

Queensborough Community College

**TechASCEND
Lasers & Fiber Optics Component**

**Sourcebook for
Parents/Counselors**

2003 Edition

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Introduction

This sourcebook is intended to provide an introduction to the field of photonics and the educational and career opportunities available in this field. It explains what photonics is, the types of careers that are available, how one trains to become a photonics technician, scholarship opportunities, educational opportunities, professional organization information, and the kind of preparation a student needs to enter this field. The information contained herein focuses on careers at the technician, or two-year degree level, because QCC had an accredited A.A.S. degree program in Lasers and Fiber Optics Technology.

Project TechASCEND is an after-school program designed to introduce high school students to this career field, along with CAD/CNC from the Mechanical Engineering Technology/Design Drafting Department. In thirty two-hour sessions, students learn some essential skills for technicians in these fields, and they also meet representatives from industry who can discuss specific career paths at their companies. The students interact closely with faculty at QCC and can determine from this experience if a career as a technician would be right for them. This program is sponsored by a grant from the National Science Foundation.

What is photonics?

Photonics is the name given to the field of technology that involves the manipulation of light to perform various tasks. It originates from the merging of the two words “photon,” which is a particle of light, and “electronics.” Photonics today encompasses specialized applications such as medical equipment, fiber optics, sensors, detectors, precision optics, high-power lasers, semiconductor micro-lasers, optical computers, and telecommunications, and more traditional applications which have been modified and improved through the use of photonics, such as industrial equipment for drilling, welding, machining, marking, and surveying, as well as supermarket scanners and consumer electronics like CD players, computer drives, and DVD players. The field of photonics also comprises devices or systems which combine optical components with electronic or mechanical systems. Robotic systems for manufacturing automation are an example of such a combination.

What does a photonics technician do?

Photonics devices are becoming more and more commonplace in today’s world, and this means there is a growing need for people with the education and skills required to build, test, install, service, and repair photonics-related equipment. It takes a minimum of a Bachelor’s degree to design such equipment, but in most cases the technicians who build, test, maintain, install, and service the equipment require only a 2-year degree. Additionally, people who make good technicians need not have strong theoretical or math skills; rather, patience, manual dexterity, an interest in how things work and a desire to work with one’s hands are often the best attributes for photonics technicians. Photonics technicians find themselves in such diverse jobs as installing and servicing high-power lasers, field-testing of fiber-optics equipment, working in a semiconductor cleanroom fabricating

lasers, or working at a precision optics company applying specialized coatings to lenses and mirrors, just to name a few. A more complete list of photonics-related career paths can be found in Appendix A. Photonics technicians who do field work can travel around the country as part of their job. Moreover, photonics technicians are needed in every part of this country and around the world, so one can relocate to almost anywhere and find rewarding, challenging, and well-paying jobs. Of course, areas of the country supporting much high-tech industry, like Silicon Valley, offer more employment opportunities than do rural areas.

What must a photonics technician know?

The specifics of what a photonics technician needs to know will depend on the job requirements, but a few general statements are applicable. A photonics technician must know the basics of how light is generated and how it travels through different types of materials. He or she must also know how to handle and care for optical elements such as lenses, mirrors, gratings, etc. He or she should understand how a laser operates and what makes laser light different from ordinary light. Alignment skills are crucial for any photonics technician, for no matter what the application, light must be made to enter a device in precisely the right way in order for the device to operate properly. A photonics technician should also be acquainted with various optical devices (interferometers, spectrometers, telescopes, spatial filters, etc.), the specifics of which are learned while taking the photonics courses as part of a degree program. Finally, a basic understanding is needed of how optical fibers are constructed and how they allow light to travel long distances without significant loss. In addition, some basic understanding of electronics is necessary because optical devices always have power supplies and supporting electronics that must be maintained. Beyond these basics, the specifics of the job being performed are usually learned on-the-job.

How does one become a photonics technician?

Photonics is still a specialized field and the programs of study are still quite limited compared to other high-tech careers such as computer and electronics technology. Most photonics programs in the US are 4-year degree programs leading to a Bachelor of Science degree in engineering or physics. A list of schools in the US offering 4-year degree programs in optics and photonics is provided in Appendix B. As you can see by perusing the information in Appendix B, there is a diversity of opportunities available. One can major in photonics directly at some schools, whereas at others there is a photonics concentration in the physics, electrical engineering, computer engineering, computer science, chemistry, chemical engineering, or materials engineering departments. These opportunities allow one to combine a photonics specialization with another discipline, if desired.

Someone wishing to become a photonics technician, at the two-year degree level, has fewer options. Queensborough Community College of the City University of New York has one of the few 2-year degree programs in laser & fiber optics technology offered in the US and the only program of its kind in the NYC metropolitan area. Upon completion of the Associates in Applied Science degree, one can transfer to a 4-year school or go straight to work as a technician, where the employer might offer tuition assistance for further education.

How does one find a job as a photonics technician?

Upon completion of a degree in lasers & fiber optics technology (LFOT) at QCC, there are a number of ways in which one can find a job. First, a decision must be made about staying local or relocating. For local jobs, the physics department at QCC has a number of contacts. Anyone about to graduate should speak to the Director of the LFOT Program or the Department Chairperson. The career services office on campus is another good resource, at any school. The student will be given any contact information that is available from local companies looking for entry-level technicians. The classified ads in the newspaper are also a good place to look. If one wishes to look on the national level for a job, there are several good internet sources for this information. The Optical Society of America (OSA) has a website called www.workinoptics.com which allows searches based on keywords, such as "laser technician," and geographical location. The Society for Photo-Optical Instrumentation Engineers (SPIE) also has a job search engine on their website, www.spie.org. An extensive list of web and other resources for career information is contained in Appendix C. Another good place to look for nationally advertised jobs is the professional society periodicals; most of them have employment ads in the back, and most professional societies are accessible online (See Appendix C).

What kind of salary and benefits do photonics technicians receive?

According to the 1999 Economic Research Institute Study, laser technicians with 1 year of experience earned an average of \$26,367 to \$38,465. With 5 years experience, they averaged \$37,145 to \$54,188, and with 10 years of experience, these numbers rose to an average of \$46,427 to \$67,729. The NYC area tends to be at the top portion of these average figures. Benefits include health, dental, pension, and paid vacation and sick leave. Additionally, technicians often are encouraged by their employers to continue their education, at the employer's expense. So, a person can join a company at the technician level and then have the company pay for a bachelor's or even master's degree, which can be obtained part-time while working full-time. Even if a higher degree is not desired, many companies will pay for professional development, such as attending conferences, trade shows, short courses, or other courses or tutorials to update one's skills. As technology evolves, technicians must keep up with the changes in equipment and procedures, so professional development is essential to staying current with the changes in the equipment and devices being used by the technician. Professional organizations like those listed in Appendix C sponsor professional development events.

What preparation does a high school student need?

If a student has an interest in a career in technology, the best thing to do to prepare is to take as much math and science as possible. Math is a tool which is used by scientists in order to communicate and to accurately express the behavior of devices; it is not necessary to be fluent in calculus in order to be a technician, but a comfortable working knowledge of high school math is important. Many students who enter technology programs make the decision to do so after high school, or in their senior year. In the event that they have not taken much math while in high school, remedial courses are available at the community college level. These courses will bring the student's math ability up to college level so they can then proceed to take college credit-bearing math courses. The LFOT program at QCC does require math courses, but not calculus. There are no high school science prerequisites for the program, but it is helpful to have as much science experience as possible.

Additionally, people who have backgrounds in other technical fields sometimes choose to augment their education with the LFOT degree. People who have degrees in computers, electrical engineering or technology and mechanical engineering or technology have taken the additional LFOT degree, which makes them more valuable to potential employers. The mechanical engineering or technology degree in combination with the LFOT degree makes one qualified to work with opto-mechanical systems (robotics is one example), while the electronics background is useful because of the power supplies and supporting electronic equipment that accompanies most photonics devices. If a student knows ahead of time that they are interested in more than one technology discipline, they can double major and graduate with both degrees from QCC.

How does one pay for college?

There are three essential resources to help pay for college: scholarships, need-based financial aid, and student loans. For a two-year degree at QCC, the current cost is \$1400 per semester for full-time students. Private 4-year schools currently have yearly tuitions in the \$20k's. For qualified students in New York who can demonstrate financial need, need-based programs like Pell and TAP are applicable. Government-subsidized need-based student and parent loans are also available. For merit-based awards, there are some special scholarship opportunities for technology students, and many special programs for minority students. Appendix D contains some links to web sites with scholarship information specific to technical careers and minorities, and in some cases both. For the sake of discussion with regard to technical careers, women count as minorities, so any scholarship program designated as targeting minorities in the sciences will usually include women. Once a student has a short list of schools that he or she is interested in, the first thing they should do is contact the financial aid office and make an appointment to meet with a counselor. They have the most up-to-date, specific information regarding scholarships that are appropriate for the programs at that particular school. The internet resources can be used to supplement the information provided by the financial aid counselor at the school of interest.

Appendix A – Photonics-Related Career Paths

The list of career paths available to someone with photonics skills is diverse; what follows is a partial list of opportunities for photonics technicians. Photonics technicians are employed in industries as diverse as government labs, construction equipment companies, automobile manufacturers, telecommunications providers, computer companies, and of course, companies that manufacture lasers and optical equipment.

Laser technician – builds, tests, installs, maintains, services, and repairs laser systems, often with much travel to customer locations. Can be high-power equipment for construction or heavy industry and academic research purposes, or low-power lasers for things like supermarket scanners, surveyors, laser pointers, and student lasers;

Fiber optics technician – can work in production of fiber optics devices and systems such as transmission/distribution/receiving equipment, or field service and installation of such systems for applications such as telephone/computer/cable TV, medical equipment, sensors;

Optics manufacturing technician – fabrication of optical components such as mirrors, lenses, gratings, polarizers, prisms, etc., including cutting, grinding, shaping, polishing, and coating;

Optics test technician – responsible for testing optical components made by the optical manufacturing technician;

Thin-film technician – specializes in very thin optical coatings for things like wavelength (color) – selective filters, anti-reflection coatings, special mirrors, polarizing elements;

Optical lab technician – responsible for the care and maintenance of optical systems in the lab, such as interferometers, spectrometers, microscopes, small lasers, and optical components like lenses and mirrors, polarizers, etc.;

Research lab technician - maintains equipment, sets up and runs optics and laser-related experiments as directed by researcher;

College laboratory technician - maintains, builds, and services optics equipment for student experiments and research;

Cleanroom technician - works in semiconductor fabrication facility, manufacturing optical devices such as multilayer thin-film stack devices (mirrors, filters, lasers) and semiconductor lasers and diodes. Usually works with microscopic devices in an extremely clean and controlled environment;

Optical device manufacturing technician - works for a company that manufactures devices and products such as spectrometers, interferometers, medical optical equipment, night vision equipment, eyewear, optical assemblies for photocopiers, computer printers, scanners, optical data drives, etc., assembling, servicing, and installing such equipment;

Optical device test technician - responsible for testing the optical devices made by the optical device manufacturing technician.

Appendix B – Four-Year Degree (Bachelor’s) Programs in Optics and Photonics in the United States

Source: SPIE and OSA 2003 International Directory of Degree Programs in optics

Common abbreviations:

ECE = Electrical & Computer Engineering

BSEE = Bachelor of Science in Electrical Engineering

BS = Bachelor of Science

BA = Bachelor of Arts

Alabama

- University of Alabama in Huntsville – Center for Applied Optics, Huntsville, AL – BS with concentration in optics and photonics technology. Mailing address: Center for Applied Optics, The University of Alabama in Huntsville, Huntsville, AL 35899. Web address: www.uah.edu/cao/ose

Arizona

- Arizona State University, Tempe, AZ – BS in optical sciences and engineering. Mailing address: Arizona State University, Electrical Engineering Dept., Tempe, AZ 85287-5706. Web address: www.eas.asu.edu/~eee
- University of Arizona, Tuscon, AZ– BS in optical sciences and engineering. Mailing address: University of Arizona, Optical Sciences Center, Meinel Bldg. #94, PO Box 210094, Tuscon, AZ 85721-0094. Web address: www.optics.arizona.edu

Arkansas

- University of Arkansas at Fayetteville, Fayetteville, AR – BA, BS in physics. Mailing address: Univ. of Arkansas at Fayetteville, Physics Bldg., Room 226, Fayetteville, AR 72701. Web address: <http://giles.uar.edu/git.html>

California

- California Polytechnic State University, San Luis Obispo, CA. BSEE with specialization in photonics. Mailing address: California Polytechnic State University, Electrical Engineering Dept., San Luis Obispo, CA 93407. Web address: www.ee.calpoly.edu
- California State University at Fullerton, Fullerton, CA. BS in physics. Mailing address: California State University at Fullerton, Dept. of Physics, PO Box 6866, Fullerton, CA 92834-6866. Web address: <http://chaos.fullerton.edu/physics.html>
- California State University Northridge, Northridge, CA. BA in biomedical physics, BA in physics, BS in physics. Mailing address: California State University. Northridge, Dept. of Physics and Astronomy, 18111 Nordhoff St., Northridge, CA 91330-8268.
- San Diego State University, San Diego, CA. BS in physics. Mailing address: Department of Physics, San Diego State University, San Diego, CA 92182. Web address: www.physics.sdsu.edu
- San Jose State University, San Jose, CA. BA in physics, BS in physics. Mailing address: San Jose State Univ., Dept. of Physics, One Washington Square, San Jose, CA 95192-0106. Web address: www.physics.sjsu.edu
- University of California at San Diego, La Jolla, CA. BS in electrical engineering, BS in computer engineering, BS in engineering physics.

Mailing address: Univ. of California at San Diego, MC 0408, Dept. of ECE, 9500 Gilman Dr., La Jolla, CA 92093-0408. Web address:

www.ece.ucsd.edu

- University of California at Santa Barbara, Santa Barbara, CA. BSEE. Mailing address: University of California/Santa Barbara, Dept. of E&CE, Santa Barbara, CA 93106. Web address: www.ece.ucsb.edu
- University of Northern California, Petaluma, CA. BS in optical & photonic engineering, BE in biomedical engineering. Mailing address: Univ. of Northern California, Dept. of Biomedical Engineering, 1304 South Point Blvd., Suite 220, Petaluma, CA 94115. Web address: www.uncm.edu

Colorado

- Colorado State University, Fort Collins, CO. BSEE with a concentration in optoelectronics. Mailing address: Colorado State University, Department of Electrical and Computer Engineering, Ft. Collins, CO 80523. Web address: www.engr.colostate.edu/depts/ee/research/optical/intro/intro.html
- University of Colorado at Boulder, Boulder, CO. BS/BA in electrical and computer engineering, physics, or chemistry. Mailing address: University of Colorado at Boulder, Dept. of Electrical and Computer Engineering, 425 UCB, Boulder, CO 80309. Web address: www.colorado.edu/OSEP/
- University of Northern Colorado, Greeley, CO. BA in physics. Mailing address: Univ. of Northern Colorado, Dept. of Physics, Ross Hall, Greeley, CO 80639. Web address: <http://physics.unco.edu>

Connecticut

- Wesleyan University, Middletown, CT. BS/BA in physics. Mailing address: Wesleyan University, Dept. of Physics, 265 Church St., Middletown, CT 06459. Web address: www.wesleyan.edu/physics

Washington, D.C.

- Georgetown University, Washington DC. BS, BA in physics. Mailing address: Georgetown University, Dept. of Physics, 37th & O St., NW, Washington DC 20057. Web address: www.physics.georgetown.edu/graduate.htm

Florida

- University of Florida, Gainesville, FL. BS in materials science and engineering. Mailing address: Univ. of Florida, Rm. 202, Rhines Hall, MS&E Dept., PO Box 116400, Gainesville, FL 32611-6400. Web address: www.mse.ufl.edu

Idaho

- Boise State University, Boise, ID. BSEE with a concentration in signal and image processing. Mailing address: Boise State Univ., Dept. of E&CE, 1910 University Dr., Boise, ID 83725. Web address: <http://coen.boisestate.edu>

Illinois

- Illinois Institute of Technology, Chicago, IL. BS in electrical engineering, BS in computer engineering. Mailing address: Illinois Institute of Technology, Dept. of E&CE, Siegel Hall, Rm 136, 3301 S. Dearborn St., Chicago, IL 60616-3793. Web address: www.ece.iit.edu

Indiana

- Purdue University, W. Lafayette, IN. BSEE, BSCMPE. Mailing address: Purdue Univ., School of Electrical & Computer Engineering, 465 Northwestern Ave., W. Lafayette, IN 47907-1385.
- Rose-Hulman Institute of Technology, Terre Haute, IN. BS in physics or applied optics, BS in optical engineering. Mailing address: Rose-Hulman Institute of Technology, Physics & Applied Optics Dept., 5500 Wabash Ave., CM 169, Terre Haute, IN 47803. Web address: www.rose-hulman.edu/phoe

Iowa

- University of Iowa, Iowa City, IA. Bachelor's degrees in physics, chemistry, electrical & computer engineering, chemical & biochemical engineering. Mailing address: Optical Science & Technology Center, Univ. of Iowa, 114IATL, Iowa City, IA 52242. Web address: <http://ostc.physics.uiowa.edu>

Kentucky

- University of Louisville, Louisville, KY. Bachelor's degrees in electrical engineering, chemical engineering, physics, chemistry, computer science & engineering. Mailing address: Univ. of Louisville, ElectroOptics Research Institute, Lutz Bldg., Room 442, Louisville, KY 40292. Web address: www.ee.louisville.edu/~eri

Maryland

- Johns Hopkins University, Electrical & Computer Engineering, Baltimore, MD. BS in electrical engineering, BS in computer engineering. Mailing address: Johns Hopkins Univ., 105 Barton Hall,

Dept. of E&CE, 3400 N. Charles St., Baltimore, MD 21218. Web address: www.ece.jhu.edu

Massachusetts

- Boston University, Boston, MA. BS in electrical engineering, BS in computer systems engineering. Mailing address: Boston University, Dept. of ECE, 8 St. Mary's St., Boston, MA 02215. Web address: www.bu.edu/msphotonics
- University of Massachusetts/Amherst, Amherst, MA. BSEE. Mailing address: Univ. of Massachusetts at Amherst, ECE Dept., Amherst, MA 01003-5110. Web address: www.ecs.umass.edu/ece/
- University of Massachusetts/Lowell, Lowell, MA. BS in physics/optics option. Mailing address: Univ. of Massachusetts/Lowell, Olney Science Center, Dept. of Physics & Applied Physics, 265 Riverside St., Lowell, MA 01854. Web address: www.uml.edu
- University of Massachusetts/Lowell – Electrical & computer Engineering, Lowell, MA. BSEE with concentration in optics. Mailing address: Univ. of Massachusetts/Lowell, Electrical & Computer Engineering Dept., Lowell, MA 01854. Web address: www.eng.uml.edu/~ece

Minnesota

- St. Cloud State University, St. Cloud, MN. BS in physics. Mailing address: St. Cloud State Univ., MS 324, 4th Ave. S., St. Cloud, MN 56301. Web address: <http://condor.stcloudstate.edu/~physics>

Missouri

- University of Missouri/Columbia, Columbia, MO. BS/BA in physics. Mailing address: Univ. of Missouri/Columbia, 223

Physics Bldg., Columbia, MO 65211. Web address:

www.missouri.edu/~physwww/physics.html

- University of Missouri/Rolla, Rolla, MO. BSEE and BS Physics in optics/smart structures. Mailing address: Univ. Of Missouri/Rolla, 121 EECH, 1870 Miner Cir., Rolla, MO 65409-0040. Web address: www.ece.umar.edu/~optics/

Nevada

- University of Nevada at Las Vegas, Las Vegas, NV. BS in physics, BS in applied physics, BS in computational physics. Mailing address: Univ. of Nevada/Las Vegas, Physics Dept., 4505 Maryland Pkwy., Las Vegas, NV 89154-4002. Web address: www.physics.unlv.edu

New Jersey

- New Jersey Institute of Technology, Newark, NJ. BSEE, BSCoE. Mailing address: New Jersey Institute of Technology, ECE Dept., Electronic Imaging Center, Newark, NJ 07102-1982. Web address: www.njit.edu
- Princeton University – Electrical Engineering, Princeton, NJ. BSEE. Mailing address: Princeton University, Dept. of Electrical Engineering, E-Quad, B-210, Princeton, NJ 08544. Web address: www.ee.princeton.edu
- Rutgers University, Piscataway, NJ. BS in ceramic and materials engineering. Mailing address: Rutgers Univ., Ceramic and Materials Engineering Dept., 607 Taylor Rd., Piscataway, NJ 08854-8065. Web address: <http://irfibers.rutgers.edu/>
- Stevens Institute of Technology, Hoboken, NJ. BS in applied physics, BE in engineering physics (optical engineering). Mailing address: Dept.

of Physics and Engineering Physics, Stevens Institute of Technology, Hoboken, NJ 07030. Web address: www.stevens-tech.edu/physics

New Mexico

- New Mexico State University, Las Cruces, NM. BS in physics, BSEE. Mailing address: The Klipsch School of Electrical and Computer Engineering, New Mexico State University, Box 30001, MSC-3-O, Las Cruces, NM 88003-8001. Web address: <http://lens.nmsu.edu>
- University of New Mexico, Albuquerque, NM. BS/BSEE with optics concentration. Mailing address: Univ. of New Mexico, Physics & Astronomy Dept., Albuquerque, NM 87131. Web address: www.optics.unm.edu

New York

- Alfred University, Alfred, NY. BS in Electrical Engineering. Mailing address: Alfred Univ., Electrical Engineering Dept., 26 N. Main St., Alfred, NY 14802. Web address: www.alfred.edu
- City College of New York, New York, NY. BS & BE, Depts. Of Physics & Electrical Engineering. Mailing address: City College of New York, Physics and Electrical Engineering Dept., 138th St. & Convent Ave., New York, NY 10031. Web address: www.ccnyc.cuny.edu
- City University of New York, New York, NY. BS & BE, Center for Ultrafast Photonics. Mailing address: City University of New York, Ctr. for Ultrafast Photonics, NY State Ctr. For Advanced Technology, 138th St. & Convent Ave., New York, NY 10031.
- Columbia University, New York, NY. BS in applied physics. Mailing address: Columbia University, 500 W. 120th Street, Room 200 Mudd, MC4701, New York, NY 10027. Web address: www.apam.columbia.edu

- Cornell University, Ithaca, NY. BS in engineering physics. Mailing address: Cornell Univ., School of Applied & Engineering Physics, 212 Clark Hall, Ithaca, NY 14853. Web address: www.englib.cornell.edu/aep/AEP.html
- Rochester Institute of Technology, Rochester, NY. BS in imaging and photographic technology. Mailing address: RIT, Imaging and Photographic Technology, 70 Lomb Memorial Dr., Rochester, NY 14623. Web address: <http://imaging.rit.edu>
- University of Rochester, Rochester, NY. BS in Optics. Institute of Optics, University of Rochester, Box 270186, Rochester, NY 14627. Web address: www.optics.rochester.edu/

North Carolina

- Duke University, Durham, NC. Conventional undergraduate degrees in science & engineering. Mailing address: Duke University, The Fitzpatrick Ctr., Box 90305, Durham, NC 27708. Web address: www.fitzpatrick.duke.edu
- University of North Carolina/Charlotte, Charlotte, NC. BA & BS in physics. Mailing address: UNC Charlotte, Dept. of Physics, Charlotte, NC 28223-0001. Web address: www.physics.uncc.edu

North Dakota

- North Dakota State University, Fargo, ND. BS in EE, optical engineering option, BS in physics, optical science & engineering option. Mailing address: North Dakota State Univ., Dept. of Physics, PO Box 5566, Fargo, ND 58105-5566. Web address: www.ndsu.edu/

Oklahoma

- University of Central Oklahoma, Edmond, OK. BS in engineering physics. Mailing address: Univ. of Central Oklahoma, Dept. of Physics & Engineering, 100 N. University Dr., Edmond, OK 73034. Web address: www.physics.ucok.edu

Oregon

- Oregon Institute of Technology, Klamath Falls, OR. BS in engineering technology. Mailing address: Oregon Institute of Technology, Laser Optical Engineering Technology, 3201 Campus Dr. PV2, Klamath Falls, OR 97601. Web address: www.oit.edu/
- Oregon State University, Corvallis, OR. BS in physics/optics, BS in engineering physics/optics, BSEE with concentration in optics. Mailing address: Oregon State University, Dept. of Electrical & Computer Engineering, 220 ECE Building, Corvallis, OR 97331. Web address: www.ece.orst.edu
- Portland State University, Portland, OR. BS in ECE, physics, chemistry. Mailing address: Portland State Univ., Dept. of E&CE, PO Box 751, Portland, OR 97207-0751. Web address: www.optics.pdx.edu/

Pennsylvania

- Carnegie Mellon University, Pittsburgh, PA. BS in ECE. Mailing address: Carnegie Mellon, ECE Dept., Pittsburgh, PA 15213. Web address: www.ece.cmu.edu/~casent
- Lehigh University, Bethlehem, PA. BSEE. Lehigh Univ., EE&CE Dept., 19 Memorial Dr W, Bethlehem, PA 18015. Web address: www.lehigh.eecs.lehigh.edu
- Pennsylvania State University, University Park, PA. BS in electrical engineering. Mailing address: Pennsylvania State University, Electrical

Engineering Dept., University Park, PA 16802. Web address:

www.ee.psu.edu/research/electro.html

- University of Pittsburgh, Pittsburgh, PA. BSEE. Mailing address: Univ. of Pittsburgh, Dept. of Electrical Engineering, 348 Benedum Hall, Pittsburgh, PA 15261. Web address: www.engr.pitt.edu/electrical/
- University of Pittsburgh – Physics and Astronomy, Pittsburgh, PA. Certificate in Photonics (including bachelor's). Mailing address: Univ. of Pittsburgh, Dept. of Physics and Astronomy, 405 Allen Hall, 3941 O'Hara St., Pittsburgh, PA 15261. Web address: www.phyast.pitt.edu/~snoke/photonics

South Dakota

- South Dakota State University, Brookings, SD. BS in physics, BS in engineering physics. Mailing address: South Dakota State Univ., Physics Dept., Box 2219, Brookings, SD 57007. Web address: www.engineering.sdstate.edu/~physics/physics.htm

Tennessee

- Fisk University, Nashville, TN. BS in physics, concentration in photonics. Mailing address: Fisk Univ., Ctr. for Photonic Materials & Devices, Dept. of Physics, PO Box 15, Nashville, TN 37208. Web address: www.fisk.edu
- University of Tennessee Space Institute, Tullahoma, TN. Bachelor's in physics. Mailing address: Univ. of Tennessee Space Institute, Dept. of Physics, Tullahoma, TN 37388. Web address: cla.utsi.edu ; www.utsi.edu
- Vanderbilt University, Nashville, TN. BE (biomedical engineering). Mailing address: Vanderbilt Univ, Biomedical Engineering Dept., Box

351631 Station B, Nashville, TN 37235. Web address:

www.bme.vanderbilt.edu/bmeoptics

Texas

- University of Texas at Arlington, Arlington, TX. BSEE. Mailing address: Univ. of Texas/ Arlington, Department of Electrical Engineering, Box 19016, Arlington, TX 76019. Web address: www-ee.uta.edu/eo/
- University of Texas at El Paso, El Paso, TX. BS in electrical engineering. Mailing address: Univ. of Texas/El Paso, Dept. of E&CE, El Paso, TX 79968. Web address: www.utep.edu

Utah

- University of Utah, Salt Lake City, UT. BS with optics concentration, bioengineering, electrical and computer engineering, physics depts. Mailing address: Univ. of Utah, Rm. 3280, Electrical Engineering Dept., 50 S. Central Campus Dr., Salt Lake City, UT 84112-9206. Web address: www.ece.utah.edu

Virginia

- University of Virginia – Physics, Charlottesville, VA. BA & BS in physics (optics concentration). Mailing address: Univ. of Virginia, Physics Dept., 383 McCormick Rd., PO Box 400714, Charlottesville, VA 22904-4714. Web address: www.physics.virginia.edu/
- Virginia Tech – Fiber and Electro-Optics Research Center, Blacksburg, VA. BSEE, BSCpE. Mailing address: Virginia Tech, Fiber & Electro-Optics Research Ctr., 106 Plantation Rd., 0356, Blacksburg, VA 24061. Web address: www.ee.vt.edu/~feorc

- Virginia Tech – Optical Sciences and Engineering Research Center, Blacksburg, VA. Mailing address: Virginia Tech, Optical Sciences & Engineering Research Ctr., 106 Plantation Rd., 0356, Blacksburg, VA 24061. Web address: www.oser.vt.edu

Washington

- Washington State University, Pullman, WA. BS/BA in physics with optoelectronics option. Mailing address: Washington State Univ., Webster Hall Rm 1245, Dept. of Physics, PO Box 642814, Pullman, WA 99164-2814. Web address: www.physics.wsu.edu

West Virginia

- West Virginia University, Morgantown, WV. BS in electrical engineering, chemical engineering, physics. Mailing address: West Virginia Univ., Dept. of CSEE, PO Box 6109, Morgantown, WV 26506-6109. Web address: www.csee.wvu.edu/pmt

Appendix C – Web and Other Resources for Career Information

Professional organizations with career services:

Optical Society of America www.osa.org

Society of Photo-Optical Instrumentation Engineers (SPIE) www.spie.org

American Physical Society www.aps.org

American Institute of Physics www.aip.org

Institute for Electrical & Electronics Engineers: www.ieee.org

Career information for laser, test, and holographic technicians:

www.chronicleguidance.com/brf415.htm

Careers in Optics:

Occupational Outlook Handbook – Occupational Outlook Quarterly, Winter 2002 – 2003 edition

National Science Foundation, document #nsf02313 – www.nsf.gov

Photonics Spectra Magazine: www.photonics.com

Laser Focus World Magazine: www.laserfocusworld.com

Other sites:

www.lightwaveonline.com

www.corning.com

www.laserinstitute.org

Web sites for optics employment opportunities:

www.optics.org

www.photonicsonline.com

www.photonicsjobs.com

www.workinoptics.com

www.spie.org

QCC Laser and Fiber Optics Technology Program:

<http://web.acc.qcc.cuny.edu/lfot/Default.htm>

For Women:

SPIE's Women in Optics: www.set4women.gov.uk

www.nsf.gov/pubs/1997/nsf9775/resource.htm

www.binarygirl.com

www.sciquest.com/k12/index.html

www.nsf.gov/sbs/srs/nsf00327/start.htm

National Council for Research on Women 2001

Balancing the Equation: Where Are Women & Girls in Science, Engineering, and Technology? By Mary Thom

Women, Minorities, and Disabled Persons in Science & Engineering:

www.nsf.gov/sbs/srs/nsf99338/hilight.htm

Career Information in General:

NSF - Trends in Science and Engineering Employment:

www.nsf.gov/sbe.srs.seind00/access/c3/c3s2.htm

Bureau of Labor & Statistics: www.bls.gov

Information about Science and Math Education for Minority Students:

O'Brien, V. , Kopala, M., Martinez-Pons, M. (1999). Mathematics self-efficacy, ethnic identity, gender, and career interests related to mathematics and science. *Journal of Educational Research*, 92 , 231-235.

Butler, M. B. (1999). Factors associated with students' intentions to engage in science learning activities. *Journal of research in science teaching*, 36 455-473.

Britner, S. L., & Pajares, F. (2001). Self-efficacy beliefs, motivation, race, and gender in middle school science. *Journal of women and minorities in Science and Engineering, 7*, 271-285.

Hoffmann, L. (2002). Promoting girls' interest and achievement in physics classes for beginners. *Learning and Instruction, 12* 447-465.

Smoot-Taylor, V., Woods-Erwin, K., Ghose, M., Perry-Thornton, E., (2001). Models to increase enrollment of minority females in science-based careers. *Journal of the National Medical Association, 93*, 74-77.

Appendix D - Web Links to Scholarship Information

Optical Society of America

www.osa.org

New York Collegiate Science & Technology Entry Program

[www.free-](http://www.free-4u.com/new_york_collegiate_science_&_technology_entry_program1.htm)

[4u.com/new_york_collegiate_science_&_technology_entry_program1.htm](http://www.free-4u.com/new_york_collegiate_science_&_technology_entry_program1.htm)

National Urban League:NYULP

www.nul.org/caaa/scholarship/acs_schol_program.html

Xerox Corporation:

Xerox Technology Minority Scholarship

www.xerox.com

American Physical Society

www.aps.org

Scholarship source information (multiple links on each of these):

Scholarships for women and minorities:

<http://conexiones.asu.edu/scholar.html>

Scholarships for women:

www.womenscenter.gatech.edu/education.html

Various types of scholarships (Office of Multi-Ethnic Student Education):

[www.inform.umd.edu/CampusInfo/Departments/OMSE/Scholarship%20P
age/test.html](http://www.inform.umd.edu/CampusInfo/Departments/OMSE/Scholarship%20Page/test.html)

Scholarships for Minorities:

<http://scholarships.kachinatech.com/scholar3.html>

Scholarships for everyone:

www.collegeview.com/

Appendix E - QCC Contact Information

Physics Department (LFOT Program): 718-631-6366;

<http://web.acc.qcc.cuny.edu/lfot/Default.htm>

Dr. Don Engelberg - TechASCEND Principal Investigator: 718-281-5766;

DEngelberg@qcc.cuny.edu

Dr. Amy Bieber - Director, LFOT Program and

TechASCEND Co-PI: 718-631-6967; ABieber@qcc.cuny.edu

Admissions Office: 718-631-6219

Financial Aid Office: 718-631-6367

Career Services Office: 718-631-6297

CSTEP Office: 718-631-6036 (College Science & Technology Entry Program)