAL APPLICATIONS. THE FINAL UNIT, ON COMMUNICATIONS DESCRIBES THE USE OF LASERS AND OTHER ELECTRO OPTICAL DEVICES, AUDIO AND VIDEO COMMUNICATIONS ALONG WITH THE RELATIVE ADVANTAGES AND DISADVANTAGES AS COMPARED WITH R.F. AND MICROWAVE TECHNIQUES.

COURSE 9. LASER PROJECTS

UNIT I. LASER/ELECTRO-OPTIC SYSTEMS

- MODULE 9- 1 OPEN-CAVITY HELIUM-NEON LASER
- MODULE 9- 2 COMMUNICATIONS LINK
- MODULE 9- 3 CW PUMPED ND:YAG LASER
- MODULE 9- 4 CARBON DIOXIDE LASER

UNIT II. ELECTRO-OPTIC DEVICES

- MODULE 9- 5 AUTOCOLLIMATOR
- MODULE 9- 6 POWER SUPPLY AND CALIBRATION OF A PHOTOMULTIPLIER
- MODULE 9- 7 OPTICAL POWER METER FOR CW LASERS

COURSE # 9 CONSISTS OF SEVEN MODULES WHOSE END PRODUCT IS A SERIES OF WORKING, STUDENT-BUILT LASERS AND ELECTRO-OPTIC DEVICES. THESE MODULES ARE DESIGNED TO EXPOSE THE STUDENT TO A WIDE VARIETY OF MATERIALS, FABRICATION AND CALIBRATION METHODS, AND MEASUREMENT TECHNIQUES USED IN TYPICAL LEO WORK ENVIRONMENTS. ALTHOUGH DESIGN INFORMATION FOR VARIOUS PARTS OF A GIVEN DEVICE (E.G., MIRROR MOUNTS FOR A CO_2 LASER) IS PROVIDED IN THE APPROPRIATE MODULE, THE STUDENT SHOULD BE ENCOURAGED TO USE HIS OWN INGENUITY IN SOLVING DESIGN PROBLEMS.

THE IMPORTANCE OF KEEPING AN ACCURATE LABORATORY NOTEBOOK IS STRESSED IN THESE MODULES. THE SUPPLEMENTARY MODULE ON LABORATORY NOTEBOOKS IS A GENERAL PREREQUISITE FOR COURSE # 9.

IT SHOULD BE NOTED THAT A GIVEN MODULE IN COURSE # 9, WITH ONE EXCEPTION, CAN BE ACCOMPLISHED BY ONE PERSON IN ONE 12 WEEK PERIOD, PROVIDED THAT ALL OF THE MATERIALS FOR THE PROJECT AND NECESSARY MACHINE TOOLS ARE AVAILABLE BEFOREHAND. MODULE 9-7, CW PUMPED ND:YAG LASER, NORMALLY REQUIRES THREE OR FOUR STUDENTS FOR COMPLETION IN ONE QUARTER.

THE STUDENT SHOULD MEET WITH HIS INSTRUCTOR AT SPECIFIED INTERVALS TO ADVISE HIM OF PROGRESS (AND PROBLEMS) ON THE VARIOUS MAJOR TASKS (MILESTONES) INVOLVED IN THE PROJECT. IN ADDITION, A ROUND-TABLE DISCUSSION ON ALL STUDENT PROJECTS, ONCE A WEEK, IS A HELPFUL OUTLET IN AIRING DIFFICULTIES ENCOUNTERED, IN GENERATING IDEAS FOR SOLVING PROBLEMS, AND IN STIMULATING INTEREST.

COURSE 10. LASER/ELECTRO-OPTIC MEASUREMENTS

UNIT I. SPECTRAL MEASUREMENTS

- MODULE 10-1 SPECTROMETERS
- MODULE 10-2 MONOCHROMATORS
- MODULE 10-3 SPECTROPHOTOMETERS

UNIT II. INTERFEROMETRIC MEASUREMENTS

- MODULE 10-4 MICHELSON INTERFEROMETER
- MODULE 10-5 FABRY-PEROT INTERFEROMETER
- MODULE 10-6 TWYMAN-GREEN INTERFEROMETER
- MODULE 10-7 MACH-ZEHNDER INTERFEROMETER

UNIT III. SPATIAL RESOLUTION

- MODULE 10-8 SPATIAL RESOLUTION OF OPTICAL SYSTEMS

THIS COURSE CONSIDERS THE STANDARD INSTRUMENTS AND MEASUREMENT TECHNIQUES IN LASER/ELECTRO-OPTICS TECHNOLOGY WHICH ARE IMPORTANT TO THE TECHNICIAN. THE FIRST THREE MODULES TREAT OPTICAL INSTRUMENTS UNDER THE GENERAL NAMES OF SPECTROMETERS, MONOCHROMATORS AND SPECTROPHOTOMETERS. THE MODULES EXPLAIN THEIR USE IN MAKING SPECTRAL MEASUREMENTS OF LIGHT SOURCES TO DETERMINE BOTH WAVELENGTH AND INTENSITY DISTRIBUTION OF THE LIGHT. THE NEXT SET OF MODULES DISCUSSES THE VARIOUS TYPES OF INTERFEROMETERS AVAILABLE TO THE TECHNICIAN AND THEIR MANY USES IN MAKING INTERFEROMETRIC MEASUREMENTS ON SMALL THICKNESSES, SURFACE IRREGULARITIES, WAVELENGTH DETERMINATION, ETC. THE LAST MODULE IN THIS COURSE CONSIDERS AN IMPORTANT PROBLEM IN MODERN OPTICS WHICH INVOLVES THE SPATIAL RESOLUTION OF OPTICAL SYSTEMS.

THE EMPHASIS IN THIS COURSE IS ON OPTICAL MEASUREMENTS WITH OPTICAL INSTRUMENTS. THE THEORY AND PRINCIPLES WHICH UNDERLIE THE OPERATION OF THESE INSTRUMENTS, PRESENTED IN DETAIL IN COURSE 5, ARE REFERRED TO AGAIN IN EACH MODULE TO STRENGTHEN THE STUDENTS' UNDERSTANDING OF WAVE OPTICS. NEVERTHELESS, IT IS THE INTENT OF COURSE 10 TO ENABLE THE STUDENT TO OBTAIN LABORATORY EXPERIENCE IN LASER ELECTRO-OPTIC MEASUREMENTS WITH MODERN OPTICAL EQUIPMENT.

VI. PROGRAM SUPPORT DOCUMENTS

The following program support documents have been prepared and are being used by institutional administrators, faculty and staff for determining the feasibility of implementing an LEOT program, program planning, local employer needs, curriculum identification, staff selection and program evaluation.

1. LEOT Curriclum Guide - A comprehensive description of the origins, composition, planning, implementation, and administration of the LEOT curriculum. Includes a detailed list of capital equipment needed, with cost information and planning guides, and a detailed bibliography of books and materials on laser technology and related fields. (90 pages).

2. Career Opportunities for LEOT Technicians - Lists potential employers of LEOT technicians, divided into six geographical regions of the United States, and describes various kinds of career opportunities. (52 pages)

3. LEOT Educational Equipment and Supplies - Describes specifications and estimated costs for all capital and expendable equipment and materials needed to implement a full LEOT program. (41 pages)

4. LEOT Evaluation Manual - Describes and evaluates the TERC/LEOT program development; presents valid and effective procedures for use by curriculum and program managers in evaluating new or modified programs. (150 pages)

VII. CAREER COUNSELING GUIDES

In an effort to enhance the effectiveness of communicating to prospective students the formal preparation and employment opportunities in new and emerging occupations, five Career Counseling Guides were developed, tested and evaluated. The author of these guides is the head of counseling activities for the San Antonio, Texas, Independent School District.

The important emphasis in these materials is on encouraging students to train for technical careers. Figures are presented to show the earning power of trained technicians, and suggestions are made for career paths using technical training rather than, or in addition to, traditional college education.

The Career Counseling Series contains five volumes:

VOLUME 1: Counseling for Careers (44 pages)

The first career counseling guide is directed to high school counselors who wish to expand their career counseling efforts in addition to maintaining the traditional academic or individual counseling. Recent statistics and case studies are presented to show the value of learning a salable skill as a direct entry into the world of work or as a means to continued higher education. Employment opportunities are grouped into career clusters, following the classifications developed by the U.S. Office of Education, to show counselors and school administrators how they can start a realistic career awareness program even at the elementary level. A broad approach to career counseling is outlined, with emphasis on making counseling more relevant to the 75% of the students who will not obtain a college degree.

The volume includes suggestions on materials that schools or counselors can obtain for students, as well as addresses where such materials can be obtained. A method of setting up a Career Corner in the counseling office or in the library is outlined. Other recommendations for group counseling, career night programs, and individual student counseling programs are included.

VOLUME 2. Preparing for a Career (43 pages)

A second career counseling guide is directed to students. After defining some common terms used in various kinds of work (e.g., blue collar, journeyman, etc.) it describes the U.S. Office of Education career clusters and suggests methods of collecting information about careers. Samples of Career Information Sheets are presented and explained: these are forms on which specific information about various careers can be collected and compared.

The guide discusses different levels of employment within different job categories, describes entry level skills, and presents a comparison between starting work early (immediately after high school graduation) and delaying employment until additional training can be obtained. Alternative career training paths are described, with comparative cost figures. Attention is given to projecting employment trends in the future.

VOLUME 3. A Parent's Guide to Technical Education (64 pages)

In Volume 3, options and alternatives in education and career choices are described, to allow parents to help their teen-age children make intelligent decisions about the future. A comparison is made between employment immediately after high school graduation, post-secondary two-year training programs, and degree education for professional careers. Technical careers are described, and probable trends in education are discussed. An informal version of the Career Information Sheet described above is also included here, as well as a Values Inventory to help students and parents evaluate the various alternatives.

VOLUME 4. A Student Guide for Securing a Job (79 pages)

This guide is designed as a do-it-yourself employment service. It attempts to reduce the anxiety of the job-seeker by describing what may happen, how to prepare for it, and how to evaluate possible employment alternatives. The guide includes frequently-encountered forms, as well as suggestions for developing letters of application, resumes, and other documents that may be needed. The forms reproduced in the guide are composites of many forms collected from business and industry; they have undergone trial and revision in high school business and technical programs and are felt to be current and representative of what may be encountered by students in the job market.

VOLUME 5. Career Counseling the Disadvantaged (64 pages)

Directed to counselors, counselor trainees, employment consultants, school administrators, and planners of programs for the disadvantaged, this last career counseling guide emphasizes the problems of the disadvantaged in our society. A person may be socially, physically, culturally, or economically disadvantaged and may feel certain that there is no way to improve his life. It is the counselor's job to understand the factors contributing to these feelings and to plan ways of bringing about change. Using case studies, the author illustrates the cyclical effect of poverty and the underachievement inertia that develops when failure becomes a habit. Suggestions are given for utlizing existing community facilities to break this cycle. A progressive goal attainment concept is presented to assist in planning for a career.

VIII. ROLE OF INDUSTRIAL ADVISORY COMMITTEE

It is the consensus of the Project Managers, the TERC staff, the faculty at TSTI, and the Evaluation Team that the key element of success in this project was an enthusiastic, involved Industrial Advisory Committee. The following individuals served on the LEOT Industrial Advisory Committee:

- Dr. Jay Chivian - Advanced Technology Center, Dallas, Texas
- Dr. Alex Glass - Lawrence Livermore Laboratories - Livermore, California
- Dr. Arthur Guenther - Air Force Weapons Laboratory - Kirtland, AFB, New Mexico
- Dr. Dave Hardwick - Tropel - Fairport, New York
- Mr. Dan M. Hull - Lockheed Electronics Aerospace Systems - Houston, Texas
- Mr. Frank Kassler - Texas Instruments, Inc.; Electro-Optics Division - Dallas, Texas
- Mr. Robert G. Klimasewski - Burleigh Instruments, Inc. - Rochester, New York
- Mr. Doug Lilly - NASA Manned Spacecraft Center - Houston, Texas
- Mr. Raymond Marlow - Nuclear Systems, Inc. - Garland, Texas
- Dr. Leno Pedrotti - AF Institute of Technology, Physics Dept. - Wright Paterson AFB, Ohio
- Dr. Douglas A. Pinnow - Bell Telephone Laboratories - Murray Hill, New Jersey
- Mr. R. James Rockwell, Jr. - The Children's Hospital Research Foundation - Cincinnatti, Ohio
- Mr. Earl J. Scribner - Stanford Research Institute - Menlo Park, California
- Dr. Jacob Silverman - North American Rockwell Corporation - Canoga Park, California
- Dr. Donald Sims - KORAD/HADRON - Santa Monica, California
- Dr. Jon E. Sollid - Los Alamos Scientific Laboratory - Los Alamos, New Mexico
- Mr. Robert E. Steinman - Gaertner Scientific Corporation - Chicago, Illinois
- Dr. Forrest C. Strome - Eastman Kodak Company Research Laboratories - Rochester, New York
- Mr. Robert A. Wallace - American Optical Corporation - Framingham, Massachusetts
- Mr. Eric J. Woodbury - Hughes Aircraft Company - Culver City California

The Industrial Advisory Committee was organized and assembled by the Project Manager for the purpose of providing Task Analysis data and reviewing instructional materials in terms of relevant content and technical accuracy. The Industrial Advisory Committee responded in this capacity and performed much more.

The individual members wrote four articles in professional journals and newsletters, introducing the program to their colleagues. Evidence is available to show that this publicity resulted in job opportunities for graduates of the Pilot Educational Program.

At all Industrial Advisory Committee meetings (which were held in Waco, Texas) at least two members of the Committee took time out to present talks on laser activities at their company to the students of the Pilot Program. This generated an enthusiasm in the students and provided them an insight on typical job functions of LEOT technicians. Student field trips were made to three industrial sites of committee members. Over twenty graduates of the Pilot Program have been hired by organizations represented by Industrial Advisory Committee members.

Organizations represented by the Industrial Advisory Committee membership have donated equipment valued at over $200,000 to the LEOT Department at TSTI. This amount should be considered as part of the matching funds for the Project. In addition, several student scholarships and co-op arrangements have been arranged through these organizations.

An indirect, but very significant, contribution made by the Industrial Advisory Committee and the Evaluation Team was the publicity in the news media that TSTI received each time the groups met in Waco. These types of news releases consistently resulted in several prospective students inquiring about the LEOT program at TSTI.

In summary, the members of the Industrial Advisory Committee felt very strongly that this was their program. They had a great deal to say when they met (and in correspondence afterwards) and the TERC staff made every effort to listen to them and respond accordingly. The Industrial Advisory Committee did not design the curriculum nor did they design the format of the instructional materials; but they were the resource upon which the curriculum and materials were based.

As additional evidence of the Industrial Advisory Committee's enthusiasm for this project, it is worthwhile to note:

- Five members authored instructional modules.
- All members edited modules; two members were solicited to edit the entire 99 modules.
- One member left his position of employment to become the Project Manager.
- One member is working with TERC to establish short courses using the instructional materials.
- One member is teaching courses at his organization using the instructional materials.
- Three members have taken the initiative to have LEOT programs established at institutions in their localities.

IX. REPORT OF THE EVALUATION TEAM

(The following report was received from the Chief of the LEOT Evaluation Team after the conclusion of the final meeting in December 1974. The report has not been edited or changed by the TERC, Project Manager).

"The basic function of evaluation in occupational education is to provide information concerning the specifically and effectiveness of the curriculum and instructional activity. Such feedback is needed to insure instructional specification and effectiveness, student development, quality control, and a basis for change and improvement. At least four groups require this information: students, instructional staff, employers of graduates and educational administrators. Unless instructional activities are successful in preparing individuals for the future, they have no rationale for existence. This focus allows for a definition of the product in terms of skills, knowledges and abilities of the graduate. Educational evaluation, therefore, has a responsibility for determining the extent that the graduate is trained for that goal.

"Training involves quality control procedures as an integral function of training development, modification, revision and improvement. Training evaluation includes a systematic collection, analysis and interpretation of feedback information.

"Procedures for quality control or training evaluation should be based on an instructional technology and begun with the development of a course and should involve everyone. There should be a systematic process of evaluation that is continuous. Evaluations are made at any point prior to the development of a course, during a course, at the end of a course and on the job. The student, instructor, supervisor and the administrator should all be involved in training evaluation.

"Instructional technology, as conceived in this project, involved at least five major aspects:

1. The determination of training requirements for the first essential aspect of a training technology. A task analysis must be conducted to insure that an indivudual is trained for the relevant tasks that he will have to perform on the job.

2. The construction of measureable objectives must be specified before the development of a training course. These should be done in such a way that the student knows precisely what is to be achieved in the course and that the student, the instructor, and the after training supervisor have a clear idea of the achievement specifications.

3. Evaluation of prior knowledge and proficiencies is the third sequence. By knowing what the students' knowledge and proficiencies are, course content can better be determined including the level at which the course should start.

4. Designing a relevant program is the fourth sequence. This should be based on a review of the relevant research, content, and instructional methodology.

5. The last step makes use of quality control principles. This step involves a rigorous quality controlled program that operates continuously. It insures that the tasks for which the course trains are appropriate, relevant, and are achieved in a efficient and effective manner. This mandates the use of a criterion-referenced measurement system.

"The TERC/LEOT program made considerable use of the systems approach to training and evaluation. A TERC survey indicated the need for electro-optic technician would appreciably be increased by 1975. This survey further amplified the need to include lasers because 43% of electro-optic technicians reported using lasers in their work. Following this lead, Texas State Technical Institute made a survey focusing on Laser Electro-Optic Technology which established the need for a LEOT Training program. In addition, the LEOT Industrial Advisory Committee was established to provide technical assistance and advice in the development of the LEOT program. Surveys were also conducted in terms of requisite tasks and tools of LEOT's work in laser related industries. The results of these surveys were used by the TERC/LEOT staff to plan and develop courses for the LEOT program. In addition, the LEOT Industrial Advisory Committee rated 156 tasks. Because many of the tasks received high ratings from the Advisory Team, the Evaluation Team suggested that certain groupings be taught within the core program.

"The Test and Measurement expert of the Evaluation team initially was not satisfied with the original module objectives nor the measurements. He worked with modular writing staffs and other experts to show the characteristics that measureable objectives must have and how they can be measured. A significant number of modules were re-developed to meet his specifications. Further checks by him revealed that he was successful in his instruction.

"The <u>Counseling</u> member of the team made an analysis of entering student profiles. He also reviewed modules and made analysis of their reading complexity. He found that the initial writing of modules was at too high a level for a number of modules. Feedback was given to module writers and revisions were made at the appropriate level.

"The <u>Curriculum Development</u> expert on the team was concerned that performance type skills were taught through demonstration and student performance of those skills. He wished to insure that module content was necessary and sufficient to the modules objectives.

"The <u>Industrial Employment Specialist</u> was concerned that performance and knowledge levels were compatible with job requirements and that training aids and equipment were supportive to the module. He was also concerned with each objective contributing to the program goal.

"The <u>Technical Instruction</u> expert started off reviewing every module to insure that it was technically accurate, current, met the needs of the laser industry and that the material within each module was cohesive and concise. He soon learned that he needed some assistance; thus, another expert and he were responsible for reviewing each module that was developed. Where modules did not meet the requirements of these two experts, they were changed by the experts or they insisted that the original authors rewrite these and return them for further review.

"Numerous service tests were made to try out modules. Where revisons were indicated they were accomplished.

"A more formal service test was made on eight modules covering the Nature of Light (which have since been integrated into the Wave Optics Course). For the purpose of this study, all eight end-of-course tests were administered to the students prior to their taking this unit of instruction. The same module post tests were administered upon completion of each module and again a few weeks after completion of the unit of instruction. In addition, the instructor made notes of difficulties encountered in the instruction of the class and student reactions to each module. All of these data were used by the Evaluation Team to determine the over-all effectiveness of this unit and the modifications that should be made. In addition to the modifications they required, the team concluded that students had little knowledge and skills of content of these modules, and that they achieved considerable as a result of instruction, both in terms of over-all achievement and student gains. Student reactions were found to be favorable to the modular format.

"In summary the team members expressed pride in having been part of the TERC/LEOT project. They felt that the materials for the program, in general, are outstanding and that the program meets the requisite characteristics that the team specified earlier. TERC personnel have also been successful in making a good beginning on the dissemination of LEOT materials. However, the team felt that more effort is required and worthwhile on the dissemination of the LEOT program."

TERC/LEOT EVALUATION TEAM MEMBERS

Technical Instruction - Dr. Arthur Guenther, Air Force Weapons Laboratory, Kirtland AFB, New Mexico.

Test and Measurement - Dr. John Hampton, Oklahoma State University, Stillwater, Oklahoma

Curriculum Development - Mr. Arnold H. Potthast, Wisconsin Board of Education, Madison, Wisconsin

Industrial Employment - Mr. John Ready, Honeywell, Inc., Hopkins, Minnesota

Counseling - Mr. Henry C. Ryniker, Independent School District, San Antonio, Texas

Team Chief - Dr. Michael A. Zaccaria, Educational Consultant, San Antonio, Texas

X. ROLE OF INSTITUTIONAL PILOT PROGRAM

The pilot Instructional Program for the Laser/Electro Optics Technology Project was established in September, 1970, at Texas State Technical Institute in Waco, Texas. In that period the department chairman, Dr. John D. Pierson, was hired, and four second year electronics students transferred into the program. Laser and Electro-Optics courses were taught, beginning in September, 1970. The LEOT Project encouraged and partially supported this initial effort by purchasing some equipment and supplies, paying the TSTI faculty for project work in curriculum development, and providing classroom and lab instruction by members of the TERC project staff. The first LEOT graduates were all employed in April, 1972. To date, forty-four students have been employed by institutions and industry, and sixty nine students are currently enrolled.

The following activities are representative of the role which the Pilot Instructional Program has contributed to the LEOT Project:

- Faculty and staff have contributed to the development and evaluation of the curriculum and course descriptions.
- The faculty has contributed to the writing and editing of the instructional modules. Students in the program have also critiqued the materials from a "learners viewpoint".
- All the modules' experimental procedures and equipment have been verified in the school's laboratories, largely by the faculty and students.
- The modules were "service tested" in the courses offered at TSTI. Service testing involved pretesting, post testing and retention testing (when practical) of students whose profiles were known. Service testing was also accomplished to a limited extent at the other schools who later implemented LEOT programs. However, the test data were more complete and more meaningful at the Pilot Institution where the training environment was known and controlled.
- The experience which the faculty gained in using these

materials has significantly influenced modifications in the curriculum structure and suggested instructional methodology. For instance, it was learned that a high student dropout rate was experienced in the first quarter because a student did not have any exposure to laser courses. The curriculum was changed to include Course #1, Introduction to Lasers, in the first quarter. However, it was also learned that this course was too long and complex to be taught in the first quarter. This resulted in several modules being moved into Course #3 and another module (on Optical Power Meters) being changed to individualized, self paced instruction with an accompanying tape cassette.

- The Industrial Advisory Committee members were able to relate to the type of instruction to which the project was dedicated because they could visit with students in the pilot program and could observe the labs. An interview by the Industrial Advisory Committee with a student who had graduated and been working six months also proved invaluable to the project.

XI. DISSEMINATION ACTIVITIES AND ACCOMPLISHMENTS

Technical education curriculum research and development can only achieve the national significance for which it was intended if the ideas and materials can be transported to other educational environments besides the pilot program. From the beginning of this project, an emphasis has been placed on eventual national dissemination. However, the project management felt that attempts at dissemination on other programs were far too limited in terms of the program flexibilities and the places where the education would take place.

Very early in the project, attempts were made to alert those in the technology and in schools that programs would soon be available. Table XI-1 lists articles in Newspapers, Magazines, journals and books describing the LEOT project and/or the pilot program.

As schools and industry learned about the activities, TERC began working with them, supplying them with draft copies of curriculum and instructional modules. When it seemed appropriate, the Project Manager would visit institutions to assist them in planning. As early as 1973, TERC taught a short course for an organization where a large number of LEO technicians worked.

The curricula and ~~the~~ instructional materials for the LEOT project were designed for maximum flexibility so that local educational institutions could implement programs that would more nearly meet local needs. This also gives the school administrators and faculty the opportunity to "invent it here."

Examples of schools who have adapted the LEOT project materials to their local needs and capabilities are:

A. San Jose City College - Implemented a LEOT option to their existing program in Vacuum and Glassworking Technology. Graduates are particularly useful to gas laser manufacturers who are centralized in the San Francisco area.

B. Idaho State University - Implemented a LEOT option to an existing Electronics Technology.

Table XI-1

Articles in Newspapers, Magazines, Journals and Books Describing the Laser/Electro-Optics Project or the Pilot Program

1. Albertson, L. "School of Skills". The Texas Star. April 2, 1972. pp. 8-13.

2. Doss, C.B., and J. D. Pierson. "The Laser/Electro-Optics Program at Texas State Technical Institute". Technician Education Yearbook. pp. 51-54.

3. Editor: "First Student Chapter Formed at Texas State Technical Institute". Lasersphere.

4. News Article: "Laser Evaluation Team Studying TSTI Program". Valley Morning Star. Harlingen, Texas. Dec. 10, 1974.

5. Goldman, L. Applications of the Laser. CRC Press, 1974.

6. Gould, G. "Help Wanted: 100,000 Laser Technicians". Lasersphere. July 15, 1972. pp. 100-11.

7. Guenther, A. "Answering the Call for Trained Laser Electro-Optics Technicians". Laser Focus. June, 1973.

8. Hull, D.M., and others. "Adaptability Through Modular Instructional Materials". Technical Education Reporter. Sept. - Oct., 1974. pp. 37-45.

9. Jones, J. "What Do You Do After You Purchase Your Laser". Optical Spectra. Nov., 1974. p. 6.

10. Pierson, J.D., and D.M. Hull. "Laser/Electro-Optics and the Technicians Who Handle It". Industrial Education. Dec., 1974. pp. 42-44.

11. Rockwell, R.J., "Growth in Technical Training". Lasersphere. p. 15.

12. Rockwell, R. J., "The Laser/Electro-Optics Technician". Lasersphere. March 15, 1972. p. 9.

C. Texas State Technical Institute, Harlingen, Texas - Implemented the Model Curriculum including all LEOT modules translated into Spanish/Bilingual versions. Ninety-five percent of the students attending this campus (located 25 miles from the Texas-Mexico border) are Mexican-Americans.

D. The University of Illinois - Incorporated more than 30 modules in a graduate level, laboratory course for engineers, physicists and chemists.

In September, 1973, a mail announcement consisting of a cover memo; a list of instructional modules and a reply form was made to approximately 2200 technical schools in the United States. The reply form had a requested return date of October 26, 1973. A second mailing was made in November to the institutions which had not replied to the first mailing.

By December, 717 replies had been received representing 33% of the total mailed, some 600 more than the expected return. The following is a breakdown as to the replies and types of data requested:

- 494 institutions requested additional information; 223 did not
- 55 institutions provide technical instruction as preparation for job requirements in Lasers
- 54 institutions provide technical instruction as preparation for job requirements in Electro-Optics
- 80 institutions provide technical instruction as preparation for job requirements in Optics
- 190 requests for a sample from Course 1
- 53 requests for a sample from Course 2
- 29 requests for a sample from Course 3
- 9 requests for a sample from Course 4
- 49 requests for a sample from Course 5
- 4 requests for a sample from Course 6
- 6 requests for a sample from Course 7
- 45 requests for a sample from Course 8

- 4 requests for a sample from Course 9
- 7 requests for a sample from Course 10
- 279 requests for the LEOT Curriculum and Equipment material
- 272 requests for Potential Employer Information
- 48% of requests for a module can be fulfilled with a module from Course 1
- 85% of requests for a module can be fulfilled with a module from Course 1, 2, 5 and 6
- 94% of requests for a module can be fulfilled with a module from 1, 2, 3, 5 and 8

Mailouts have been made to all those who responded, and the materials that were requested have been sent. Followup on these schools is continuing.

In August, 1974, a workshop was held for administrators and faculty who were interested in using the LEOT curriculum and/or instructional materials. The workshop was attended by twenty-two participants.

It was suggested by the Industrial Advisory Committee that less than half of the requirements for LEO Technicians was for new hires. A large percentage of the educational requirements involves the retraining and updating of existing employees. To meet these needs, TERC made significant efforts to have these materials used in "in house" industrial training programs and in short courses.

In July, 1973, TERC conducted a one week short course in Lasers for engineers and technicians at the Lawrence Livermore Labs. The instructional materials for the course consisted of selected LEOT modules from Course 1, 3 and 7. The presentations and lab demonstrations were videotaped.

For the past three years the University of Cincinnait has been using LEOT modules in their Laser Safety Short Course. In August, 1974, TERC, the University of Cincinnati, and the Laser Institute of America jointly sponsored a one week short course on "Introduction to Lasers". The content is the entire Course 1 of the LEOT modules. Morning sessions consisted of lectures and afternoons were devoted to the lab exercises outlined in the modules. This course will be offered twice in 1975.

In November, 1975, four LEOT modules were compiled for a one day Professional Advancement Course (PAC) presented by TERC and TSTI personnel. This PAC was held at the Laser Institute of America and the Society for Photo Instrumentation Engineers's National Meeting in San Francisco, California.

Table XI-2 lists the organizations who are currently using or are planning to use LEOT Project Materials. A more detailed explanation of LEOT dissemination activities in six organizations is provided in an article by Hull in the September/October issue of the Technical Education Reporter. This article is included in the Appendix to this report.

An attempt was made to obtain a publisher for the LEOT Project Materials and the Career Counseling Guides. In accordance with the terms of the Grant, notice was sent via Publishers Alert Service on a Request for Proposals. Separate requests were sent for the LEOT materials and the Counseling Guides. Four companies expressed an interest in only the Counseling Guides and three companies were interested in both. RFP's were sent to all parties who requested them.

A bidders meeting was held at the Marina Hotel of the Dallas/Fort Worth Airport on November 25, 1974. One bidder attended. On December 21, 1974, when all bids were due, none were received. Subsequent followup, a week later, revealed that, in general, all the organizations who had indicated an interest were currently financially limited and could not invest in new publication ventures that appeared to them to be limited in broad appeal.

TERC plans to continue to supply materials to interested individuals and organizations on a reimbursible basis.

Table XI-2

Organizations Who are Using or Planning to Use LEOT Project Materials

A: PROGRAMS ESTABISHED

	Institution	Type of Program	Total Students	Total Grads	Starting Salary Range
(1)	TSTI, Waco	Modified Model Curriculum	113	44	$6144-15,999
(2)	TSTI, Harlingen	Model Curriculum	20	--	---
(3)	San Jose City College	LEOT Option to Vacuum & Glassblowing	33	3	---
(4)	Idaho State Univ.	LEOT Option to Electronics	48	4	$9,000-11,000
(5)	Univ. of Illinois	Graduate Course for Engrs., Physicists, Chemists	--	--	---
(6)	Univ. of Cincinnati	Short Courses-Intro. to Lasers & Laser Safety	300	300	---
	Industry				
(1)	Lawrence Livermore Labs	Retraining			
(2)	Los Alamos Scientific Labs	Retraining			
(3)	Honeywell Research Labs	Retraining			
	Professional Societies				
(1)	Laser Institute of America	Professional Development Course	44 Students		

B.	PROGRAMS BEING PLANNED	TYPE PROGRAM	START DATE
(1)	University of Albuquerque	Night Courses	Fall '75
(2)	University of New Mexico (Northern)	Retraining	Fall '75
(3)	San Francisco City Coll.	EMT Option	Has not been determined
(4)	Springfield Technical Community College	Model Curriculum	Fall '75
(5)	Raymond Walters General and Technical College	Electronics Option	Fall '75
(6)	Univ. of Houston, Clear Lake Campus	Masters of Laser Tech.	Fall '75
(7)	Wentworth Institute	Three year curriculum	Has not been determined

APPENDIX

"Adaptability Through Modular Instructional Materials", *Technical Education Reporter*, Sept.-Oct., 1974, pp. 37-46

Adaptability Through Modular Instructional Materials

Daniel M. Hull, Technical Education Research Centers/Southwest

Daniel M. Hull received his BS from the University of Texas and his MS in Electrical Engineering from the University of Pittsburgh. He has thirteen years of experience as an engineer and manager of laser development and application at Lockheed, Sandia Corporation and Westinghouse. Mr. Hull is now manager of the Laser/Electro-Optics Technology Program at Technical Education Research Centers/Southwest in Waco, Texas.

Laser/Electro-Optics Technology requires flexible teaching materials for diverse educational options. The author introduces lasers, LEOT modules, and six differing educational programs.

The use of lasers spread rapidly after the first one was made operational in 1960. As a result, a demand emerged for a new kind of specialist—the laser/electro-optics technician. Responding to this need, the U.S. Office of Education gave Technical Education Research Centers (TERC) a grant for a project to analyze the new occupation and to develop a curriculum and instructional materials for it.

By means of an occupational analysis, the project confirmed that a variety of technicians were working with lasers. These technicians frequently were involved with other kinds of electro-optical systems as well. Moreover, the project found that not only technicians, but also engineers and other professionals were seeking a better understanding of the hardware and laboratory practices associated with lasers. Although there were certain tasks performed by almost all of these personnel concerned with lasers, many other activities were common to only a few places of employment.

To take account of the diversity of personnel and tasks, educational programs in this new field had to vary significantly in character and content. Two-year programs in laser/electro-optics technology (LEOT) were an evident need, for example, and so were laser options within existing programs in Vacuum and Glassblowing Technology and in Electronics. Furthermore, laboratory laser courses were attractive potential additions to baccalaureate and graduate level studies in physics and engineering. Also needed were short courses and industrial in-house training programs with laser information for employed technicians and professionals.

The challenge faced by the LEOT curriculum developers was to devise instructional materials for use in all these settings. To be adaptable to such a diversity of learning environments, the materials had to be both *flexible* and *valid.*

WHAT ARE LASERS

The laser is a device which converts electrical power into a special beam of light power This beam results from "Light Amplification by Stimulated Emission of Radiation," or LASER. A laser beam differs from ordinary light in several ways:

- it is directional and collimated so that it spreads very little as it propagates through space. For example, a laser beam transmitted from the earth illuminates an area on the moon less than two miles in diameter Since the beam diffuses so little, the intensity within the beam remains high.
- its light waves do not vary significantly in length. Therefore, laser light has the purest color of any light source known to man.
- its light waves are "in phase," so laser communications systems can transmit many wide-band signals with minimal interference problems.
- its energy can be concentrated into an extremely short duration pulse to produce tremendously high bursts of light power. This power can cause explosive effects by rapidly heating materials to several million degrees.

Various types of lasers are in use, differing in their construction and methods of operation. They have output wavelengths ranging from the ultraviolet to the visible region and extending to the far infrared. Some lasers are small enough to be held in the hand and have an output power less than a flashlight Other lasers occupy 10,000 square foot buildings and are powerful enough to melt holes through thick metal plates.

As heat sources, lasers are employed in welding or drilling materials and in repairing eye retinas. In surgery or clothing manufacturing, they can serve as precise cutting tools, while they are information transmitters in radar and communication systems Lasers are also used for aligning objects and measuring distances in such fields as highway construction. Grocery stores and other merchandizing establishments are beginning to experiment with computer linked lasers which scan the prices of items on automatic check-out counters. Among its many uses, the laser even has a photographic application in non-destructive testing of objects and in art, it can produce a "hologram"—a negative from which a three-dimensional object can be reconstructed.

A MODULAR APPROACH

To assure flexibility. TERC chose a modular approach to curriculum development Modules are short instructional units with clear and measurable learning objectives. Although short films are sometimes used to convey the unit of information, modules are usually based on booklets They can include laboratory exercises to provide "hands-on" experience, in fact, laboratory learning can be the key element of each module as in the LEOT modules developed by the project.

Typically, modules begin with a statement of the topic to be covered, then present the information, and conclude with questions to test the student's understanding of the material. No previous knowledge is assumed in most modules. They are independent units which might be arranged and rearranged to produce a great variety of courses.

If the modules are valid, they effectively and efficiently teach the student what he or she needs to know to be able to work competently in a remunerative and satisfying job. Not only must the materials foster learning, but they must also have *relevant* content. They must present information which reflects what employers want their technicians to know and be able to do.

In the case of TERC's LEOT Project, a national Industrial Advisory Committee consisting of sixteen members identified the duties normally expected of technicians working with lasers. An occupational survey confirmed these duties and continued guidance from the Advisory Committee ensures current validity.

The duties of the Laser/Electro-Optics technician are many. They construct systems in which the laser is an important component and keep lasers clean, aligned and calibrated. They also select and purchase LEOT hardware, including such specialized instruments as interferometers and spectrophotometers. In addition, the LEO technician must have considerable expertise in operating laser systems and performing exacting tests and measurements. Monitoring, troubleshooting and repairing laser systems are among the technician's other responsibilities.

These duties were subsequently broken down into 155 specific tasks for which learning objectives were established. The objectives formed the basis for the subject matter of the modules. A total of 101 modules were carefully developed and grouped into the following ten courses

Course #1	Introduction to Lasers (11 modules)
Course #2	Geometrical Optics (11 modules)
Course #3	Laser Technology (11 modules)
Course #4	Experimental Optical Methods (9 modules)
Course #5	Wave Optics (11 modules)
Course #6	Laser and Electro-Optics Components (11 modules)
Course #7	Laser/Electro-Optics Devises (10 modules)
Course #8	Laser Applications (10 modules)
Course #9	Laser Projects (7 modules)
Course #10	Laser/Electro-Optics Measurements (8 modules)
Plus	2 modules on lab notebooks and measurement accuracy

The technical accuracy of these modules was then checked by members of the Industrial Advisory Committee, and by two experienced technical editors. Validity was obtained by incorporating "hands-on" learning experiences which used laboratory equipment typical of that found in the organizations which employ LEO technicians. The effectiveness of these modules was subsequently verified through pre- and post-tests conducted with students in the pilot LEOT program at the Texas State Technical Institute in Waco, Texas.

A two-year Model LEOT Curriculum is being tested at TSTI. However, schools which implement LEOT instructional materials are cautioned that both the Model Curriculum and the LEOT course content are based on broad, national needs, and might not adequately represent local demands. They are accordingly urged to form their own Industrial Advisory Committees for setting educational objectives and choosing the LEOT Modules relevant to their local needs.

OPTIONS

For instance, the LEOT program at San Jose City College is skill-oriented in response to the character of its student body and the needs of local employers. By introducing several groups of LEOT modules into the college's existing program in Vacuum and Glass-blowing Technology, it became possible to offer a laser/electro-optics option. The San Jose students can now obtain the skills necessary for various entry-level jobs depending on how much of the two-year program they complete. (This program and the others sketched here are elaborated in the descriptions which follow.)

In contrast, the Technical School of Idaho State University has elected to initiate a Laser/Electro-Optics option in its Electronics Technology Program. It should be emphasized that a complete two-year laser program is not necessary to provide students with LEOT skills useful in the world of work. Employers or research institutions which incorporate a laser or electro-optical device as a component of a larger instrument or system (e.g. transmitter for a radar system) find the laser/electro-optics option in an electronics program to be especially attractive.

Selected LEOT modules can also be included as texts in physics and engineering laboratories. The University of Illinois at Urbana has successfully experimented with this use of the LEOT modules since last fall. In addition the modules have been used effectively in short courses which attempt to familiarize a wide variety of students with the laser and its many applications. The one-week courses in Introduction to Lasers and in Laser Safety given at the University of Cincinnati are important examples of how the modules can be used to advantage for intensive training.

Employers engaged in training or retraining personnel can also benefit from the modular approach. Current examples of this are the AEC Contractor Laboratories - Sandia, Los Alamos, and Lawrence Livermore Labs—where major workforce shifts into the development of high power lasers and the use of lasers for generating electric power have made substantial retraining necessary. The LEOT modules have facilitated this retraining.

LEOT MODULES POINT THE WAY

For over ten years, the laser and electro-optics field has had a shortage of trained technicians. With advent of the LEOT modules, both educational institutions and industry have been provided with teaching options that did not exist before. *The success of the modules has been due to their validity and flexibility, characteristics that have made them adaptable to a number of learning environments. Indeed, the modular approach may be the most effective for all technologies that have a diversity of applications. The use of modules in curriculum development will hopefully extend far beyond the Laser/Electro-Optics field.*

by Daniel M. Hull

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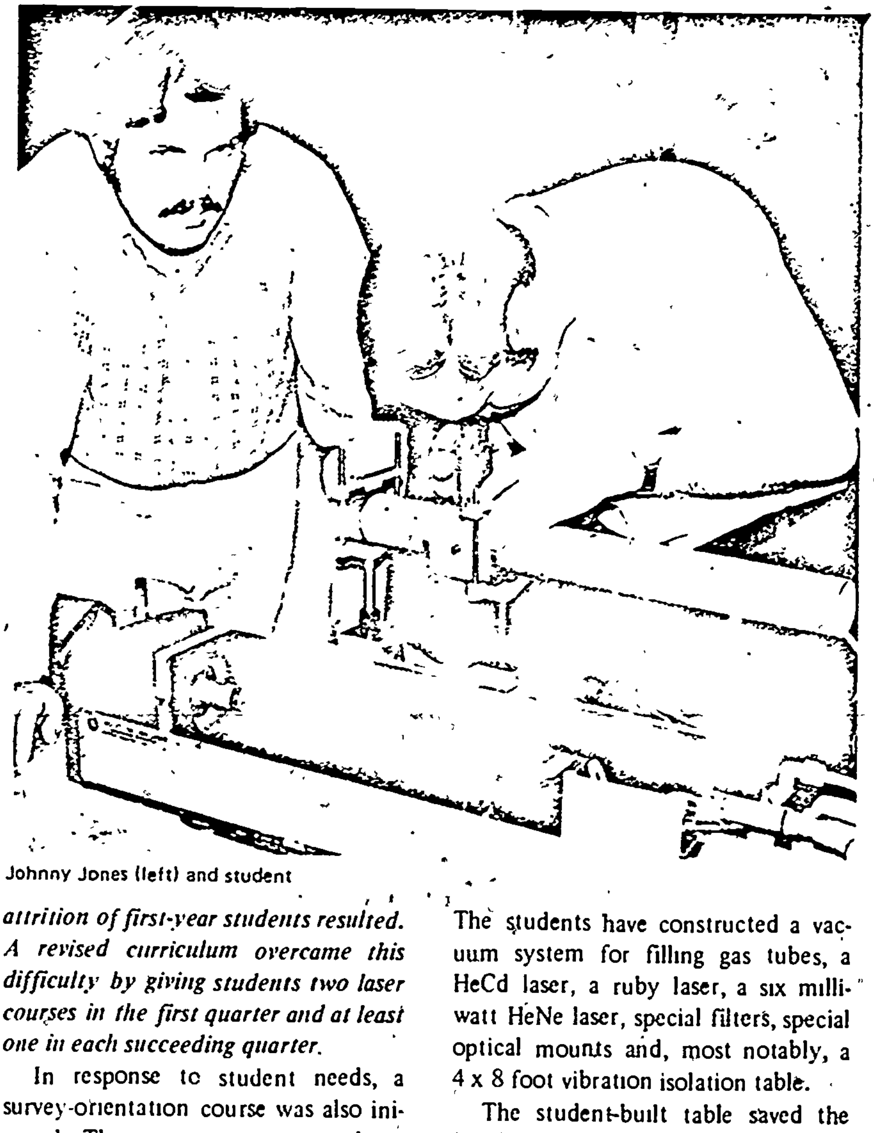
Motivated Students Innovate



Johnny Jones (left) and student

Johnny Jones, Texas State Technical Institute

Johnny Jones holds BS and MS degrees in Physics from Stephen F. Austin State University in Texas. After constructing a HeCd laser system for his thesis project, he joined the Laser Electro-Optics faculty at Texas State Technical Institute in Waco.

The Laser/Electro-Optics Department of the Waco Campus of Texas State Technical Institute (TSTI) first opened its doors to students in 1970. Since that time, the Department has grown to three technical faculty members and over one hundred students. The Department offers a two-year curriculum and an option of two additional years. Fifty graduates are currently employed in the laser and optics industries of ten states. Each two-year graduate has had several job offers with an average starting salary of $9300 annually.

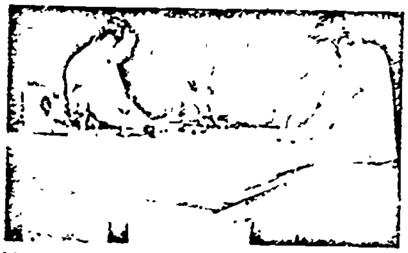
One of the reasons for the success of the TSTI-Waco program has been the constant scrutiny of its LEOT curriculum. A growing understanding of industrial needs, an increasing availability of text materials, and a willingness to listen to the needs of its students have all contributed to the development of the program.

A chief disadvantage of the original curriculum was that students did not take their first laser course until the third quarter. *Because first-year students had little contact with their major department, many became disenchanted with their major and a high attrition of first-year students resulted. A revised curriculum overcame this difficulty by giving students two laser courses in the first quarter and at least one in each succeeding quarter.*

In response to student needs, a survey-orientation course was also initiated. The course presents students with job descriptions and occupational opportunities in laser/electro-optics, and facilitates student adjustment to the TSTI campus.

Another course, "Laser Projects," is a favorite of many students. The course comes at the end of the two-year program and allows students to apply the knowledge and skills they have acquired to individual projects. Most projects involve design, construction, and evaluation of equipment. The students have constructed a vacuum system for filling gas tubes, a HeCd laser, a ruby laser, a six milliwatt HeNe laser, special filters, special optical mounts and, most notably, a 4 x 8 foot vibration isolation table.

The student-built table saved the LEOT program a considerable expenditure of funds. The table top consists of 2,200 pounds of concrete reinforced with steel, and rests on five legs made of concrete pier blocks. Damping is provided by layers of carpet between the blocks and by an inner-tube on the top of each leg. An air compressor and manifold provide pressure control for the tubes. The entire table was constructed for less than $150, equivalent commercial tables cost over two thousand dollars.



Making Holograms on a vibration free table built by students

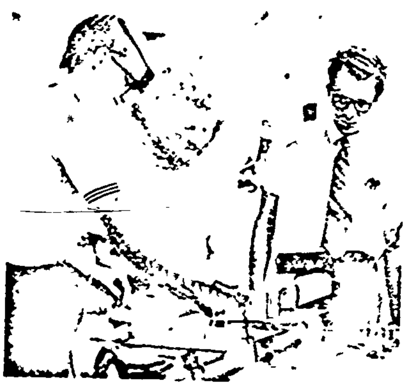
One of the most important assets of the LEOT Department has always been high student morale. In addition to the building and maintaining of equipment, student participation in classroom presentation clearly contributes to morale and the quality of instruction. *Yet perhaps the most important motivational factor is a clearly defined employment goal.* Graduates frequently visit the Department, speaking about their jobs, and members of the Industrial Advisory Committee and other representatives of employers often address the students on trends and opportunities in the field of lasers and electro-optics. Such exposure helps the student develop a realistic view of the career for which he or she is preparing.

By maintaining good relations with industry, the Department has been able to respond rapidly to changing manpower needs, as well as keep abreast of employment opportunities as they become available. An additional dividend has been the donation of equipment from organizations interested in the training of technicians.

The Laser/Electro-Optics Department at TSTI emphasizes job skills. A great deal of practical, hands-on laboratory experience is provided with exposure to as much of the industry as possible. While LEOT modules make up the major portion of most course materials, they cannot train technicians by themselves. They are an important and versatile tool when used in conjunction with other source materials, additional laboratory exercises, special projects, and contacts with industry. The key to a successful program is the maximum utilization of all resources available.

by Johnny Jones

An LEOT Option in Electronics



Richard R. Davis (right) and students

Richard R. Davis, Idaho State University

Richard R. Davis holds a BS and an EdM from Idaho State University. He has performed research in the field of laser communications and is the author of *AF and RF Circuit Approximations*. Mr. Davis is presently at the School of Vocational-Technical Education of Idaho State University.

Idaho State University offers a program in Laser/Electro-Optics technology which draws upon the already existing three year electronic technology curriculum. As an option within the electronics department, the LEOT program attempts to prepare a technician who is proficient in both electronics and laser/electro-optics.

All courses in the LEOT program are taught by faculty members of the Electro-Technologies programs. If a student needs a course in English, math or physics, the course is closely related to his or her total program. This can best be accomplished by faculty members who can approach related subject matter from an electronics, laser and optics standpoint.

Student projects are an important feature of every semester after the first three. Ranging from three to twelve weeks in length, these projects encourage the development of self-reliant technicians who can also work in teams. Students gain practice in working from engineering notes, in manual skills needed to implement ideas, and in writing final reports. These experiences reinforce theoretical concepts and introduce students to the kind of work they will be doing on the job.

The demand for technicians who combine a knowledge of LEOT with a sound electronics base far exceeds the supply. This type of graduate is preferred by companies which develop or utilize systems with laser components. Already over 75 companies have indicated an interest in employing the first ISU class of LEOTs.

by Richard R. Davis

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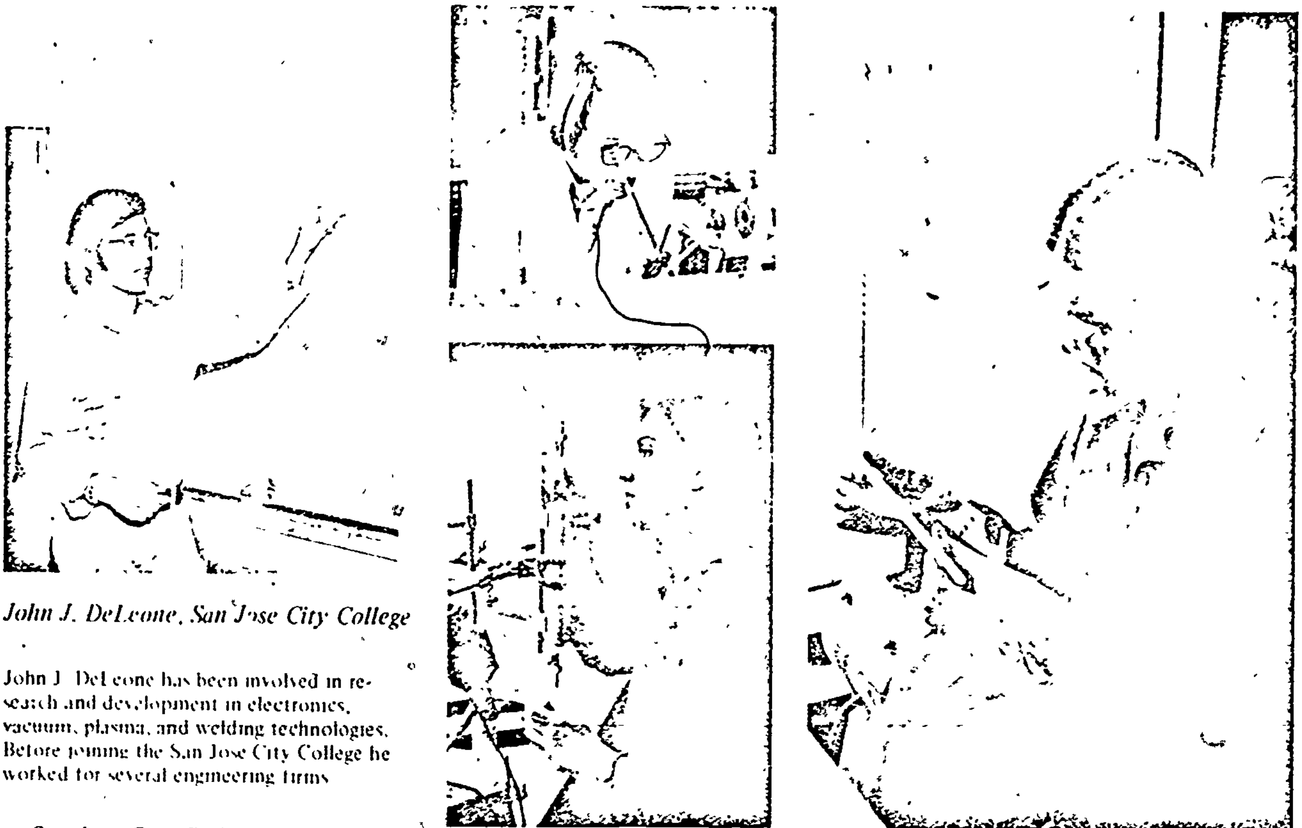
Adapting Facilities for Local Needs



John J. DeLeone, San Jose City College

John J. DeLeone has been involved in research and development in electronics, vacuum, plasma, and welding technologies. Before joining the San Jose City College he worked for several engineering firms.

San Jose City College is a two-year institution with no tuition charges and minimal entrance requirements. The school offers local residents a chance to acquire skills that will qualify them for better jobs.

One San Jose program with this objective is Vacuum Technology and Technical Glass Fabrication. The program, which has been operating since 1965, evolved in response to local work force needs. It boasts a well-equipped vacuum laboratory, and a complete facility for glass fabrication.

As the manufacturers of gas lasers became concentrated in the San Francisco Bay area, San Jose City College began investigating the feasibility of a laser technician training program. The school's existing Vacuum and Glassblowing Technology program seemed to offer an excellent base for the envisioned training effort. Vacuum systems and glassworking facilities are necessary for making, evacuating, filling and sealing gas laser tubes, as well as for growing crystals, coating mirrors, and developing semiconductor integrated circuits.

With the assistance of an Industrial Advisory Committee, an introductory course in laser technology was planned during 1973. In the spring of 1974, thirty-six students registered for the course. The composition of the first class is fairly representative of the student body at San Jose. Many of the course participants were veterans, five were full-time employees of local electronics firms, seven were women and six were physically handicapped.

Although some of the LEOT modules were appropriate for the introductory course, they had to be carefully selected and modified to meet the course objectives using existing laboratory facilities. Moreover, the majority of students, who entered the course unprepared for much of the theory, had to spend the first semester developing basic mathematic skills. The resulting course utilized some of the modules in LEOT course #1, but substituted glassblowing activities for the more difficult modules.

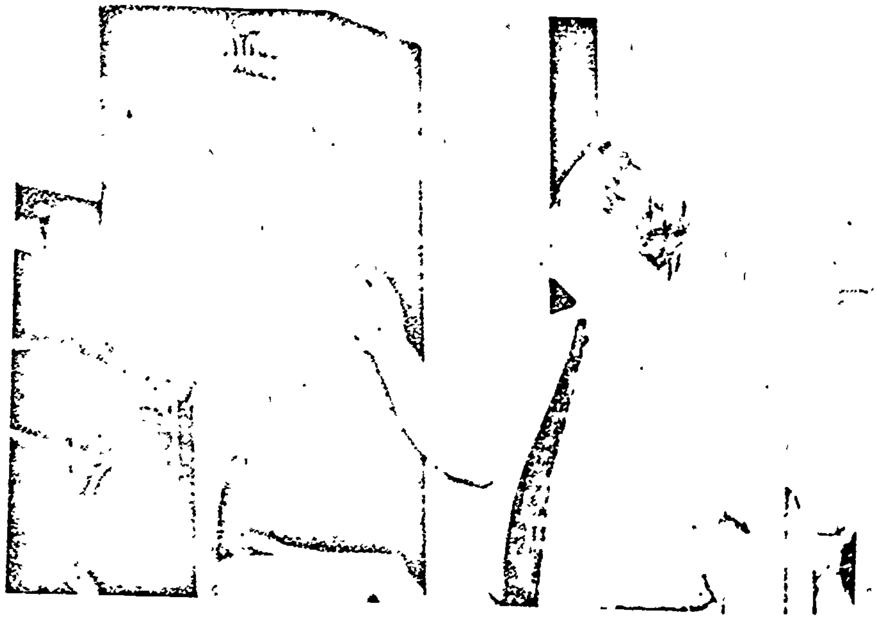
In general, the skills developed in the introductory course provided the student with the option to continue in the program, to seek another vocation, or to enter the industry as an assembler. Similarly, the expanded laser technology program, scheduled to begin in the spring of 1975, will encourage students to "spin off" and enter industry whenever they feel they are ready.

by John J. DeLeone

Module Use in Continuing Education

R. James Rockwell, Jr., University of Cincinnati

R. James Rockwell, Jr. received his BS and MS degrees in Physics from the University of Cincinnati. He is Directing Physicist of the Laser Laboratory at the Medical Center of the University and also is the current president of the Laser Institute of America. Mr. Rockwell has published numerous papers and is co-author with Dr. Leon Goldman of the recent book, *Lasers in Medicine*.



Two one-week courses in laser technology are offered as continuing education programs at the University of Cincinnati. These courses provide ongoing training for people who are working in jobs which require some knowledge of lasers and their applications. One of these two courses, "Laser Safety," has been given thirteen times during the last four years, and has been attended by over five hundred students. The average level of educational attainment of these attendees has been approximately four years of college. These students have represented industrial laser research, laboratories, government agencies, corporate or military safety units, and legal and insurance firms, to name only a few.

At its inception, the Laser Safety course was strictly lecture in format. Like most lecture courses, participants were inundated with facts and theories by the second day of the weeklong session. The use of a wide range of visual aids such as slides, films and closed circuit television have enhanced the continually-updated lectures. As the course evolved, however, student desire to have hands-on experience led to the present format, which includes some laboratory "workshop" sessions designed to reinforce the lecture material.

The workshop sessions concentrate on optical principles, laser measurement, hazard calculation, and control measures. They introduce students to the basic physical concepts of electro-optics and lasers, and then allow them to verify these principles in their laboratory work. In two of these sessions, LEOT modules are now used extensively to provide hands-on experiences with lasers and measurement equipment.

Due to the successful use of these modules in the safety short course, a second short course was planned relying primarily on the LEOT modules. The course, called "Introduction to Lasers," was given for the first time in July of 1974. Participants in this course included engineers and technicians from industrial and government laboratories using laser-related equipment, and teachers from two-year colleges considering the implementation of LEOT options in their programs.

The success of the modular concept in the continuing education program on laser technology suggests that the approach may be of value in similar programs at other institutions. It may, in fact, be the most appropriate way for orienting professionals from many fields to a specialized technical topic.

by R. James Rockwell, Jr.

LASER SAFETY

This symbol has become the universal signature for a laser beam. The United States requires that all lasers be labeled with this symbol and a safety classification, numbered one through four from least to most dangerous. Lasers range in power from those that can be safely viewed head-on to those which can melt steel.

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Laser Orientation for Graduate Students

Thomas A. DeTemple, University of Illinois at Urbana

Thomas A. DeTemple received his BS and MS degrees from San Diego State College and his PhD in Electrical Engineering from the University of California at Berkeley. He taught at the University of Arizona before joining the engineering faculty at the University of Illinois.

Thomas A DeTemple (right) with student

In 1973 a new laboratory course in Quantum Electronics was initiated in the Department of Electrical Engineering at the University of Illinois at Urbana. *The course was developed partly in response to student interest in lasers and partly because the Urbana faculty perceived the need to train students experimentally for research at the graduate level.* Twenty students participated in the course during its first year and the number of participants is expected to double this year.

Although the Department had previously offered three textbook courses in lasers both at the baccalaureate and the graduate level, the Quantum Electronics course was the first laboratory course in this subject area. The University of Illinois course also represents the first attempt in the United States to incorporate LEOT modules as a means of providing hands-on experience with lasers to advanced engineering students. The goals of the course are to illustrate the fundamental characteristics of lasers, to develop laboratory techniques, and to impart information regarding the use and misuse of lasers.

To attain these goals, the faculty had to attend to a wide variance in student backgrounds. In addition to an expected enrollment of students from the electro-mechanical disciplines, a significant number of chemistry, mining, and metallurgy students attended the course. There were some individuals who had no background in Quantum Electronics and others who were starting dissertation research in the field, all in the same course!

A partial solution to teaching this range of students was found in the LEOT modules. Since these were geared primarily for use in associate degree programs, they had to be considerably modified for use with advanced engineering students. Much of the material in the modules was incorporated into the laboratory notes as orientation information for experiments. Interestingly enough, even those students with a graduate level knowledge of Quantum Electronics found the inclusion of the modules to be helpful.

In order to quickly familiarize students with lasers, laboratory work begins by requiring students to assemble the equipment they will be using during the course. Coursework then proceeds to an integrated series of lectures and planned experiments. During the last third of the semester, students initiate individual projects, some of which consist of building important pieces of equipment. This segment of the course is expected to expand considerably as course enrollment grows and a greater amount of materials and equipment becomes available.

The expansion of the course in Quantum Electronics confirms the commitment of the University of Illinois to providing hands-on experience with lasers at the graduate and undergraduate levels. Other engineering schools might consider initiating development of similar programs. If the University of Illinois experience is generally valid, the LEOT modules can be most useful in developing these programs.

by Thomas A. DeTemple

Training LEOTs in Industry

Raymond M. Dovik (right), technician on left.

Raymond M. Dovik, Lawrence Livermore Laboratories

Raymond M. Dovik is Electronic Technician Supervisor in the Controlled Thermonuclear Reaction program of Lawrence Livermore Laboratories where he has been employed for 20 years. He was an electronics technician in the U.S. Navy and holds an AS in Electronics from Diablo Valley College in California.

At Lawrence Livermore Laboratories in Livermore, California, the development of laser-fusion for electrical power plants has been progressing steadily. The objective of the laser-fusion program is to develop a new, safer method of generating electrical energy from atomic power. A problem for the program is the scarcity of well-trained laser technicians.

None of the technical schools in the nearby community graduated highly-trained laser technicians, and very few even offered courses in optics. LLL initially solved this problem by hiring seven LEOTs graduating from Texas State Technical Institute. However, the fast-growing demand for this type of specialist at LLL and the availability of technicians without laser training suggested the need for an in-house training program as well.

A one-week exploratory training session held during the summer of 1973 resulted in the partial retraining of fourteen Livermore staff persons. LEOT instructional modules were used in this session. The flexibility of the modules enabled the training staff to choose only the material relevant to the specific objectives of the training session. Due to the success of this initial effort, the training program was expanded during the summer of 1974 to include 27 students. Among these were two electronic engineers engaged in laser research for controlled thermonuclear reactions, while the others were electronic or mechanical technicians.

Much of the success of the training program is due to the cooperation between the Livermore staff and the LEOT staff at TERC and the Texas State Technical Institute in Waco. LLL has received invaluable assistance in implementing the LEOT modules, and TSTI has gained insight into the needs of one potential employer of its graduates. *Such employer-educator cooperation is badly needed in technical education, and the Livermore-TSTI experiment deserves the attention of all those concerned about laser technology, as well as many other technical fields.*

by Raymond M. Dovik

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