Practical Hands on Program in Laser/Optics Technology

Shen-Yuan Chou[a], Wai-Min Liu[*b]

[a]National Huwei Institute of Technology, 64 Wunhua Rd., Huwei Yunlin 63208, Taiwan ROC

[b]Pasadena City College, 1570 E. Colorado Bl., Pasadena Calfornia 91106, USA

ABSTRACT

Practical hands on program philosophy and ideas will be discussed. This program was planned and carried out in three Taiwan technical colleges as well as one junior college in USA and in a four year university BS degree program. The products and successes from this program and curriculum will be discussed in detail. What are the best topics and opportunity areas in optics and photonics to meet the broader social and industrial needs will be discussed.

Keywords: Optics, education, curriculum, courses, laser

1. BASIC PHILOSOPHY

Wai-Min Liu graduated from California State University, Northridge, specialized in Physics in 1968. Working on laser/optical engineering field for seven years. He has a dream to develop laser/optics technology two years certificated program for technician and four year optical engineering BS degreed program. The courses, he took in colleges and graduate school, did help him to become successful optical engineers and scientist are only few. Such courses did give him the fundamentals to learn new and updated technology by himself. In laser/optical engineering field, an optical engineer/scientist from time to time very often works in different and new sub-field such as detector, laser, optical testing, optical design, ...,etc.. To be a successful optical engineer/scientist, he should be able to switch from one sub-field to another sub-field assignments without too much formal training. Therefore a successful laser/optical technology curriculum should provide a student the following training : (i) a few important and fundamental laser/optical engineering courses to enable the student to learn new project and sub-fields. (ii) projects in each course to develop a student independent ability to study on their own. (iii) projects to encourage students to work in a team environment. The most important idea is to teach a student to have ability to learn on his/her own without formal teacher in the future. Chinese sayings stated we need 100 years to find out the results of successful educational program. We need 10 years to find out the results of planting a tree. However, due to the technology advancements, the product (trained technician & engineer) from developed curriculum & program have been proved to be successful and useful to the society as a whole within 20 years. The names of a few graduates from the developed curriculum and their success will be listed later in this article.

2. TWO YEAR LASER/OPTICS TECHNOLOGY CURRICULUM

As a practicing senior optical engineer/scientist at Xerox, TRW, JPL and Rockwell, Wai-Min Liu found out the most important and useful mathematics are algebra and Trigonometry. Based upon the four year optics program at University of Rochester, Two year laser/optics technology curriculum was formulated with geometrical optics, wave optics, laser fundamental, and algebra/trigonometry as major and core courses. Such laser electro-optics technology curriculum/program and courses are listed in the following :

2.1. Laser Electro-Optics Technology

This curriculum prepares students for careers in Laser Electro-Optics Technology. The Pasadena City College sequence will provide flexible options: (1) early preparation for an entry-level job in the laser industry with work experience credit for those students who find such a job; (2) careful training in program-solving and modern techniques of laser electro-optics technology; (3) a basis for continuing education beyond the Associate in Arts degree upgrading the skills of those currently employed; (4) students who wish to transfer as Laser Physics or Electro-Optics Engineering majors should major in Physics

*Correspondence: Email: wliu@controloptics.com; Telephone: 626-813-1991; Fax: 626-813-1993

In *Sixth International Conference on Education and Training in Optics and Photonics*, J. Javier Sánchez-Mondragón, Editor, SPIE Vol. 3831 (2000) • 0277-786X/00/$15.00

or Engineering and complete the basic Laser Electro-Optics courses (Laser 100, 101, 102, 103, 104, 106, 108).

2.2 The Program (Requirements for the Major)

Semester I (Recommended)		**Units**
Laser 100	Intro to Laser Tech	3
Laser 101	Math Applications of Laser Studies	4
Laser 110	Holography	2
Laser 122	Intro to Fiber Optics	1
Semester II		
Laser 102	Laser Optics	4
Laser 103	Computer Usage for Laser Technology	3
Elctry 9	Principles of Network Analysis (AC & DC)	6
Laser 124	Intro to Vacuum Technology	2
Semester III		
Laser 104	Laser Measurements	4
Laser 108	Optical Radiation Sources and Detectors	3
Elctrn 121A	Circuit Analysis	4
or 131A	Circuit Analysis	5
Laser 126	Laser Application of Metal Processing	1
Semester IV		
Laser 106	Laser Equipment and Applications	4
Laser 128	Laser Design and Construction	2
MP 14	Metal Working Fundamentals	2
or Elctrn 132	Digital and Control Electronics	4
Laser 131	Optical Control Devices	2

Recommended Electives : Eltctrn 132, 125/135, Physics 1A/2A, Machine Shop, Laser 111, 133,135.

The Laser Program provides equal opportunity for both men and women. Classes are offered days and evenings during the regular fall and spring semesters. Classes are offered evenings during summer sessions.

Pasadena City College Laser Electro-Optics Technology Program had been very successful from 1976 to 1995. Four hundred successful laser/optics technicians were trained and are working in laser/optics technology field. At Pasadena City College, we hired the part-time instructors from Electro-Optics industries. These part-time instructors have not only given the students the new updated technical information but also offered the students career opportunities. These are Win-Win arrangements.

Due to the successful PCC Laser Technology Program, the author Wai-Min Liu was invited to develop National Junior College Laser Electro-Optics Program for the Republic of China in 1986. In summer 1987, the author was invited to National Central University in Taiwan to arrange and teach the Laser Electro-Optics 10 weeks seminar to train 60 Junior College instructors to be laser Electro-Optics technology instructors. Dr. Peter Shih and President Wei-Chun Chen of Lien Ho College of Technology were the major driver and promoter of Laser/Electro-Optics Technology education in Republic of China. Especially Dr. Peter Shih have continuously given a lot research grants to Electro-Optics educator. Personally, the author consider Dr. Peter Shih is the father of Electro-Optics in Republic of China. Since 1988 three junior colleges in Republic of China have established Laser/Electro-Optics Technology Program. They are Lien Ho Junior College of Technology, Huwei Institute of Technology, and Taipei Institute of Technology. They provide more than 500 laser technicians a year.

2.3 Courses Description

Laser 100, Introduction to Laser Technology **3**
Elements, classifications and operation of light amplification by stimulated emission of radiation. Optical power measurements, theory of light, operating modes, coherence, gas laser case studies, safety.

Laser 101, Mathematical Applications of Laser Studies 4

Applications of mathematics in the fields of geometrical optics, physical optics, electro-optics, physics and other laser studies. Applications from algebra, trigonometry, analytical geometry, matrices and introductory calculus. Prerequisites : (1) High school algebra and (2) high school geometry. Recommended enrollment in or completion of Laser 100.

Laser 102, Laser Optics 4

Geometry optics : light rays, reflection, refraction, plane and curved boundaries. Optical components and systems. Laser optics : Gaussian profile of laser beams, intensity calculations, propagation, beam systems, holography. Prerequisite : Laser 100. Lecture 3 hours, lab 3 hours. Recommended enrollment in or completion of Laser 101.

Laser 103, Computer Design of Optical Systems 3

Basic optical system design of doublet, triplet and telescope systems. Fundamentals of third order aberrations, chromatic aberrations theory and error functions. Optical systems design software. Prerequisite : Laser 102 or equivalent.

Laser 104, Diffraction Optics and Laser Measurements 4

Diffraction optics theory and applications in laser measurements. Standard laser instruments and measurement techniques, spectral measurements, interferometric measurements, spatial resolutions. Prerequisites : Laser 101 and 102. Lecture 3 hours, lab 3 hours.

Laser 106, Laser Equipment and Applications 4

Theory and operation of devices to measure laser output parameters, to manipulate laser beams and to modulate lasers. Applications of lasers by specialized groupings. Prerequisites : Laser 104 and Elctrn 121A or 131A. Lecture 3 hours, lab 3 hours.

Laser 108, Optical Radiation Sources and Detectors 3

Basic physical relationships and mathematics of optical radiation and optoelectronics, photometric and radiation units, black bodies and Lambert radiators, laws of radiation, luminescence, photoemission phenomena and photoelectric effect detectors. Prerequisites : Laser 101 and 102.

Laser 110, Holography 1

Principles of the holographic process. Laser, coherence, laser safety, single-beam transmission holograms, time-lapse, time-averaged, sigle-beam and multi-beam holograms. 360 holograms and white light reflection holograms. Holographic systems and film processing. Lab 3 hours.

Laser 111, Holography with Dichromated Gelatin 1

Principles of dichromated gelatin holographic process. Single and multiple-beam white light transmission and reflection holograms. Preparation of dichromated gelatin plates. Prerequisite : Laser 110. Lab 3 hours.

Laser 122, Introduction to Fiber Optics 2

Principle and operations of fiber optic components and systems. Light guiding properties of optical fibers, light sources and transmitters, couplers, connectors, detectors, receivers and integrated devices. Various systems will be discussed with emphasis on telecommunications. Prerequisite : Laser 100 or equivalent. Lecture 3 hours, lab 3 hours.

Laser 124, Introduction to Vacuum Technology 2

Fundamentals of modern vacuum technology. Applications to optical coating. Prerequisite : Laser 100 or equivalent. Lecture 1 hour, lab 3 hours.

Laser 126, Laser Processing of Materials 3

Introduction to the field of materials processing with lasers. Designs and applications of various laser types : scientific, industrial, medical, military. Beam handling and conditioning equipment: lenses, mirrors, gratings. Ancillary equipment: material handling equipment, computerized controllers, roots. Safety considerations. Prerequisite : Laser 100 or equivalent.

Laser 128, Laser Design and Construction 2

Principles and techniques used in the design and construction of a laser. Individual experience in the planning, design and building of a laser. Prerequisite : Laser 100 or equivalent. Lecture 1 hour, lab 3 hours.

Laser 131, Optical Control and Measurement Devices **2**
Application of x-y translators and positioning devices and servo control techniques in optical positioning devices. Prerequisites : Elctrn 8A and enrollment in Elctrn 8B and Laser 102. Lecture 1 hour, lab 3 hours.

Laser 133, Medical Laser Applications **3**
Use of lasers in the field of clinical and research medicine. Applications in surgery, ophthalmology, pulmonary medicine, gynecology, phtobiology and cancer research. Prerequisite : Laser 100 or equivalent.

Laser 135, Semi Control Laser **3**
Principles of injection laser operations and materials. Optical fields and wave propagation in injection lasers. Heterojunctions. Advanced laser diode structure. Fabrication and operating characteristics. Applications of laser diode. Prerequisite : Laser 100 or equivalent.

3. FOUR YEAR OPTICAL ENGINEERING DEGREE PROGRAM

Due to the success of Laser Technology Graduates from PCC, we are requested to establish a four optical engineering BS degree program at an University. University of LA Verne was picked due to the fact that ULV is a small private university. Procedure and paper works to setup an optical engineering department and major are a lot easier than at a public and major institute and university. ULV was contacted in early 1983. Optical engineering major and department was established in September 1984, students were accepted to major in optical engineering. In June 1986, two students were awarded BS degree in optical engineering. They were Dawn Evans (now in Optical Research Assoc.) and William Dougherty (now in Boeing). The junior and senior level courses set-up are based upon the M.S. optics degree program at University of Arizona. As a matter of fact, we were using their text books for our classes. During courses teaching, we had stressed practical, laboratory hands on assignment rather than mathematical derivation as stressed by most graduate school teaching. Again, most instructors were hired from electro-optical industries. Vernon Spaulding and Wai-Min Liu shared chairmanship of the optical engineering department. The courses and curriculum of BS Degree in Optical Engineering are listed in the following :

3.1 Support Courses

1. Calculus I (4)
2. Calculus II (4)
3. Calculus III (4)
4. Advanced Eng. Math (4), or Approved Math. elective
5. Engineering Physics I (4)
6. Engineering Physics II (4)
7. Chemistry I (4)
8. FORTRAN (4)

Total: 32 semester units (Math 105, Pre-Calculus may be required of some freshmen (4).)

3.2 Core Courses : Completion of the following courses or equivalents, Optics/Laser Sciences

1. Op Eng 100 Introduction to Laser Sciences	3
2. Op Eng 102 Laser Optics	4
3. Op Eng 110 Holography	1
4. Op Eng 204 Diffraction Optics	4
5. Op Eng 206 Basic Opto-Electronics	4
6. Op Eng 208 Basic Radiometry	3
7. Op Eng 302 E-M Wave Foundations of Optics	3
8. Op Eng 308 Advanced Radiometry	3
9. Op Eng 320 Optical Systems Design	4
10. Op Eng 424 Advanced Diffraction Optics	3
11. Op Eng 440 Optical Testing and Measurement	4
12. Op Eng 499 Senior Seminar/Project (variable)	1-4
13. El Eng 150 Introduction to Electronics and Computer Engineering	4
14. El Eng 202 Introduction to Active Circuits	4

Total: 45-48 Semester Hours Minimum

3.3 Course Sequence : (Recommended)

Semester I	
Op Eng 100 Introduction to Laser Sciences	3
Op Eng 110 Holograph	1
Math 201 Calculus I	4
El Eng 150 Introduction to Electronics and Computer Engineering	4
General Education	4
Semester II	
Op Eng 102 Laser Optics	4
El Eng 202 Introduction to Active Circuits	4
Math 202 Calculus II	4
General Education	4
Semester III	
Op Eng 204 Diffraction Optics	4
Op Eng 208 Basic Radiometry	3
Phys 203 Engineering Physics I	4
General Education	5
Semester IV	
Op Eng 206 Basic Opto-Electronics	4
Math 311 Calculus III	4
Phys 204 Engineering Physics II	4
General Education	4
Semester V	
Op Eng 320 Optical System Design	4
Chem 201 General Chemistry I	4
Math – Advanced Eng. Math or Approved Math. Elective	4
General Education	4
Semester VI	
Op Eng 302 E-M Wave Foundations of Optics	3
Op Eng 308 Advanced Radiometry	3
Math 361 FORTRAN	4
General Education/(Electives)	9
Semester VII	
Op Eng 440 Optical Testing and Measurement	4
Op Eng 424 Advanced Diffraction Optics	3
General Education/(Electives)	9
Semester VIII	
Op Eng 499 Senior Seminar/Project (Variable)	1-4
General Education/(Electives)	12-15

3.4 Entrance Preparation

High school students preparing to study at AAIC/ULV for a career in optical engineering should take a balanced high school program. The following courses are particularly recommended :

1. College prep English, written and oral communication.

2. College prep mathematics, including intermediate algebra, trigonometry and plane geometry.
3. College prep laboratory science, including chemistry and physics.
4. College prep history and/or social science.

3.5 Graduation Requirements (Bachelor's Degree Program)

To receive a bachelor's degree from the American International College/University of La Verne, a student must complete the following :

1. A minimum of 128 total semester hours including all general education and major requirements.
2. A minimum of 32 semester hours at AAIC/ULV.
3. A minimum of 44 semester hours at the upper division level.

A minimum in Optical Engineering may be completed by 24 semester hours in the field of which 16 must be upper division (see Dept. chair for recommended courses).

3.6 Courses Description

Op Eng 100, Introduction to Laser Sciences **3**
Elements, classifications and operation of light amplification by stimulated emission of radiation. Optical power measurements, theory of light, operating modes, coherence, gas laser case studies, safety. GEPS.

Op Eng 102, Laser Optics **4**
Geometry optics : light rays, reflection, refraction, plane and curved boundaries. Optical components and systems. Laser optics : Gaussian profile of laser beams, intensity calculations, propagation, beam systems, holography. Lab.

Op Eng 110, Holography **1**
Principles of the holographic process. Laser, coherence, laser safty, single-beam transmission holograms, sigle-beam reflection holograms and 360 holograms. Holographic systems and film processing Lab.

Op Eng 204, Diffraction Optics **4**
Standard laser instruments and measurement techniques : spectral measurements, interferometric measurements, spatial resolutions. Lab.

Op Eng 206, Basic Opto-Electronics **4**
Theory and operation of devices to measure laser output parameters, to manipulate laser beams, and to modulate lasers. Applications of lasers by specialized groupings. Lab.

Op Eng 208 Basic Radiometry **3**
Basic relationships and mathematics of optical radiation and opto-electronics. Photometric and radiation units. Radiation sources, types of detectors, measurements and applications.

Op Eng 302 E-M Wave Foundations of Optics **3**
Electrostatic fields, dielectric media, currents and magnetic fields. Faraday's Law and the magnetic behavior of matter. Transient oscillations, filters, and transmission lines. Maxwell's Field Equations. Guided E-M waves. Relatively and electromagnetism.

Op Eng 308 Advanced Radiometry **3**
Review of E-M radiation based on Maxwell's Equations. Radiometric quantities, sources and propagation. Theory and application of Blackbody radiation. Advanced topics in radiometry. Classes of radiation detection, detection types and calibration. Prerequisites : Op Eng 208, Math 202.

Op Eng 310, Fiber Optics Communications (Optics and Lightwave Overview) **3**
Integrated optic waveguides. Fiber designs, coupling systems and evaluation. Light sources, modulation, distribution, optics communications, detection and noise evaluation. System design. Prerequisite : Op Eng 206.

Op Eng 314, Optical Engineering Mathematics 4

Mathematical methods of solution for geometrical optics, optical imaging, and diffraction optics problems. Includes ordinary and partial differential equations, matrices operations, complex analytic functions, sequences and series, probability and statistics, FOURIER series, and transforms in optical applications. Prerequisite : Math 202.

Op Eng 320, Optical System Design 4

Optical system and configuration design procedures for various types of lenses, mirrors, catadioptic laser electro-optics and telescope systems. Lab.

Op Eng 410, Thin Film in Optics 3

Optics of dielectric layers and basic design units. Optics of metals, systems of layers, general theorems and metal/dielectric design units. Synthesis of tuned multilayers, inhomogeneous layers and thick layer considerations.

Op Eng 420, Advanced Optical System Design 4

Advanced systems consideration and design. Optimization techniques and image evaluation in Code V. Laser raster output scanner system, optical disk system, imaging spectrometer system, gradient index optical system, holographic optical elements system design, MTF analysis. LAB Prerequisite : Op Eng 320.

Op Eng 424, Advanced Diffraction Optics 3

Diffraction studies with application using Fourier Synthesis techniques. Constructs theory of image formation, optical data processing, and holography based upon diffraction and Fourier series. Stresses design and practical applications of theory.

Op Eng 440, Optical Testing and Measurement 4

General concepts and procedures utilized in optical testing and measurements with emphasis on individual components and complete lenses or systems. Lab.

The optical engineering program department of ULV had awarded about 120 BS in optical engineering from 1984 to 1996. Most graduates from ULV have good career position with good pay. Their achievements and contribution to our society are very, very impressive!

4. THE GRADUATES AND PRODUCT FROM THE PRACTICAL HANDS ON PROGRAM

The graduates and product from the two Practical Hands on Programs are very impressive. They have made a lot of contribution to their families as well as to the community. In the following, the names, current position, and associations are listed. From the table, we can find out the field they are in are quite different from what they originally were educated. It has shown the programs have offered their training in independent learning.

Name	Graduated College/University	Current position	Current Association	Field
Andrew, Jeff	PCC	Laser Engineer	BECKMAN LASER INST/UCI	Medical Laser
Ang, Anthony	ULV	Sr Engineer	XEROX	Laser Scanner Design
Banh, Loi	PCC/ULV	Optical Engineer	POC	Fiber Optics
Bell, Steve	PCC	Engineer	UDT	Detector
Bossin, John	PCC	President/Owner	MACHINE OPTICS	Opto-Mechanics
Brown, Vernon	PCC	Sr Engineer	TELEDYNE	Fiber Optics
Cady, Geoffrey	PCC/ULV	Teacher	CRESTI High School	Education
Campbell, Michael	ULV	Sr Engineer	HUGHES	Optical Design
Chakigari, Agauni	ULV	Engineer	MELLES GRIOT	Optics/Laser
Chao, Andy	PCC/ULV	Field Engineer	CYMER	Excimer Laser
Chen, John	PCC/ULV	Vice President	ALPHA PHOTONICS	Semiconductor Laser
Chu, Nancy	PCC/ULV	General Manager	SOLTEC	Trade
Cobb, Steven	PCC	Engineer Technician	JPL	Optics
Coito, Jose	PCC	Project Engineer	JPL	Space Optics
Cook, David	PCC/ULV	Sr Optical Engineer	PERKIN-ELMER	Spectrometer

Name	Graduated College/University	Current position	Current Association	Field
Delcamp, Spencer	PCC/ULV	Project Engineer	ROCKETDYE	Optics/Laser
Diep, Joseph	PCC/ULV	Vice President	SEMCO	Semiconductor Laser
Dougherty, William	PCC/ULV	Scientist	BOEING	Integrated Optics
Duong, George	PCC	Packing Eng	ORTEL	Laser
Garcia-Nunez, Dawn	PCC/ULV	Project Engineer	OPTICAL RESEARCH ASSOCIATES	Marketing/Optical Design
Geraghty, Edward	PCC/ULV	Project Engineer	BAUSH &LOMB	IOL
Huang, Kang	PCC/ULV	Operation Director	CONTROL OPTICS	Laser Safety & Optics
Jiang, Paul	PCC/ULV	Vice President	AVANEX	Fiber Optics
Jimenez, George	PCC	Manager	UDT	Detector
Kadogawa, Hiroshic	PCC/ULV	Sr Optical Engineer	JPL	Optical Design
Kalindjian, Viken	ULV	Manager	TELEDYNE	Fiber Optics
Kunzler, Friedrich	ULV	Manager	OCA/CORNING	Aerospace
Moen, Jeff	PCC	Tech Support Manager	CYMER	Excimer Laser
Peterson, Joel	PCC/ULV	Vice President	WAVEFRONT TECH	Holography
Reyes, George	PCC/ULV	Engineer	JPL	Optical Testing
Rich, Chris	PCC	President	WAVEFRONT TECH	Holography
Taylor, Carolyn	PCC	Supervisor	ORTEL	Telecommunications
Tu, Chan	PCC/ULV	President/Chairman of Board	SEMCO	Semiconductor Laser
Valdez, Robert	PCC/ULV	Manager, Optics	MELLES GRIOT	Optics

5. CONCLUSION

We developed our curriculum based upon our educational concepts. We carried out our mission to produce our educational product–laser technician, optical engineer and entrepreneur. It had been proved successful. With the fast technology advancement, as educator, we need to train our student with independent learning ability to meet future needs. Basically, we need to train our student with capability to learn without teachers. Sometimes, this is a tremendous difficult task. As educator for year 2000, we should be happy to take on such challenge!

ACKNOWLEDGMENTS

During the development of PCC laser technology program and ULV optical engineering program, Vernon Spaulding was the most important contributor, driver and performer. Dr. Richard Meyers, president of former PCC president, and Dr. Norman Juster, former Chair of Physical Science offered a lot of encouragement in establish PCC laser technology program. Without Dr. Meyers and Dr. Juster's support, 400 trained laser/optics technician and 120 BS degreed optical engineer would not be educated. From 1986 to 1996, Dr. Bruce Carter had given a lot of support to PCC laser technology program. Dr. Armen Sakafian of former ULV president had given us a lot of support and encouragement.

In Republic of China, Dr. Peter Shih of National Electro-Optics Council and president Wei-Chun Chen supported the concept and development of laser electro-optics tech and optical engineering education in Republic of China (Taiwan).

REFERENCES

1. Pasadena City College, PCC Catalog 1985-1986, Pasadena, CA, 1985.
2. University of La Verne, ULV Catalog 1986-1997, La Verne, CA, 1986.
3. University of Rochester, UOR Catalog 1982-1983, Rochester, NY, 1982.
4. University of Arizona, UOA Catalog 1983-1984, Tucson, AZ, 1983.
5. V. Spaulding, "History of PCC Laser/Optics Technology," Private Communication, Pasadena, CA, 1984.