OP-TEC PHOTONICS CURRICULUM CATALOG

Leading the Development of Photonics Technicians in U.S. Community and Technical Colleges

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What is Photonics

Photonics is the technology of generating and harnessing light and other forms of radiant energy whose quantum unit is the photon. Photonics involves cutting-edge uses of lasers, optics, fiber-optics, and electro-optical devices in numerous and diverse fields of technology - alternate energy, manufacturing, health care, telecommunication, environmental monitoring, homeland security, aerospace, solid state lighting, and many others.

Why Photonics is Important

Rapid growth in the number and complexity of photonics and photonics-enabled technologies has caused the demand for technicians to exceed supply. The number of college degrees in engineering is decreasing, causing fierce competition for the relatively small pool of qualified optics technicians and engineers. The number of U.S. technician jobs in photonics and photonics-enabled technologies is expected to grow more than 800 per year on average.

Types of Photonics Technicians

<table>
<thead>
<tr>
<th>Photonics System Technician</th>
<th>Precision Optics Technician (POT)</th>
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</thead>
<tbody>
<tr>
<td><strong>Job Functions</strong></td>
<td>Integrating lasers and optics in system applications</td>
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<tr>
<td><strong>Need</strong></td>
<td>70%-80% of new photonics technician jobs. More than 800 new jobs per year</td>
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<tr>
<td><strong>Education</strong></td>
<td>AAS in Electronics + 2 - 4 courses in lasers and optics Core Curriculum: Electronics</td>
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<tr>
<td>OPTIONS:</td>
<td>Laser/Optics Integration OR Optical Fabrication</td>
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About OP-TEC | National Center for Optics and Photonics Education

The mission of the National Center for Optics and Photonics Education is to increase the supply of well-educated photonics technicians by building and strengthening the capacity and quality of photonics education in U.S. two-year colleges. OP-TEC is a consortium of two-year colleges, high schools, universities, national laboratories, industry partners, and professional societies funded by the National Science Foundation’s Advanced Technological Education (ATE) program.

Headquartered in Waco, Texas, OP-TEC serves secondary STEM programs and postsecondary programs devoted to lasers, optics, and photonics technology or technologies enabled by optics and photonics. In addition, OP-TEC provides support through curriculum, instructional materials, assessment, faculty development, recruiting, and support for institutional reform. OP-TEC serves as a national clearinghouse for teaching materials; encourages more schools and colleges to offer programs, courses, and career information; and helps high-school teachers and community and technical-college faculty develop programs and labs to technical content.

**OP-TEC Services:**

- Information about Photonics Technology and Technician Careers
- Technical Assistance in Program Feasibility and Planning
- Technical Assistance in Designing Laboratories
- Professional Development and Teacher Training About Photonics

**OP-TEC Materials**

OP-TEC has created employer-validated national skill standards, which provide specifications for curriculum and course content that can be adapted and adopted by two year colleges to educate and train optics and photonics technicians. The Center and its Partner Colleges have designed curriculum models, developed/tested teaching materials, and documented successful strategies to plan/implement quality programs and assure growth in student enrollment and completion rates. Information about these materials and their availability are described on pp 6-8 in this catalog.

OP-TEC teaching materials are designed to be used by students and faculty for specific courses that support OP-TEC’s curriculum models; however, these course materials each consist of 3-6 modules that can be used independently or in different groups to alter the content of a course. Photonics-Enabled Technology (PET) modules teach about specific applications of lasers and optics. PET modules are often combined with modules about specific lasers to make the instruction more relevant to current practice.

The following pages of this catalog describe curriculum models for infusing OP-TEC’s photonics courses into existing institutional programs (like electronics and manufacturing). This practice is commonly used because it builds on courses and resources that are already available, which make initiating photonics courses more cost effective for the institution. The models that are shown in the block diagrams have been validated by focus groups of photonics-industry employers and will prepare students for demand occupations; however, a college that is planning new photonics courses and programs may find that employers in its service area will require further “fine tuning” of the content to meet their local needs. OP-TEC is available to advise college administrators and faculty on appropriate changes to these models.

**OP-TEC Curriculum Guides**, which are also described in this catalog, provide useful information for using the course materials, including prerequisites, lab design, laser safety procedures, lab equipment specifications and sources. **Monographs** are also available which describe curriculum structures and successful strategies for program development and student recruitment that are currently being used by OP-TEC Partner colleges.
Electronics Program Infusion

Creating a Photonics Program from a Two Year Electronics Technology Curriculum

Photonics Systems Technicians (PSTs) work in industries whose processes and operations require the extensive use of photonics devices to meet production or mission goals. PSTs frequently integrate photonics devices or subsystems into larger systems where photonics is an enabling technology. PSTs have the responsibility of ensuring that these photonic devices operate within prescribed specifications and are compatible and/or complementary with the entire integrated system. These technicians must know how these photonic devices operate and interface with the equipment or systems in which they are embedded. They must also understand how photonics devices and subsystems enable equipment and systems to accomplish specific tasks.

Photonics devices and systems are typically composed of optics, electro-optics, and/or lasers that are imbedded in electronics and electro-mechanical systems. Photonics technicians must have broad, working knowledge and skills of electronic and electromechanical devices/systems, combined with their specialty knowledge and skills in photonics, to efficiently and effectively repair systems; operate, maintain, and calibrate photonics subsystems; and integrate these subsystems into full systems.
The diagram, shown to the left, describes curriculum pathways that infuse photonics courses on an existing electronics core. This strategy invigorates struggling electronics programs by providing preparation for careers in emerging technologies. The column on the left supports careers for Photonics Systems Technicians, an extremely high-demand job market. Other columns provide options that support employment in photonics-enabled technologies. These options also require a basic understanding of photonics and the applications within that specialty.

Building new, high-demand curricula by adding a few specialty courses enables colleges to strengthen enrollments and provide career opportunities for deserving students in a cost-effective manner, because the curricula utilizes existing equipment, laboratories, and faculty that are already in place. New photonics courses can be added with minor equipment/lab costs and taught by existing electronics faculty that receive training in OP-TEC professional-development, online courses. Completers of these programs typically receive an Associate Degree in Electronics Technology with a certificate in the specialty area.

- The courses shaded in beige can be constructed by teaching materials shown on pp. 6-7.
- “PET Modules” shown on p. 6 provide instruction that applies photonics to the job specialty.
- Information and guidelines for creating a Photonics Systems Technician program can be found in the Photonics Systems Technician Curriculum Guide listed on p. 6.

**OP-TEC Partners**

**Partner Colleges:** OP-TEC Partner Colleges (PCs) are highly experienced in educating photonics technicians and have highly qualified faculty with expertise in photonics curriculum development, lab design, laser-safety practices, and student recruitment. PCs assist OP-TEC to develop and test new curricula/teaching materials and provide technical assistance for colleges who are planning new courses and programs.

- Texas State Technical College
- Camden County College, NJ
- Irvine Valley College, CA
- Indiana University of PA

**Technical Societies:** Support OP-TEC and photonics colleges by providing student recruitment materials, grants and professional-development conferences.

- SPIE  www.spie.org
- Optical Society of America  www.osa.org
- IEEE/Photonics  www.photonicsociety.org
- Laser Institute of America  www.lia.org

**Photonics Regional Centers:** Described on back cover.

- LASER-TEC, Indian River State College, FL  www.laser-tec.org
- MPEC, Indian Hills Community College, IA
Creating a Photonics Program from a Two-Year Manufacturing Curriculum

Manufacturing Technology curricula are being revitalized by placing Laser Materials Processing Technology specialization courses on a manufacturing technology core curriculum.

Manufacturing Technology programs can be enhanced by infusing photonics courses to provide specializations for emerging technician careers. Building a Photonics Systems Technician specialty from a manufacturing technical core will enable completers to enter careers in manufacturing/materials processing that utilize lasers.

A Digital Manufacturing Specialty will prepare manufacturing technicians for careers that include optical sensors for precise measurement and control of manufacturing processes.

An Additive Manufacturing Specialty will enable completers to enter careers in the rapidly emerging fields of 3D printing, rapid prototyping and other forms of additive manufacturing.

Teaching materials for photonics courses shown in beige are listed on page 6.
Precision Optics Program Infusion

About Precision Optics

Precision optics is a critical U.S. industry from both an economic and security perspective, and precision optics technicians (POTs) are vital to the quality and future growth of this industry. These technicians produce, test, and handle optical components that are used in lasers and sophisticated electro-optical systems for defense, homeland security, aerospace, biomedical equipment, remote sensing, alternate energy production, and nanotechnology. Precision optics technicians also measure quality, add coatings, and integrate optical components into electro-optical systems.

In 2009, the National Center for Optics and Photonics Education (OP-TEC) conducted a study of POT employers to project the demand for new precision optics technicians. The findings of this study showed that 6,019 POT technicians were currently employed, and that the demand in five years would increase by 3,100 additional precision optics technicians.

Creating a Precision Optics Program from a Two-Year Manufacturing Curriculum

Manufacturing Technology programs can be enhanced by infusing precision optics courses to provide a high-demand program in Precision Optics Manufacturing and Testing. Students completing this program will enter rewarding careers in precision optics fabrication, testing, and integration.

Teaching materials for the following courses are shown in beige on pp. 6-7.

- Fundamentals of Light and Lasers
- Quality Assurance of Precision Optics
- Metrology of Optical Systems

Books for teaching the Fabrication of Precision Optics courses are also available from other sources.
Curriculum and Teaching Resources

Laser, Optics and Photonics Series

Course 1, Fundamentals of Light and Lasers (Available as interactive ebook) $75 ($60 ebook)
Course 1, Fundamentals of Light and Lasers, is a comprehensive study of photonics that was specifically written for AAS/AS students enrolled in enabling technology programs or for employed technicians working in these same areas.

Course 2, Laser Systems and Applications $90
Course 2, Laser Systems and Applications, is a two-semester course that deals with specific photonics systems and applies the principles presented in Course 1, Fundamentals of Light and Lasers.

Photonics Systems Technician Curriculum Guide Free Download
The purpose of the Photonics Systems Technician Curriculum Guide is to support implementation and successful teaching of the Photonics Systems Technician (PST) program and courses. The Guide contains some information to help colleges plan new PST programs; but most importantly, the Guide provides assistance to faculty who will be developing laboratories and teaching the three courses in the PST curriculum.

Modules in Photonics Enabled Technologies Free Download
Photonics involves cutting-edge uses of lasers, optics, fiber-optics, and electro-optical devices in numerous and diverse fields of technology—manufacturing, health care, telecommunication, environmental monitoring, homeland security, aerospace, and many others. The applications of photonics as an “enabling” technology are extremely broad.

• Modules in Manufacturing
  • Laser Welding & Surface Treatment
  • Laser Material Removal: Drilling, Cutting, & Marking
  • Lasers in Testing and Measurement: Alignment Profiling and Position Sensing
  • Lasers in Testing and Measurement: Interferometric Methods and Nondestructive Testing

• Modules in Forensic Science and Homeland Security
  • Lasers in Forensic Science & Homeland Security
  • Infrared Systems for Homeland Security
  • Imaging System Performance for Homeland Security Applications

• Modules in Biomedicine
  • Lasers in Medicine & Surgery
  • Therapeutic Applications of Lasers
  • Diagnostic Applications of Lasers

• Modules in Environmental Monitoring
  • Spectroscopy & Remote Sensing
  • Spectroscopy & Pollution Monitoring

• Modules in Optoelectronics
  • Photonics in Nanotechnology
  • Photonic Principles in Photovoltaic Cell Technology
  • Photonics in Nanotechnology Measurements: A Study of Atomic Force Microscopy
Precision Optics Series

Two of the courses in the POT curriculum are Quality Assurance of Precision Optics (QAPO) and Metrology of Optical Systems. These courses can be infused into OP-TEC’s Photonics Systems Technician curriculum to prepare technicians to measure the quality of precision optics and integrate them into laser and other electro-optics systems. The full AAS degree Precision Optics Technician curriculum is built on a manufacturing technology core, and prepares technicians who can not only perform the tasks described earlier, but also fabricate precision optics components. The fabrication courses are to be developed in 2016.

- **Quality Assurance of Precision Optics** $40
  - A standards-based introductory text that provides an introduction to quality assurance practices required to identify, inspect, and measure optical components.

  Includes modules on:
  - Fabrication of Precision Optics
  - Characterization of Optical Materials and Precision Optics
  - Specifications and Drawings for Precision Optics

- **Metrology of Optical Systems** $40
  - A standards-based introduction to measurement practices essential to comprehensive quality assurance of optical components.

  Includes modules on:
  - Optical System Parameters and Performance Metrics
  - Non-Interferometric Measurement of Optical Performance
  - Using Interferometry to Measure Precision Optics

Teaching Resources

**Program Planning Guides  Free Download**

Program Planning Guides are manuals for community/technical college planners (technical program chairs, deans and faculty) to enable them to determine whether and how to include photonics education in existing programs. Each guide addresses the following topics:

- Strategies for implementation
- Course designs
- Available student and instructor materials
- Lab and equipment overview
- Criteria for selecting faculty/training
- Recruitment strategies

**High School Program Planning Guides  Free Download**

- High School Photonics Lab Manual
- High School Program Planning Guide
Reports and Monographs  Free Download

- Hands-on Green Energy Activities
- Outreach Activities to Enlist High School Students for Electro-Optics Technician Programs at Indiana University of Pennsylvania, Northpointe Two-Year Campus
- Restoring a Declining Photonics Program at Tri-County Technical College
- Revitalizing Electronics Engineering Technology Programs Through a Core Curriculum Structure and Emerging Technologies
- TSTC Waco’s Photonics Summer Institutes for High School Science and Technology Teachers

Skill Standards for Technicians  Free Download

The National Photonics Skill Standards for Technicians and The National Precision Optics Skill Standards for Technicians represents the consensus of a broad cross-section of U.S. employers regarding the technical and workplace skills required of photonics technicians and precision optics technicians. They are designed to give educators and employer-advisory committees a solid foundation for generating courses and programs that will enable two-year colleges (and their feeder high schools) to produce globally competitive workers.

- The National Photonics Skill Standards for Technicians – 3rd Edition
- The National Precision Optics Skill Standards for Technicians – 2nd Edition

Math Supplements  Free Download

- Mathematics for Photonics Education
- Math Student Assessment & Answer Key
- Essential Mathematics for Engineering Technicians (Interactive eBook)-$29.99

Topics Include:
Scientific Notification & Unit Conversion
Introductory Algebra/Geometry/Trigonometry
Powers & Roots/Ratio & Proportion
Exponents & Logarithms
Angle Measures in Two & Three Dimensions

Graphing
Trigonometry
Special Graphs
Sinusoidal Motion
Complex Numbers

Faculty Professional Development

Professional development is available to faculty preparing to teach the Fundamentals of Light and Lasers introductory course. OP-TEC has developed an open entry/open exit course for faculty whose schedules demand a more flexible course timeline. The course is taught interactively online during the school year followed by a summer 3-day hands-on laboratory-capstone experience at an OP-TEC partner college. Its 24/7 accessibility is convenient for busy faculty who might have difficulty keeping up with weekly assignments in a “scheduled” course but who would have a period or periods of time during the semester or school year that would allow them to complete assignments and exams independently and at their own pace. The course is also a useful opportunity for junior faculty, adjunct faculty, and lab technicians who may need to prepare to teach a college level or dual credit introductory photonics course. Advanced faculty development courses for Laser Systems and Applications and Quality Assurance of Precision Optics are also available to completers of the prerequisite Fundamentals of Light and Lasers course. The professional development courses are offered at no charge to high school, community college, and technical college faculty.
OP-TEC has designed a variety of recruiting materials that can be used by high school teachers, counselors, and recruiters from 2-year colleges. All materials have been evaluated by recruiters from 2-year colleges that are a part of OP-TEC’s Photonics Student Recruiter Network. To learn more about OP-TEC’s student recruiter materials, please visit www.op-tec.org.

OP-TEC is currently seeking colleges and employers interested in providing employed technicians a hybrid, online course in optics and laser fundamentals. This course provides a foundation for developing a basic understanding of the use of optics and photonics and will enhance the skills of technicians already employed in photonics-related industries. This course also provides technicians retraining into these industries, a quicker path for becoming fully work ready. Through this course, technicians will rapidly gain skills necessary to work with processes and equipment that are enabled by photonics.

**Course Content:** This online course will present the following content: the basic properties of light, the techniques for properly and safely handling optical equipment and lasers, the fundamental principles of geometric and wave optics, and an overview of how lasers operate.

**Laboratories:** Laboratories can be taught at the OP-TEC Partner College facilities. Schedules for conducting labs can be coordinated with employers to provide maximum educational benefit while meeting workplace demands.

**Course Duration:** The online portion of this course can be taught in either a highly condensed format (3 weeks at 16 hours/week) or over more extended periods as determined by employers and their employee time compensation policies. The course can also be customized to present just that content deemed by employers as most important to their technicians. Such customization will reduce the amount of time needed for both the online and laboratory components. OP-TEC can provide time estimates based on the customization desired.

**Course Materials**

**Course 1: Fundamentals of Light and Lasers**

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OP-TEC  www.op-tec.org  (254)751-9000

The Southeast Regional Center for Laser and Fiber Optics Education, located at Indian River State College in Fort Pierce, Florida, is comprised of community and state colleges, universities, high schools and technical centers, trade associations, and laser and fiber optic (LFO) companies located in FL, GA, AL, MS, KY, TN, SC and NC. LASER TEC’s mission is to develop a sustainable pipeline of qualified laser and fiber optics technicians to meet the industry demand across the southeast region by assisting two-year colleges and high schools with creating and offering courses in lasers and fiber optics.

The Midwest Photonics Education Center (MPEC) is located at Indian Hills Community College in Ottumwa, Iowa. The Center’s goals are to increase the supply of well-educated photonics technicians in the Midwest, and to serve as the national leader in photonics education for advanced manufacturing and laser materials processing. MPEC is accomplishing these goals by building and strengthening the number, capacity and quality of two-year photonics education programs at two-year colleges in IA, IL, MI, MO, OH, NE, MN, IN, and WS.