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ABSTRACT

This report describes a program to prepare students for employment as laser technicians and laser operators and to ensure that they have the necessary skills required by the industry. The objectives are to prepare a curriculum and syllabus for an associate degree program in Electro-Optical Laser Technology. The 2-year Electro-Optical Laser program leading to an associate degree entails five courses. The first course, Introduction to Lasers, presents the theory of light and laser operation coupled with an overall view of laser properties. Following the basic course, a four-credit lecture/laboratory course called Geometrical and Wave Optics was developed, this presents the geometrical ray nature of light along with reflection, refraction, and propagation of light. The third course, Laser Measurements and Equipment, covers the use of specialized equipment for measuring laser parameters. The fourth course is a continuation of Laser Measurements and Equipment. The fifth course, Laser Projects and Practical Applications, concentrates on laboratory projects and applications. Five appendices provide detailed information on each of the five courses. Each course outline includes the following: (1) title; (2) course description; (3) suggested audience; (4) co-requisites; (5) course competencies; textbooks; (7) evaluation; (8) attendance requirements; (9) safety considerations; and (10) summary of topics/course outline. (NLA)

FINAL REPORT

ELECTRO-OPTICAL LASER TECHNOLOGY

CURRICULUM UTILIZATION

[redacted]

John H. Nawn

DELAWARE COUNTY COMMUNITY COLLEGE

Media, Pennsylvania 19063

May 1988

PENNSYLVANIA DEPARTMENT OF EDUCATION
BUREAU OF VOCATIONAL AND ADULT EDUCATION
CURRICULUM AND PERSONNEL DEVELOPMENT SECTION

I. Contents

II. Final Report

A. Abstract

1. Agency: Delaware County Community College
   Media, Pa. 19063

   Contract #: 85-6016

   Funding Period: July 1, 1987 - June 30, 1988

   Approved Funds: $ 8,207

In July 1987, Edwin Glasberg, Assistant Dean of Technologies, contacted John H. Nawn, adjunct faculty of Delaware County Community College and curriculum specialist for the technologies, concerning program development for a Laser/Electro-Optics Technology program. Some of the topics discussed were:

I. Need for a Laser/Electro-Optics program in the greater Philadelphia area.

II. Employment outlook including salary for graduates.

III. Formation of an advisory committee.

IV. The number and overall content of required courses.

2. **Statement of Purpose**

The Laser/Electro-Optics industry is expanding rapidly across the nation and, like so many other high-tech industries, it is plagued by a shortage of properly trained technicians. At present, there is one Laser/Electro-Optics technology program in the Philadelphia metropolitan area. The primary goal of this program is to expand the pool of Laser/Electro-Optics technicians and to ensure that they have the necessary skills required by industry.

3. Objectives Planned

To prepare a curriculum and syllabus for an associate degree program in Electro-Optical Laser Technology. This program would be designed to mesh with the existing Electronics Technology program so that a core of courses would be available as a basis for further work with lasers.
It was also intended to establish and use the input of an advisory committee for this subject area.

All objectives have been met.

4. Objectives Achieved

Initally four new technical courses were planned. When the project was completed, five courses were required and a two - year Electro-Optical Laser program leading to an A.A.S. degree was developed.

B. Financial Summary

see page 3.a

B. FINANCIAL SUMMARY

	Approved Budget	Actual Expenditure
Non-instructional Salaries:		
Project Administrator - Edwin Glasberg	$ 348.00	$ 348.00
Curriculum Specialist - John Nawn, 150 hrs./10 credit hrs. @ $355 per credit hr.	3,550.00	1,400.00
Faculty Coordinator - Joseph McGinn, 30 hrs. @ $26.60 per hour	800.00	800.00
Advisory Committee support @ $100/day	600.00	0.00
Clerical Staffperson - Unknown, $9.80/hr. x 80 hours	784.00	784.00
	6,082.00	3,332.00
Non-instructional Benefits:		
Project Administrator @ 27%	94.00	93.96
Curriculum Specialist @ 4%	142.00	56.00
Faculty Coordinator @ 30.75%	246.00	246.00
Clerical Staffperson @ 14%	110.00	109.76
	592.00	505.72
Other:		
Program materials, supplies, communications: Word processing paper and ribbons, photo copy paper/supplies, binders, postage, pads, pencils, telephone, etc.	400.00	400.00
Travel - advisory meetings, industry visits, school visitations, staff conferences 2,500 miles @ .21/mile	525.00	411.58
	925.00	811.58
Subtotal	7,599.00	4,649.30
Indirect costs @ 8%	608.00	371.94
TOTAL	8,207.00	5,021.24

III. Project Approach/Methodology

A. Materials Reviewed

1. Business/Industry Trends

The use of Electro-Optics Technology, both in industry and in research, has shown rapid growth in the past 10 years. Some studies have indicated the need for 360,000 laser technicians nationally by 1990. High technology industries tend to congregate in certain geographical areas. A recent report indicated that 83% of high technology manufacturing employment is located in only 24 states.[1] Since the laser industry is developing most dramatically in the heavily populated areas of the East and West Coast, these sections of the country appear to have the greatest employment opportunities.

Delaware County Community College has an Electronics Technology program in the Career Education Department. Therefore, the development of a laser program becomes a natural progression in curriculum development.

2. Philadelphia Area Employment Outlook

Current applications of laser technology are relatively new. Users of lasers can be found in the following industries: construction and excavation; machining; communications; surveying; testing and measurement; data processing; medicine and surgery; military; manufacturing; and research and development.

1. The State Role in Implementing a High Technology Program. National Workshop on High Technology Careers. John H. Lloyd, St. Louis, Missouri, December 2, 1982.

There are immediate job openings in this field for professionals in both technical and non-technical positions. Entry level salaries for a Laser/Electro-Optics technician reflect that of an engineering technician.

Salaries/Wages - 1987:

Phila. Area Ave. Starting Salary:	$15,600 to $18,200/yr.
Phila. Area Average Salary:	$23,400 to $28,400/yr.
Maximum Salary:	$33,800/yr.

ALL ENGINEERING TECHNICIANS

National Average Annual Salaries

Engineering Technicians 1	$16,881/yr.
Engineering Technicians 2-3	$20,312-$23,896/yr.
Engineering Technicians 4-5	$28,412-$32,718/yr.

Benefits and Working Conditions

1. Some laser technicians work in laboratory like conditions. Others are employed at construction sites, manufacturing plants, and hospital operating rooms.
2. Working conditions, in general, are good.
3. Most technicians work a five day, 40 hour week.
4. The usual benefits are available: health and life insurance, paid holidays and vacations, and sick leave. In some cases, employers provide their employees with paid prescription, optical and dental plans.
5. Laser technicians often work as a team with engineers and scientists.

Disadvantages

1. The laser technician training program is difficult.
2. The work can be dangerous if safety procedures are not followed very closely.
3. Special eye protection must be worn when working around lasers.

Advancement Opportunities

Laser technicians with experience and ability, can advance to laser technologists. Some become field laser technicians, working outside the laboratory in business settings. Laser technicians usually need a two-year college degree or equivalent. Laser technologists need a four-year college degree.

B. Advisory Committee

Delaware County Community College uses an advisory committee in the development of its programs. The individuals who serve on the committee help to develop the curriculum content.

An advisory committee consisting of two industry experts, a faculty member from a leading university, and the curriculum specialist was formed. The Laser/Electro-Optics committee members are:

Joseph W. Romanek
Lasers & Optronics
King of Prussia, PA

Dr. Paul Maruska, Sr. Engr.
Electro-Optics Laboratory
General Electric Space Div.
Valley Forge. Pa.

John E. Mulholland, Ph.D.
Associate Professor
Villanova University
Villanova, Pa.

John H. Nawn
Curriculum Specialist
Adjunct Faculty
Delaware County Comm.College
Media, Pa.

IV. Project Summary

A. Products Produced

1. Curriculum and Course Development

It was decided that four courses were necessary to adequately cover the proposed Laser/Electro-Optics program. By late July 1987 the first course was drafted and a textbook was chosen. This course, Introduction to Lasers, is a four credit lecture course that presents the theory of light and laser operation coupled with an overall view of laser properties. (Appendix A) Following the basic course, Geometrical & Wave Optics, a four-credit lecture/laboratory course, was developed. It presents the geometrical ray nature of light along with reflection, refraction, and propagation of light. (Appendix B) The third course developed was Laser Measurements and Equipment, another four-credit lecture/laboratory course. This course covers the use of specialized equipment used to measure laser parameters. The fourth course, Laser Projects & Practical Applications, concentrates on laboratory projects and applications. (Appendix E)

A recommended program of studies leading to the A.A.S. Degree was developed in mid July 1987. Depending upon the individual student's educational and career objectives, 65 to 70 total credit hours will be required to obtain the Associate in Applied Science degree.

The advisory committee met on April 7, 1988. The committee reviewed the overall curriculum, the four

Laser/Electro-optics courses in detail, textbook selections, and suggested laboratory equipment. The committee decided to split the third course, Laser Measurements & Equipment, into two 3 credit courses, Laser Measurements & Equipment I (Appendix C) and Laser Measurements & Equipment II (Appendix D). It was determined that there was an insufficient amount of time to cover the material in one course. When all revisions were completed, the entire program was submitted to the college curriculum committee for internal approval.

2. Course Descriptions

TEL 401 INTRODUCTION TO LASERS. The theory of light and laser operation coupled with an overall view of laser properties, principles of operation and safety is presented in this course. The Helium Neon low power gas laser is studied in depth. Two hours lecture, four hours lab. 4 Credits

TEL 402 GEOMETRICAL & WAVE OPTICS. The first half of this course presents the geometrical ray nature of light through mathematical and graphical methods. Reflection, refraction, and propagation of light using wave optics theory is studied in the second half of this course. Two hours lecture, four hours lab. 4 Credits

TEL 403A LASER MEASUREMENTS & EQUIPMENT I. Support hardware and components are investigated. The student is required to understand the operation of specialized equipment. Two hours lecture, two hours lab. 3 Credits

TEL 403B LASER MEASUREMENTS & EQUIPMENT II. This course is a continuation of Laser Measurements & Equipment I. Beam manipulators, modulation, spectrometers, and interferometers are studied. Calibration procedures, measurements, and Q switching are also explained. Two hours lecture, two hours lab. 3 Credits

TEL 404 LASER PROJECTS & PRACTICAL APPLICATIONS. Using lecture, carefully combined with demonstrations and laboratory sessions, practical applications, fabrication methods, and special materials are studied. The emphasis in this course is laboratory projects. One hour lecture, six hours lab. 4 Credits

3. Electro-Optical Laser Technology Program

The Laser/Electro-Optical Technology Program prepares graduates for employment as laser technicians and laser operators in industry.

All graduates of the Electro/Optical - Laser Technology Program should be able to:

---- operate laser systems
---- identify the malfunctions in laser and optical instruments and systems
---- repair non-functioning laser and optical instruments and systems
---- test input/output parameters of laser systems
---- fabricate and assemble components for laser and optical devices
---- present technical information in oral, written or graphic form

The Associate in Applied Science degree is awarded at the completion of this program.

FIRST YEAR

<u>First Semester</u>	<u>Sem.-Hrs.</u>
English Composition I ENG 100	3
*Technical Mathematics I MAT 110	3-5
Introduction to Lasers TEL 401	4
Electric Circuits TEL 101	4
Total	14-16

<u>Second Semester</u>	<u>Sem.-Hrs.</u>
Geometrical & Wave Optics TEL 402	4
*Technical Mathematics II MAT 111	3-5
A.C. Analysis TEL 102	4
**Technical Physics I PHY 100	3
English Composition II ENG 112	3
Total	17-19

SECOND YEAR

First Semester	Sem.-Hrs.
Technical Physics II	
PHY 101	3
Laser Measurements & Equipment I	
TEL 403 A	3
Laser Measurements & Equipment II	
TEL 403 B	3
Electronics I	
TEL 110	4
Social Science	
Elective	3
Total	16

Second Semester	Sem.-Hrs.
Laser Projects & Practical Apps.	
TEL 404	4
Electronics Elective	
TEL	3-4
Electronics II	
TEL 111	4
Digital Electronics	
TEL 121	4
Humanities Elective	3
Total	18-19

Total Hours Required: 65-70

*MAT 140, 141 or MAT 160, 161 may be elected instead.
**PHY 110, 111 or PHY 131, 132 may be elected instead.

V. Attachments/Appendices

Appendix A - TEL 401 Introduction to Lasers

Appendix B - TEL 402 Geometrical and Wave Optics

Appendix C - TEL 403A Laser Measurements & Equipment I

Appendix D - TEL 403B Laser Measurements & Equipment II

Appendix E - TEL 404 Laser Projects/Practical Applications

APPENDIX A

DELAWARE COUNTY COMMUNITY COLLEGE

Career Education

1. Title: Introduction to Lasers (TEL 401)   4 Credits

2. Course Description: The theory of light and laser operation coupled with an overall view of laser properties, principles of operation and safety is presented in this course. The Helium Neon low power gas laser is studied in depth.

3. Suggested Audience: Laser/Electro Optical Technology Students

4. Co-requisits: Math 110, TEL 101

5. Course Competencies:

COMPETENCY 1: Laser Fundamentals

In order to attain this competency, the student should be able to:

1.1 describe the properties of laser light and stimulated emission

1.2 sketch the basic elements of several types of lasers

1.3 understand and use the required the safety precautions for operating low power lasers

1.4 safely operate a HeNe laser

1.5 calculate the power of a laser beam

1.6 use a photoelectric power meter

1.7 describe eye damage caused by laser emissions

1.8 determine the eye hazards involved from reflections and emissions

COMPETENCY 2: Emission, Propagation and Absorption of Light

In order to attain this competency, the student should be able to:

2.1 define frequency, wave length, period, phase, and polarization

2.2 draw and label a plane-polarized electromagnetic wave

2.3 understand the significance of Brewster's angle and calculate Brewster's angle given the index of refraction

2.4 sketch plane and spherical wave fronts

2.5 describe temporal and spatical coherence

2.6 use a grating spectroscope to measure wavelength

2.7 explain the stimulated emission of a photon by an atom

2.8 determine the wavelength, frequency, and energy of a photon

2.9 observe and compare the absorption spectra of Nd:YAG and Nd:glass

COMPETENCY 3: Lasing Action - Modes of Operation

In order to attain this competency, the student should be able to:

3.1 understand absorption coefficient and the exponential law of absorption

3.2 calculate the transmission property of a filter given the optical density

3.3 explain normal population distribution and inversion

3.4 for a typical laser emission line, sketch gain vs wavelength

3.5 sketch the energy level diagram of a laser

3.6 measure the transmission properties of colored filters at the HeNe laser wavelength

3.7 draw a diagram of an optical cavity and explain the losses in the cavity

3.8 determine the gain and output power as a function of time for pulsed and CW lasers

3.9 explain the advantages and disadvantages of different laser cavities

3.10 sketch the longitudinal modes in a laser system

3.11 clean and align an open cavity HeNe laser

COMPETENCY 4: The Temporal and Spatial Characteristics of Lasers

In order to attain this competency, the student should be able to:

4.1 define pulse duration, repetition rate, and peak power

4.2 understand normal, Q-switched, and mode locked laser pulses

4.3 sketch amplifier gain, loop gain, and power vs time in a Q-switched laser

4.4 understand mode-locking

4.5 determine frequency bandwidth of laser output and longitudinal coherence length

4.6 measure the temporal output characteristics of a pulsed laser

4.7 draw some transverse electromagnetic modes of a laser

4.8 discuss the significance of the TEMoo mode in lasers

4.9 sketch and label the irradiance of the TEMoo mode as a function of beam width

4.10 calculate diffraction-limited beam divergence and determine beam divergence angle

4.11 discuss the near field and the far field of a laser

4.12 measure transmission through a calibrated aperture

COMPETENCY 5: Helium-Neon, Argon, Ruby and Other Lasers

In order to attain this competency, the student should be able to:

5.1 describe the energy transfer process and superradient lasing

5.2 calculate the helium and neon gas pressures for maximum power output of a HeNe laser

5.3 sketch a voltage versus current curve for a HeNe laser

5.4 describe the failure mechanisms of HeNe lasers

5.5 discuss the operation and efficiency of various lasers including HeNe, Argon, CO_2, Ruby, Nd:YAG

5.6 list the types of gases used as the active media of lasers

5.9 understand applications of semiconductor lasers

6. Textbooks: Introduction to Lasers
   Laser/Electro-Optical Technology Series Vol.1
   Center for Occupational Research & Development

7. Evaluation: How will the grade for the course be computed?

Tests	60%
Laboratory	20%
Homework/Final	20%

8. Attendance Requirements: Students are expected to attend all class sessions of courses in which they are enrolled. A student who misses more than the number of meetings per week of a class may, on the recommendation of the instructor, be dropped from the course with a grade of W.

9. Safety Considerations: Students are urged to dress appropriately, exercise caution in the laboratory, and wear eye protection.

10. Summary of Topics/Course Outline:

	Chapter	Weeks
Elements and Operation of a Laser	1	1.5
Elements and Operation of an Optical Power Meter	2	0.5
Introduction to Laser Safety	3	0.5
Properties of Light	4	2
Emission and Absorption of Light	5	1
Lasing Action	6	2
Optical Cavities and Modes of Operation	7	1.5
Temporal Characteristics of Lasers	8	1
Spatial Characteristics of Lasers	9	1
Helium-Neon Gas Laser - A Case Study	10	1.5
Laser Classifications and Characteristics	11	1.5
Review		1

APPENDIX B

DELAWARE COUNTY COMMUNITY COLLEGE

Career Education

1. <u>Title:</u> Geometrical & Wave Optics (TEL 402) 4 Credits

2. <u>Course Description:</u> The first half of this course presents the geometrical ray nature of light through mathematical and graphical methods. Reflection, refraction, and propagation of light using wave optics theory is studied in the second half of this course.

3. <u>Suggested Audience:</u> Laser/Electro Optical Technology Students

4. <u>Pre-requisites:</u> Introduction to Lasers (TEL 401)

5. <u>Course Competencies:</u>

COMPETENCY 1: Geometrical Ray Nature of Light

In order to attain this competency, the student should be able to:

1.1 discuss the properties of light rays

1.2 trace the path of light rays at plane and spherical surfaces and predict the direction of reflection on plane and spherical surfaces

1.3 understand the principles of refraction, reflection and color dispersion

1.4 determine the relative and absolute index of refraction

1.5 determine the refraction angle at plane and spherical surfaces using the graphical ray tracing techniques

COMPETENCY 2: Optical Systems

In order to attain this competency, the student should be able to:

2.1 through a series of sketches, define a thin lens, converging lens and diverging lens

2.2 identify the following lens: equi and plano convex, positive and negative meniscus, equi and plano concave

2.3 determine the primary and secondary focal points of various lenses through analytically, graphical, and experimental methods

2.4 define field stop and aperture stop

2.5 determine the exit pupil, the entrance pupil, and aperture stop for two lenses analytically and graphically

2.6 illustrate the principle of a simple magnifier and calculate lateral and angular magnification

2.7 sketch different types of laser beam expanding collimators

2.8 illustrate a ray tracing procedure for an optical system

COMPETENCY 3: Light Fundamentals

In order to attain this competency, the student should be able to:

3.1 describe and measure the irradiance of a point source of light

3.2 identify different types of spectra

3.3 produce line, band, and continuum spectra using a spectral source

3.4 differentiate between radiometry and photometry

3.5 draw and explain the standard luminosity curve

3.6 nderstand spectral photometric and spectral radiometric quantities

3.7 measure irradiance and illuminance for a HeNe laser

COMPETENCY 4: Wave Optics - Reflection and Refraction

In order to attain this competency, the student should be able to:

4.1 differentiate between geometrical and wave optics

4.2 discuss wave parameters including wavelength, frequency, wave number, and wave speed

4.3 understand Huygen's principle

4.4 develop by construction, reflected and refracted plane waves using Huygen's principle

4.5 state the laws of reflection and refraction

4.6 use Fresnel's equation for the percentage of light reflected from a di-electric surface

4.7 explain the law of reflection and refraction at a di-electric interface

COMPETENCY 5: Light Attenuation

In order to attain this competency, the student should be able to:

5.1 explain laser propagation through the atmosphere

5.2 discuss beam irradiance, absorption coefficient, transmittance, and optical density

5.3 determine absorption coefficient and measure the transmittance of a laser beam through a material

5.4 define Raleigh, Mie, and diffraction scattering mechanisms

5.5 understand interference and explain the importance of coherence in the interference process

5.6 understand diffraction and distinguish between Fraunhofer and Fresnel diffraction

5.7 sketch several Fraunhofer diffraction patterns

5.8 discuss the meaning of Rayleigh's criterion for determining the limit of resolution

5.9 define diffraction-limited optics

5.10 produce, using several different openings, the far field diffraction pattern of a laser beam

COMPETENCY 6: Polarization and Holography

6.1 determine the difference between natural and polarized light

6.2 understand linear, circular, and elliptical polarization of light

6.3 explain how polarized light is produced

6.4 determine the effect of wave retarders on polarized light

6.5 determine the state of polarization of light of unknown polarization

6.6 sketch a laboratory arrangement that can be used to produce a hologram of a three-dimensional object

6.7 make a hologram of a three-dimensional object and reconstruct the virtual image

6. <u>Textbooks:</u> Geometrical Optics
Laser/Electro-Optical Technology Series Vol.2
Center for Occupational Research & Development

Light Sources and Wave Optics
Laser/Electro-Optical Technology Series Vol.5
Center for Occupational Research & Development

7. <u>Evaluation:</u> How will the grade for the course be computed:

Tests	60%
Laboratory	20%
Homework/Final	20%

8. <u>Attendance Requirements:</u> Students are expected to attend all class sessions of courses in which they are enrolled. A student who misses more than the number of meetings per week of a class may, on the recommendation of the instructor, be dropped from the course with a grade of W.

9. <u>Safety Considerations:</u> Students are urged to dress appropriately, exercise caution in the laboratory, and wear eye protection.

10. Summary of Topics/Course Outline:

	Chapter	Weeks
Reflection and Ray Tracing	2-1	1
Principles of Refraction	2-2	1
Refraction and Ray Tracing	2-3	0.5
Imaging With a Single Lens	2-4	1
Imaging With a Multiple Lens	2-5	0.5
F Stops and Apertures	2-6	0.5
Optical Systems	2-7	1.5
Matrix Optics	2-8	0.5
Light Sources and Their Characteristics	5-1	1.5
Radiometry and Photometry	5-2	0.5
Wave Nature of Light	5-3	1
Reflection and Refraction	5-4	1
Propagation	5-5	1
Interference	5-6	0.5
Diffraction	5-7	0.5
Polarization	5-8	1
Holography	5-9	0.5
Review		1

APPENDIX C

DELAWARE COUNTY COMMUNITY COLLEGE

Career Education

1. Title: LASER MEASUREMENTS & EQUIPMENT I (TEL 403A)
   3 Credits

2. Course Description: The theory and operation of specialized equipment used to measure laser parameters is studied. Support hardware and components are investigated.

3. Suggested Audience: Laser/Electro Optical Technology Students

4. Pre-requisites: Geometrical & Wave Optics (TEL 402)

5. Course Competencies:

COMPETENCY 1: Support Hardware and Components

In order to attain this competency, the student should be able to:

1.1 Understand the performance of optical tables and benches and recognize when a bench or table is suitable

1.2 name the classes of optical benches and list the advantages and disadvantages of each

1.3 align an optical bench parallel to an optical axsis established by a laser beam

1.4 investigate the vertical and horizontal vibrations in an optical table

1.5 select, recognize and use many types of component mounts

1.6 calculate the linear resolution of piezoelectric and differential-screw micrometer translators

1.7 set up an optical system to expand, collimate, reflect and disperse a light beam

COMPETENCY 2: Electro-Optical and Laser Components

In order to attain this competency, the student should be able to:

2.1 describe the characteristics of optical windows and the principles employed for the selection, specification and use of these windows

2.2 demonstrate a knowledge of windows and flats

2.3 understand the limitations and applications of various mirror types

2.4 compare the advantages and disadvantages of front and rear surface mirrors

2.5 predict the effect of several neutral density filter combinations on the power output of a HeNe laser

2.6 divide an optical beam into several components using a beam splitter

2.7 discuss classes of prisms and understand their applications

2.8 draw ray diagrams through prisms showing image inversion, reversal and rotation

2.9 identify and demonstrate a knowledge of lenses

2.10 construct a simple beam expander using two positive lenses

2.11 differentiate between ruled gratings and holographic gratings

2.12 calculate the wavelength of light incident upon a grating

2.13 experimentally determine the plane of polarization of several types of polarizers

2.14 generate the visible second harmonic of the invisible Nd:YAG laser wavelength

COMPETENCY 3: Detectors

In order to attain this competency, the student should be able to:

3.1 understand the theory of operation and application of basic photoemissive, photoconductive, photovoltaic devices, and related devices

3.2 calculate the shot noise current from a photodiode detector

3.3 measure the absolute responsivity and linearity of a photodiode detector

3.4 demonstrate a knowledge of optical power meters

3.5 describe the strength and effect of optical radiation using both the radiometric and photometric systems

3.6 sketch a block diagram of a laboratory power/energy meter and discuss the function

3.7 calculate the output energy of a pulsed laser using peak power measurements and pulse shape

COMPETENCY 4: Instrumentation & Techniques - Photographic and Holographic

In order to attain this competency, the student should be able to:

4.1 understand the techniques of oscilloscope photography necessary to record repetitive and non-repetitive events

4.2 discuss the characteristics and applications of image converters, image intensifiers, and high speed camera systems

4.3 explain the operation of a simple infrared image converter

4.4 operate a Q-switched laser and photographically record the pump pulse and laser pulse output

4.5 using the measured values of pulse shape and energy output, calculate the peak power output of a Q-switched laser

4.6 demonstrate a knowledge of holographic instrumentation

4.7 define split beam transmission and reflection holograms and sine grating holograms

4.8 explain with a sketch how the intensity of the reference beam may be adjusted using a diverging lens, a neutral density filter or another beam splitter

4.9 reduce noise using beam blocks and spatial filters

4.10 produce a split beam transmission hologram

6. <u>Textbooks:</u> Laser and Electro-Optic Components
Laser/Electro-Optical Technology Series Vol.6
Center for Occupational Research & Development

Laser/Electro-Optic Devices
Laser/Electro-Optical Technology Series Vol.7
Center for Occupational Research & Development

7. <u>Evaluation:</u> How will the grade for the course be computed:

Tests	60%
Laboratory	20%
Homework/Final	20%

8. <u>Attendance Requirements:</u> Students are expected to attend all class sessions of courses in which they are enrolled. A student who misses more than the number of meetings per week of a class may, on the recommendation of the instructor, be dropped from the course with a grade of W.

9. <u>Safety Considerations:</u> Students are urged to dress appropriately, exercise caution in the laboratory, and wear eye protection.

Summary of Topics/Course Outline:

	Vol.	Chap.	Weeks
Support Hardware & Components	6	1-2	1
Photographic Recording Mediums	6	3	1
Windows, Mirrors, Flats, and Filters	6	4-6	3
Prisms and Lenses	6	7-8	2
Gratings and Polarizers	6	9-10	2
Non linear Materials	6	11	1
Detectors	7	1-2	1
Photography & Holography	7	3-4	1
Review			1

APPENDIX D

DELAWARE COUNTY COMMUNITY COLLEGE

Career Education

1. Title: LASER MEASUREMENTS & EQUIPMENT II (TEL 403B)
   3 Credits

2. Course Description: The theory and operation of specialized equipment used to measure laser parameters is studied. Calibration procedures, measurements, and Q switching are also explained.

3. Suggested Audience: Laser/Electro Optical Technology Students

4. Pre-requisites: Laser Measurements & Equipment (TEL 403A)

5. Course Competencies:

COMPETENCY 1: Beam Manipulators

In order to attain this competency, the student should be able to:

1.1 discuss how the autocollimator is used to determine flatness, straightness, parallelism, and precision angular measurements

1.2 explain how to align spherical mirrors with an autocollimator

1.3 obtain a well collimated beam of light using a simple collimator and a light source

1.4 align a laser with the autocollimator

1.5 discuss the fundamentals of spatial filtering and the characteristics of beam expanders

1.6 discuss Galilean and Keplerian beam expanders

1.7 explain the need for spatial filtering of a laser beam

1.8 list sources of spatial noise in a laser beam

1.9 calculate the angular divergence and the diameter of the focal spot of an expanded beam

1.10 align a spatial filter

1.11 demonstrate a knowledge of optical isolators

1.12 describe the Faraday rotation effect

1.13 demonstrate the rotation of the plane of polarization of a HeNe laser using a Faraday rotation device

1.14 understand how a bleachable dye functions as an optical isolator

COMPETENCY 2: Modulators I - Mechanical & Bleachable Dye

In order to attain this competency, the student should be able to:

2.1 discuss the operation of a bleachable dye Q-switch

2.2 understand the mode-locking phenomenon

2.3 calculate the minimum pulse duration in a mode locked pulse train

2.4 discuss the properties of several different Q-switches

2.5 explain light beam deflection using mechanical methods

2.6 discuss the advantages and disadvantages of mechanical light beam deflectors

2.7 operate a ruby laser with a bleachable dye Q-switch

COMPETENCY 3: Modulators II - Electro-Optic, Acoustic-Optic, and Mode Locking

In order to attain this competency, the student should be able to:

3.1 discuss the operation and application of electro-optic devices

3.2 understand the phenomenon of birefringence

3.3 explain the advantages and disadvantages of electro-optic devices

3.4 calculate the transmission of an electro-optic modulator for radiation from a HeNe laser

3.5 discuss the operation and application of acoustic-optic devices

3.6 explain the advantages and disadvantages of acousto-optic devices

3.7 calculate the angle of deflection of a light beam and the number of resolvable spots for an acousto-optic light beam deflector

3.8 explain how an acousto-optic device can be used either as a modulator or as a detector

3.9 compare the output of a mode locked laser and that of a non-mode locked laser

3.10 sketch and explain the pulse train produced by a mode locked pulsed laser

3.11 discuss the operation of the acousto-optic mode locker and the saturable absorber mode locker

3.12 calculate minimum pulse duration, pulse repetition time and number of oscillating modes

COMPETENCY 4: Spectrometers, Monochromators, and Spectrophotometers

In order to attain this competency, the student should be able to:

4.1 demonstrate a knowledge of prism and grating spectrometers

4.2 calculate resolving power and dispersive power of both types of spectroscopes

4.3 align a prism spectrometer

4.4 explain the basic components of a monochromator and its use

4.5 set up a monochromator to view light from both spectral line sources and broadband sources

4.6 discuss the techniques used to obtain the absorption spectrum of a liquid

4.7 experimentally determine the percent transmission and the absorbance as a function of wavelength for a material

4.8 list applications of spectrophoto meters

COMPETENCY 5: Interferometers

In order to attain this competency, the student should be able to:

5.1 explain the operation and applications of the Michelson, Fabry-Perot, Twyman-Green, and Mach-Zehnder interferometers

5.2 determine the wavelength of a spectral line and the difference in wavelength between spectral lines

5.3 experimentally compare the coherence length of the green light of mercury and the red light of a HeNe laser

5.4 discuss the difference between the simple plane mirror and the spherical mirror Fabry-Perot interferometers

5.5 determine and/or reduce the line width of an optical source using a Fabry-Perot interferometer

5.6 align and use the Twyman-Green interferometer to test for imperfections and optical inhomogenieties

5.7 explain why the Mach-Zehnder instrument is the most suitable to study airflow around models of aerodynamic structures

5.8 measure the index of refraction of a gas

COMPETENCY 6: Consumer Equipment

In order to attain this competency, the student should be able to:

6.1 discuss the operation of consumer equipment including laser compact disks and laser printers

6.2 explain the advantages and disadvantages of laser based consumer equipment

6.3 evaluate the various types of equipment used by consumers

6.4 troubleshoot and repair the equipment

6. Textbooks:

Laser/Electro-Optic Devices
Laser/Electro-Optical Technology Series Vol.7
Center for Occupational Research & Development

Laser/Electro-Optic Measurements
Laser/Electro-Optical Technology Series Vol.10
Center for Occupational Research & Development

7. Evaluation: How will the grade for the course be computed:

Tests	60%
Laboratory	20%
Homework/Final	20%

8. Attendance Requirements: Students are expected to attend all class sessions of courses in which they are enrolled. A student who misses more than the number of meetings per week of a class may, on the recommendation of the instructor, be dropped from the course with a grade of W.

9. Safety Considerations: Students are urged to dress appropriately, exercise caution in the laboratory, and wear eye protection.

Summary of Topics/Course Outline:

	Vol.	Chap.	Weeks
Beam Manipulators	7	5-7	3
Modulation I	7	8	1
Modulation II	7	9-11	3
Spectral Measurements	10	1-3	3
Interferometers	10	4-7	3
Consumer Equipment (Laser compact disks, laser printers, etc.)			1
Review			1

APPENDIX E

DELAWARE COUNTY COMMUNITY COLLEGE

Career Education

1. Title: LASER PROJECTS & PRACTICAL APPLICATIONS (TEL 404)

4 Credits

2. Course Description: Using lecture, carefully combined with demonstrations and laboratory sessions, practical applications, fabrication methods, and special materials are studied. The emphasis in this course is laboratory projects. One hour lecture, six hours lab. 4 Credits

3. Suggested Audience: Laser/Electro Optical Technology Students

4. Pre-requisites: Laser Measurements and Equipment (TEL 403)

5. Course Competencies:

COMPETENCY 1: Welding, Cutting, and Drilling

In order to attain this competency, the student should be able to:

1.1 list the advantages and disadvantages of laser welding

1.2 calculate the penetration depth of heat into a metal

1.3 using a ruby laser, weld two wires together

1.4 using a CO_2 laser, weld two lucite sheets together

1.5 list the system elements necessary for laser welding

1.6 list the advantages and disadvantages of laser hole drilling

1.7 cut thin pieces of plastic and measure the cutting rate

1.8 scribe a line on a ceramic surface and break the material along this line

1.9 drill holes in metal targets, calculate and measure the hole depth

COMPETENCY 2: Data Recording and Display

In order to attain this competency, the student should be able to:

2.1 sketch and describe a bit-oriented optical memory

2.2 describe a holographic optical computer memory

2.3 compare bit-oriented and holographic optical memories

2.4 explain optical processing

2.5 discuss the limitations of optical display systems

2.6 describe the operation of the ferroelectric-photoconductor sandwich devices and calculate the transmission of the ferroelectric material

2.7 given the laser power and area of display, calculate the brightness of the display

2.8 construct and demonstrate a display system using a laser

COMPETENCY 3: Environmental and Non Destructive Testing

In order to attain this competency, the student should be able to:

3.1 draw a laser system for monitoring air quality

3.2 describe how pollutant composition and concentration can be measured using absorption spectroscopy

3.3 compare Raman scattering to optical radar techniques for measuring air pollutant concentrations

3.4 identify and measure the concentration of air pollutants using Raman scattering

3.5 discuss optical heterodyne techniques

3.6 name four laser systems that can be used to measure ambient air pollution

3.7 explain the desirable and undesirable features of nondestructive optical testing

3.8 describe how diffraction and scattering techniques are used in measurements

3.9 discuss holographic interferometry and applications of various types

COMPETENCY 4: Range Measurement, Angle Tracking, and Alignment

In order to attain this competency, the student should be able to:

4.1 describe range measurement techniques in CW and pulsed laser systems

4.2 draw the waveforms for a pulsed ranging system and identify the transmitter pulse, the receiver pulse and the transit time

4.3 calculate the maximum pulse rate and minimum received power for a non-cooperative ranging system and the maximum frequency and received power for a CW system

4.4 operate a GaAs laser diode pulsed ranging system

4.5 discuss the techniques by which electro-optical systems can be used in alignment systems

4.6 draw a diagram illustrating the rotation of an optical axis in elevation and in azimuth

4.7 describe the following types of position sensitive detectors: quadrant photodiode, silicon position sensor, image dissecting photomultiplier, vidicon, and scanning mirror angle tracker

4.8 operate a laser angle tracking receiver employing a silicon position sensor

COMPETENCY 5: Medical & Fiber Optic Applications

In order to attain this competency, the student should be able to:

5.1 discuss the phenomenon of absorption of laser light by human tissue

5.2 calculate the depth of tissue penetration and the temperature rise resulting from laser exposure

5.3 explain the treatment of eye defects using photocoagulation methods

5.4 describe the use of acoustic holography to evaluate internal body structures

5.5 understand the operation of clad glass fiber in transmitting light

5.6 calculate the maximum angle between a light ray and the axis of a glass fiber given the indices of refraction

5.7 discuss the use of fiber optic bundles in medicine

5.8 illuminate and view the interior of a structure using fiber optics

COMPETENCY 6: Lasers in Communication and Construction

In order to attain this competency, the student should be able to:

6.1 demonstrate the knowledge of an optical communication system with a block diagram

6.2 understand CW and pulsed optical transmitters and receivers

6.3 define analog and digital modulation

6.4 sketch the modulating signal and the modulated carrier in AM, FM, and PAM systems

6.5 describe the sources of noise in optical receivers

6.6 measure signal to noise ratios and bit error rates

6.7 describe the use of a low power HeNe laser in surveying, pipe and building alignment, and heavy equipment guidance

6.8 make a topographic profile of a given area

6.9 align sections of pipe to a prescribed grade

COMPETENCY 7: Projects

In order to attain this competency, the student should be able to:

7.1 use his own ingenuity to solve a variety of design problems and to fabricate a system from drawings and schematics

7.2 maintain a complete and accurate account of project results and progress in a laboratory notebook including drawings, schematics, data, calculations and photographs

7.3 design and fabricate a working, student built laser or other electro-optic device from the material in CORD Course #9 or other sources as approved by the instructor

6. <u>Textbooks:</u> Laser Applications
Laser/Electro-Optical Technology Series Vol.8
Center for Occupational Research & Development

7. Evaluation: How will the grade for the course be computed:

Tests	60%
Laboratory	20%
Homework/Final	20%

8. Attendance Requirements: Students are expected to attend all class sessions of courses in which they are enrolled. A student who misses more than the number of meetings per week of a class may, on the recommendation of the instructor, be dropped from the course with a grade of W.

9. Safety Considerations: Students are urged to dress appropriately, exercise caution in the laboratory, and wear eye protection.

Summary of Topics/Course Outline:

	Chap	Weeks
Welding, Cutting, and Drilling	1&2	2.5
Data Recording and Display	3&4	2.5
Environmental and Nondestructive Testing	5&6	2.5
Measurements, Tracking and Alignment	7&8	3
Medical Applications	9	1
Fiber Optic Applications	–	1
Communications and Construction	10&11	2
PROJECTS	Vol. 9 all	Sem.
Review		1