PHOTON NEWS

A PROJECT OF THE NEW ENGLAND BOARD OF HIGHER EDUCATION (NEBHE)

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PHOTON is a project of the New England Technology Education Partnership (NETEP) at the New England Board of Higher Education (NEBHE), and is funded in part by the Advanced Technological Education (ATE) program of the National Science Foundation (NSF). For more information, please visit our web site: www.nebhe.org/photon.html. You may also contact the program staff at NEBHE:

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Project PHOTON2 is Launched with NSF Funding

Project PHOTON has enabled educators and career counselors from over 30 New England middle schools, high schools, and community and four-year colleges to introduce photonics technology education to their institutions. The New England Board of Higher Education is pleased to announce new funding, over the next three years, from the Advanced Technological Education (ATE) program of the National Science Foundation (NSF) for Project PHOTON2.

Why would the ATE program invest additional resources into professional development in photonics during a downturn in the technology sector?

It is true that, over the past several years, technology companies and particularly telecommunications companies have suffered significant losses of business and consequent layoffs of employees. Nevertheless, in spite of this cyclical downturn, photonics technology continues to grow thanks to its diverse applications in industries such as defense, the environment, transportation and more. Companies that design and manufacture laser systems, whether for automotive welding, medical procedures, precision optical testing or security systems, are experiencing tremendous growth.

Photonics Spectra magazine's most recent industry survey, published in 2002, states that "although one would expect recruiting to be down, the number of those employed who are being recruited has remained steady from 2001 and 2002." As the photonics industry emerges from its slumber,

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PHOTON Instructors Disseminate to "Science in Motion" Program

The Clarion University Science in Motion consortium, in collaboration with Pennsylvania State University's Electro-Optic Center and the Office of Naval Research sponsored a one-day PHOTON "Introduction to Photonics Technology" workshop on June 17, 2003. Project PHOTON team members Nicholas Massa, professor of laser electro-optics at Springfield Technical Community College in Springfield, Mass., and Fenna Hanes, senior director of the office of programs at the New England Board of Higher Education, delivered the workshop. Held at the Penn State Electro-Optics Center (EOC) in Kittaning, Penn., the lab-based workshop used components from the unique PHOTON laboratory kit.

Science in Motion participants construct a Michelson interferometer.

The Clarion University consortium serves 18 school districts and 23 schools through the use of a travelling science lab in a van. The 15 high school and middle school teachers who participated in the workshop worked in teams of four

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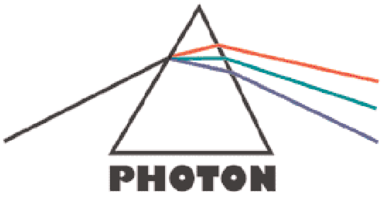


SPIE 2003 Educator Award Winner Announced—Project PHOTON PI Donnelly Named

Above, PHOTON PI Judy Donnelly receives the SPIE Educator Award from Anthony DeMaria, Chief Scientist at Coherent DEOS.

SPIE, the International Society for Optical Engineering, presented its first annual SPIE–Educator Award to Professor Judy Donnelly of Three Rivers Community College (TRCC), Norwich, Conn., during its 48th Annual Meeting, August 3-8, 2003 in San Diego, Calif. The award is given in recognition of outstanding contributions to optics education by an SPIE instructor or an educator in the field. Professor Donnelly was honored for advancing the field of photonics education in Connecticut and throughout New England and for playing an integral role in photonics workforce development in the state of Connecticut.

Professor Donnelly was recognized for designing a new associate degree program in Photonics Engineering Technology that was approved by the Connecticut Board of Higher Education and is the only degree of its kind in the state and in New England. The program at Three Rivers was created as a result of her participation in the Fiber Optic Technology Education Program (FOTEP), administered by the New England Board of Higher Education (NEBHE) between 1995-1998 and funded by the Advanced Technological Education (ATE) program of the National Science Foundation (NSF). Since that time, Donnelly has managed to secure additional grants from NSF for lab improvement and industry donations so that TRCC now has three separate labs for optics/photonics with approximately a half million dollars in equipment. Three Rivers has also worked with the Connecticut Business and Industry Association to provide innovative hands-on incumbent and displaced worker training in optics, lasers and fiber optics both on site and by web-based distance learning for several Connecticut photonics companies.

Donnelly is the principal investigator for Project PHOTON, which has been a model for the cooperation of high school and community college teachers, optics professionals, industry, regional bodies, and university educators. Also administered by NEBHE and supported by a NSF/ATE grant, the project has been so successful that the New England Board of Higher Education was asked to propose PHOTON2, which has been funded. PHOTON2 will expand the professional development efforts of PHOTON nationwide (see page 1).

Another one of Donnelly's key technical contributions to the field has been the development of optics and photonics laboratory materials tailored to the community college or advanced high school student interested in a technical position in the photonics industry. The immensely talented and hard working PHOTON instructional team that also includes professors Nicholas Massa and Barbara Washburn from Springfield Technical Community College, Mass., wrote a comprehensive text with a lab manual. The instructional materials are accompanied by a custom designed industry quality PHOTON lab kit. The lab kit will also be distributed to participants of PHOTON2.

SPIE–The International Society for Optical Engineering is dedicated to advancing scientific research and engineering applications of optical, photonic, imaging, and optoelectronics technologies through its meetings, education programs, and publications. For more information, contact media@spie.org or visit our website at http://spie.org. ■

Adapted from an SPIE press release announcing the SPIE Educator Award.

Project PHOTON Presents at NSTA National Convention

The National Science Teachers Association (NSTA) National Convention, "Partnerships: Excellence and Equity in Science," held March 27 – 30, 2003, in Philadelphia was a smashing success. The convention was the fifth largest in 51 years, with a registration count topping 13,500. The energy level soared as thousands of science educators attended more than 1,500 workshops, sessions, tours, and short courses and scoured 27 aisles of exhibitor booths.

The PHOTON team of Judy Donnelly, Fenna Hanes, Nick Massa and Barbara Washburn delivered two presentations. The first presentation, "Project PHOTON: Applied Learning in Photonics," was held on Friday, March 28, and reached an audience of teachers from as far away as Alabama, Kentucky, Missouri and Puerto Rico. Hanes provided attendees with an overview of the three-year curriculum and professional development and laboratory improvement project, while Donnelly, Massa and Washburn discussed technical content of the curriculum. The second presentation, "The Light Fantastic—Experiments and Explorations from the PHOTON Project," was a hands-on workshop. The members of the PHOTON team demonstrated sample labs from the PHOTON curriculum, including Snell's Law–the index of refraction; polarization–Malus' law; single slit diffraction and the diffraction of a hair; and Michelson's interferometer. Workshop participants represented students from California, Maine, Florida, Indiana, New Jersey, New York, Arizona and Virginia.

The PHOTON team had the opportunity to visit hundreds of vendor exhibits as well as stimulating workshops presented by experts and practitioners like themselves. They also attended a presentation by the members of Project Science in Motion, a Pennsylvania state-wide traveling science education project (see page 1). ■

Advisory Committee Member Profile: Margaret Sullivan, MKS On-Line Products Group

What has your career path in Photonics been?

Both an economic need and a fascination with technology brought me to photonics. I was 27, a single mother with a young son and I needed to find a career with both job opportunities and health benefits. Lasers had always fascinated me. Fortunately, my academic strengths in math and science enabled me to choose photonics as a career option as an adult learner. The associate degree program in laser electro-optics I enrolled in at Springfield Technical Community College (STCC) had a challenging course load and an impressive 99% employment placement. It took me 3 years to complete the degree.

By graduation, the surplus of jobs had dwindled alarmingly, and not a single recruiter came on campus that year. Luckily, I had spent the summer before working at a small laser processing company and although the pay was a lower than I had hoped for, at least I found work in my field. I spent 8 years there learning, learning, learning. When the economy began to turn around, I contacted my former STCC advisor (PHOTON instructor Nick Massa) to see what opportunities were available. I was very interested in the field of fiber optics and with Massa's help, I found work in a division of 3M Corp.

After a couple of years there, my job moved out of state and my family commitments did not allow me to move. It was again time to reevaluate my opportunities. Fortunately for me, my AS degree plus more than 10 years of experience put me a step ahead of a new graduate with a four-year engineering degree with no experience. I began to actively pursue engineering positions and promoted my strengths, not my limitations. Now, I am a manufacturing engineer at MKS On-Line Products Group, which is a world-wide provider of instruments and subsystems that measure, control, power and monitor critical parameters of advanced manufacturing environments.

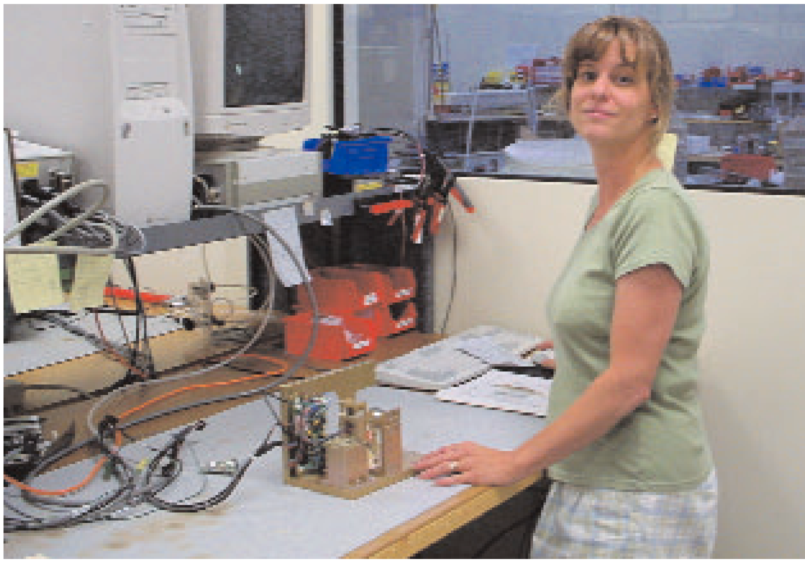
What are you currently doing at MKS On-Line Products Group?

My time is divided between technician duties (building a complex photonics system, a spectrometer) and manufacturing engineering duties such as process control, improvement and surveillance.

How do you see your role as a member of the PHOTON Advisory Committee?

I have always been a joiner, starting in grade school with baton twirling and the audio-video club. When Nick Massa invited me to join the PHOTON Advisory Committee, he didn't even finish giving the specifics before I was gladly on board. As a technician and engineer and a woman in a technological field, I wanted to share with students the numerous career opportunities in the photonics industry.

I was an assistant instructor during the PHOTON summer professional development workshop and shared my industry experience with the PHOTON teachers. I was also invited by PHOTON Principal Investigator Judy Donnelly of Three Rivers Community College to be a keynote speaker at the college's annual Exploring New Horizons workshop. Five hundred high school women and more than 25 professional women met in small groups to explore technological career areas. I strongly believe that as a photonics professional talking with young women about careers in technology, I can broaden their horizons just as doors were opened for me at STCC.



Margaret Sullivan with some of the MKS On-Line products she works with.

Where do you see the opportunities for students in this field?

I think there are still a lot of opportunities for students entering this field. Unfortunately, many enter under the false impression that little effort will reap great rewards and that is simply not true. Young men and women need to create their own opportunities. Hard work, determination and commitment will always produce the greatest rewards. Another critical component is strong communications and social skills. One can be extremely bright but unable to intelligently articulate his/her thoughts or worse, cannot work with or within a group—perhaps the product of too much time alone in front of video games.

What effect do you see the current economic climate having on the field of photonics?

The economic situation is certainly not conducive to inspiring the next generation of engineers. Schools are in trouble, cutting back on programs for advanced students and even basic studies. Parents are being laid off and cannot find new work in their fields. However, I strongly believe that photonics is the technology of the 21st century. It enables advances in medicine, communications, security and more. A good foundation in math will provide a basis for numerous fascinating careers in science and technology. And, as my own experience has shown, photonics is not only a career path for young students, it is also a great opportunity for adults returning to the workforce.

Photonics Industry Provides Job Shadowing Experiences for Connecticut Educators

Preparing students for employment in high tech industries can be a challenge. The skill requirements for entry-level employees are constantly growing, and teachers face the difficulty of keeping up with changing technology so they can impart timely information to their students. One way for teachers to keep current is to participate in an industry internship or externship.

During the summer of 2003 Judy Donnelly, professor at Three Rivers Community College (TRCC) and PHOTON principal investigator, participated in an industry externship at Zygo, a manufacturer of precision optics and metrology instruments in Middlefield, Conn. The two-week intensive job shadow experience was funded by a grant from the National Science Foundation's Advanced Technology Education program to the Connecticut Business and Industry Association (CBIA). Twenty-five high school and college teachers were given the opportunity to choose a company with which to complete the workplace experience, and CBIA made the initial contact with the company.

CBIA provided the teachers with detailed guidelines for a successful externship. In addition to suggestions for goal setting and expectations, participants were coached in practical matters such as dress code and parking arrangements.

Donnelly began her externship by meeting with Zygo managers to map out a work plan. Each day she was assigned to a different employee who gave an overview of his or her area of the business. Later in the day, technicians, assemblers and opticians explained and demonstrated the specific knowledge and skills required for their work. Engineers were available to answer more advanced technical questions.

The first week was spent in the optics manufacturing area. Day one was an overview of the process used to create customer quotes and "methods," the instructions to the shop for creating optical components. The remainder of the week was spent observing the manufacture and testing of precision glass optics from the generation of the initial shape through grinding, polishing and metrology. Friday afternoon, Donnelly was able to try her hand at polishing a scrap glass flat and testing it by creating an interferometric surface map.

The second week was dedicated to the optics assembly and laser areas. Technicians and assemblers demonstrated the skills and techniques needed to create precision optical assemblies and to manufacture and align helium neon lasers. Each day also included an opportunity to talk with employees about their education and work backgrounds and to discuss with managers what skills would make graduates of TRCC's Photonics Engineering Technology program more valuable employees.

After completing their externships, Donnelly and the other teachers will create classroom lessons, labs or activities based on their work experience. These will be posted on a web site linked to the CBIA site (www.CBIA.com). Donnelly's Zygo externship resulted in several new laboratory experiments that will be introduced into the TRCC photonics program, including laser beam alignment and testing of fiber optic cables. Zygo employees also suggested problems for homework or discussion that will be included in several Three Rivers courses.

Zygo Corporation (NASDAQ: ZIGO), headquartered in Middlefield, Conn., is a worldwide developer and supplier of high precision optics, optical assemblies, high performance metrology instruments, and automation for the semiconductor and industrial markets. See ZYGO's web site at www.zygo.com for additional information.

CBIA is the largest statewide business organization in the country, with 10,000 member companies. CBIA has represented Connecticut businesses for more than 175 years. CBIA works with state legislators and officials to help shape specific laws and to promote a regulatory system that responds to businesses' needs.

Making Connections: Photonics in Everyday Life Brighten the Classroom

Martin G. Drexhage, Ph.D.

"Where's the telephone?"

The voice is that of the first in a line of twenty-five 9th grade Physical Science students winding their way into my combination storeroom and holography lab. Each spends a moment staring into the wonderfully detailed 8 x 10 inch commercial hologram illuminated by the helium neon laser's reddish glow. The three-dimensional still life shows a magnifying glass in front of a touchtone phone; you can see enlarged digits and letters on the instrument's face.

"Where is the telephone?"

The voice in the darkened room sounds mystified.

"The telephone isn't really there," I answer, "anymore than a scene in a normal photograph is when you look at it. What you're seeing is a three-dimensional projection of the phone that's been recorded in a very special way with a laser. The unique properties of laser light make it possible."

"Awesome! How do you do it?"

It's the response I'm looking for.

"Why don't you take my 'Introduction to Light and Lasers' course next year? You'll learn how holography works, and you'll get to make and keep a bunch of holograms. By the way, you all get to play with lasers a lot……."

This is one way I attempt to connect photonics to a student's every day life; the majority have seen a rudimentary hologram somewhere and have experienced the beauty and power of the laser, even if its only been in Star Wars!

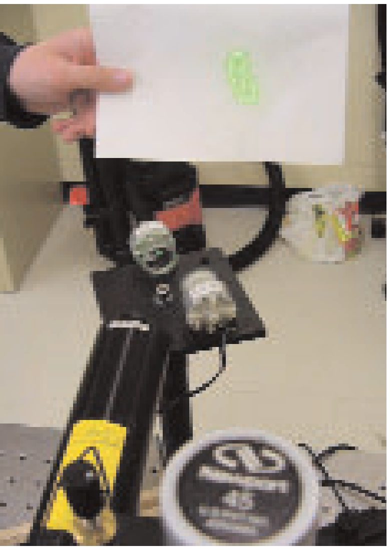
The equipment, experiments, and tutorial materials developed by Project PHOTON are an integral part of the curriculum.

At Tantasqua Regional High School, we offer a multi-year program in photonics technology which spans topics such as basic optical phenomena, lasers, fiber optics, and optical instruments, with a smattering of electronics thrown in. The equipment, experiments, and tutorial materials developed by Project PHOTON are an integral part of the curriculum. Originally designed as a "vocational" program, individual courses in the photonics sequence are also available to "academic" students as science electives. Our goal is not to graduate junior electrical engineers. The curriculum is aimed at exposing young learners to a variety of technologies, so that they can make intelligent choices regarding entry into the workforce or continuing with their education at a two- or four-year institution.

I start my introductory class with some hands-on activities involving laser light shows. Most students have seen them, either in music videos or on vacation at venues like Disney World. They are quite curious about these effects and, after a safety lecture, are given their first opportunity to handle various lasers. For about $25, you can purchase what I refer to as the "Stone Age Model." It consists of a 4" diameter piece of plastic sewer pipe across which is stretched a latex rubber membrane. A laser pointer is aimed at a small piece of mirror glued to the membrane. The whole thing is mounted on a wooden frame such that when you talk, sing, whistle, scream, or shout into the pipe, the vibrating membrane/mirror assembly causes wonderful patterns to appear on the wall. To generate more geometric and reproducible effects, we utilize a $30 kit with two small motors whose shafts support a pair of rotating mirrors. These are coupled to a simple printed circuit board (which the students must build) allowing the direction and speed of the motors to be varied independently. Finally, the class has access to a small commercially manufactured scanner housed in a clear plastic box which also allows audio signals from a CD player to modulate the light pattern. Strong linkages are made when we examine and discuss these devices from both the technical and artistic side. What causes the pattern to be formed? Why does varying motor/mirror speed cause it to change? Would it be as interesting if we used incoherent monochromatic light? How can we create other visual effects with the laser? Now I understand what I saw at Disney World! Indeed, this mini-lesson has led to a larger project: a group of students is trying to devise a portable laser light show which we can use at school dances!

Han Solo from Star Wars is immortalized as a student-made hologram.

Photonics Technology students work with both single and multimode fiber, generously donated by OFS's Sturbridge Optical Fiber Division. Here, they learn to create flat fiber end faces with YORK cleavers (white and grey units on either side of fiber spool). Reading the manual before beginning work speeds the process!



A simple but versatile laser light show can be constructed using two mirrors mounted on a pair of motors. A student-assembled printed circuit board (not shown) controls the motors speed and direction. When projected on a wall, 6 foot by 6 foot continuously variable patterns are produced.

Until I attended one of Project PHOTON's special workshops, I had difficulty in trying to get students to grasp that light wavelengths exist which are outside the range of human vision. Connecting this with an everyday photonic gadget has done the trick.

"What is this and how does it work?"

I hold up a device easily identified as a TV remote control. A few students venture hesitant guesses that it functions via radio waves or ultrasound. I then produce a phosphor coated sensor card which glows bright orange when illuminated by the remote control, and we begin a discussion of the nature of infrared light and its place in the optical spectrum. To "illuminate" the other end of the spectrum, I draw analogies with fluorescent minerals, paints, and ultraviolet "black lights." The demonstration also allows us to begin addressing data transmission, as depressing each key on the control causes the phosphor card to blink in a different pattern.

After exploring the basic principles of light and waves, my classes turn their attention to more complex phenomena such as diffraction and interference. Many of these lessons are difficult (for me also!) because of the students' rudimentary understanding of, for example, trigonometric functions and their relation to waves. Nevertheless, using a ripple tank and JAVA animations available on the web, they develop a good semi-quantitative appreciation of Young's double slit experiment and Bragg diffraction. Then, it's on to the lab where we conduct the PHOTON experiment in which a laser's wavelength is determined using a diffraction grating. The work is fun because we use a bluish argon as well as red and green helium-neon lasers. Yet, some students have a hard time grasping that a wavelength of, say, 632 nanometers is a very small distance. To bring it home, I extend the experiment by having them measure the diameter of a hair donated by a classmate. Shining the laser on the hair creates a diffraction pattern on a screen. Knowledge of the laser wavelength, and measurements of the pattern and hair/screen distance yield hair diameters which compare favorably with those determined in a microscope or with a micrometer.

Until I attended one of Project PHOTON's special workshops, I had difficulty in trying to get students to grasp that light wavelengths exist which are outside the range of human vision. Connecting this with an everyday photonic gadget has done the trick.

"Do you realize that you've just measured a classmate's body part that is about 100 millionths of a meter in diameter with just a laser, meter stick and a diffraction grating?" You can almost see the light bulbs going on above their heads when they think of the experiment in this way. It paves the way to other sensor-related lab activities we do, including construction of a laser barcode scanner, laser level, and a simple rangefinder.

The time spent on interference and diffraction effects has proven useful in other photonics lessons.

"How many of you have a CD or DVD player?" Almost every hand in the class goes up.

"What makes these devices work?" I ask.

"You put batteries in them!" Shouts a student, accompanied by much laughter and a few groans.

"There's a laser inside," says another. Now we're making progress.

We spend the rest of the class discussing in a semi-quantitative fashion appropriate to 10th and 11th graders how the CD player system works: the laser, its wavelength, detection, amplification, the structure and composition of the disc, and encoding of the music. I supplement the lesson with some Internet surfing, breaking the students into groups with instructions to search out sites containing graphics infinitely superior to anything I could ever sketch on the board illustrating these concepts.

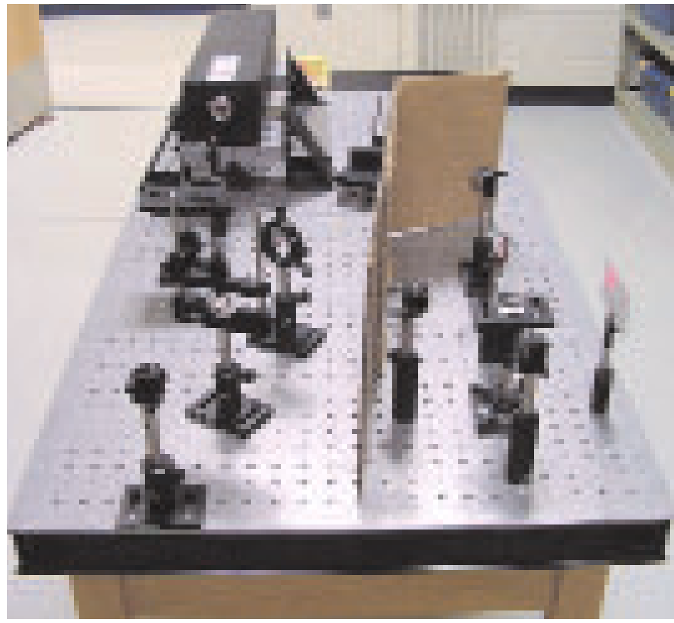
I opened this discussion with a vignette related to holography. As a physics undergraduate in the late 1960s, my interest in all things optical had been kindled by this then-novel approach to three dimensional imaging. I thus decided to incorporate a brief holography lesson in my "Introduction to Light and

Learning to dissect optical fiber cables and applying connectors requires good hand-eye coordination. Students gain experience with all the tools commonly employed in the field to cleave, splice, connect, and test lightguides. They quickly realize that dealing with fragile glass filaments the diameter of a human hair is not as easy as it looks!

Lasers" course; student interest in the topic was so great that I was forced to double the planned one-week classroom and laboratory period. Building on the optical principles outlined earlier, we discuss (again semi-quantitatively) how a hologram is formed by the interference of a reference and object beam, what the important optical requirements are (e.g., vibration isolation), and how the unique pattern recorded on the film plate can be illuminated by laser or white light to reconstruct an image. The students are then required to put these "theories" into practice. They must set up the apparatus, including the laser, spatial filters, lenses, and mirrors. They must construct a scene using objects brought from home, and learn to work cooperatively and carefully in the dark to expose their plates. An iterative diagnostic process then commences. What went right? What went wrong? How can I improve my image? Is this the one I want to take home or should I try again? Throughout the holography lessons, students have been very motivated. I strongly encourage all who teach photonics to include this multi-dimensional (literally and figuratively!) topic in your curriculum, if only because of the sense of pride and accomplishment which the kids exhibit when they hold the finished product in their hands.

Everyday Photon Connections
at Tantasqua Regional High School

LASER LIGHT SHOWS
REMOTE CONTROL
DIAMETER OF A HAIR
CD PLAYER
HOLOGRAPHY
FORENSICS



Three dimensional imaging using lasers has rapidly become a popular part of the photonics curriculum. Students are first taught fundamental principles, including interference and diffraction effects.
This knowledge is then extended to encompass holography. Over time, various setups are built; the one above incorporates a Michelson interferometer (right of cardboard) to monitor table vibrations in real time. An on site darkroom provides experience with holographic plate processing.

We are fortunate enough to own an optical fiber-coupled Ocean Optics Corp. spectrometer mounted on a card which fits inside a personal computer. Its software allows display and manipulation of spectra between about 400 and 1000 nanometers. In this case, the connection I make is between the recent spate of crime scene investigation shows on TV and photonics. We begin with lessons on absorption and emission spectra and their uniqueness to a given material. Students find the instrument easy to operate (it is, after all, computer based!), and then begin an examination of various spectral lamps such as hydrogen, helium, sodium, and mercury. The forensics problem may seem simple and silly, but students jump at the chance to use a sophisticated instrument to get an answer. I've stored the spectra of various after-shaves, mouthwashes, and other household liquids in the computer. Students are given an unknown and must provide a brief crime lab report describing how they identified it.

Hmmm…. Let's see now. If the school principal would just let me drip some human blood around, spray it with Luminol, and demonstrate that the material bonds with hemoglobin and fluoresces in the blue just like on *CSI-Miami*, I'd have another photonic connection……. ■

Students learn to measure that most fundamental of constants, the velocity of light. The phase shift of a laser beam modulated at 3 MHz is detected after reflection from a distant mirror; typical results are within 5 per cent of the accepted value. They must design the experiment, assemble the apparatus using parts from various vendors, take data, and submit a formal written report.

Martin Drexhage, Ph.D. is a PHOTON participant and physics teacher at Tantasqua Regional High School in Sturbridge, Mass. He was formerly executive director of CAFA, the Center for Advanced Fiberoptic Applications, in Sturbridge, Mass. He can be reached at drexhagem@tantasqua.org

Interviews with PHOTON Participants Highlight Project's Achievements and Challenges

How have PHOTON participants implemented what they have learned over the past three years? To answer this question, Project PHOTON's independent evaluator held in-depth interviews with a sampling of teachers and counselors from eight of the 37 participating institutions. The interviewees came from five of the six New England states including Connecticut, Maine, Massachusetts, New Hampshire and Rhode Island. Three community colleges were represented by one physics and two technology professors and a Tech-Prep coordinator. At the high school level, three science and one technology instructor, two guidance counselors and one School-to-Career coordinator participated in the interviews. One science instructor from a middle school shared her experiences with the program. The interviews covered four main topics:

- Scope of photonics program implementation
- Student interest and access to photonics programs
- PHOTON Alliances and opportunities for articulation and sustainability
- Collaborative relationships with industry

The findings from the interviews provided up-to-date information that reflects how the proposed outcomes of the project compare with the actual outcomes. The findings also will be used to inform implementation of PHOTON2, which commenced in September of 2003.

Scope of photonics programs

In one community college the NSF funding for PHOTON was leveraged to enhance the current photonics offerings and seed an advanced fiber optic/photonics laboratory for the Information Systems Technology degree program. A $120,000 grant from the International Society of Optical Engineering (SPIE) will be used to expand the existing lab and to support joint projects between the IST/Electronic Technology and Biotechnology departments.

PHOTON PI Judy Donnelly with optics students from Three Rivers Community College (CT) at the April 2003 FiberFest Expo.

Another community college already had an associate's degree program in Photonics Engineering Technology and a 14.5 credit program Certificate Program in Fiber Optics prior to participating in PHOTON. As a result of the college's participation in PHOTON activities, photonics technology units are now being offered in four additional courses: Physics, Electrical Technology, Electronic/Computer Repair Technology and Pre-Engineering. Furthermore, students enrolled in the General Engineering Technology program can now elect to take a concentration in photonics.

For the last two years one high school has offered a science and technology elective called "Photonics and Solar Energy." After participating in Project PHOTON the school's instructors have updated the curriculum and changed the course name to "Lasers, Optics and Solars" to describe the new focus of the course more accurately.

Another high school has added photonics courses within its Pre-Engineering program as follows:

- Pre-Engineering 1, with a course in Photo-sensors and Emitters
- Pre-Engineering 2, with a course in Fiber Optics and Lasers
- Pre-Engineering 3, with courses in Optical Command Control and Communications

A number of teachers and counselors shared how helpful the PHOTON listserv has been as they began to introduce photonics technology education into the classroom. The listserv is guided by the project instructional team and several industry mentors who respond to questions and share their knowledge about the science and technology of photonics and trends in the industry.

Student interest and access to programs

Most of the schools' counselors have been successful in introducing students to careers in photonics by providing career information, field trips to colleges and job shadowing in industry. However, the issues of staff turnover and a slowdown in the technology industry sector were mentioned as challenges by several educators.

One counselor shared that students really like the photonics course because it provides hands-on, project-based learning. However, the counselors urged caution that the students' focus is not too narrow. She suggested that, especially at the high school level, it is important to make photonics education part of a broader set of technological skills. This gives students a series of options making their skill sets more responsive to changes in industry needs.

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employers will once again need the usual suspects—skilled engineers, technicians, and team leaders—to propel their companies forward.

But as the "Sputnik" generation leaves the work force, the nation is faced with a talent shortfall that could endanger the growth and success of the economy. For companies that intend to build upon a continued stream of innovation, the challenge will be in finding a new domestic supply of intellectual and technical labor. NSF and the PHOTON2 team believe that one solution to this challenge is a wider dissemination of the materials developed by Project PHOTON.

Given the demand for more photonics technicians in the future, what state-of-the-art technologies can help to disseminate PHOTON's successful professional development curriculum?

With the advent of the World Wide Web higher education has undergone a revolution in the delivery of educational materials, instruction and training. Web-based courses in particular allow learners to work at their own pace, access information conveniently, and communicate easily with their instructors and peers. In contrast to face-to-face instruction, online courses give learners extended reflection time through "asynchronous dialogue," letting them compose thoughtful, probing contributions. Through web-based instruction, people around the corner and around the globe come together to form a close-knit community of collaborative learners based on professional and common interests.

Although web-based instruction has many positive aspects, it also has some downsides. These include high dropout rates, a feeling of isolation in the learning process, and a lack of personal connection to instructors and fellow students. PHOTON2 will develop a web-course designed to address these issues in collaboration with experts in adult learning.

By engaging learners through active, continuous, and coherent learning via web-based instruction, PHOTON2 will create a collaborative learning environment that will allow participants to: (1) develop self-directed study skills for life-long learning; (2) adapt and apply the PHOTON2 content and pedagogical strategies for use in their own courses; and (3) establish and maintain a collaborative community of students, educators, and industry professionals that supports the transfer of learning through synergistic learning activities.

My school would be interested in participating in this challenging project. How can we participate and what are our responsibilities?

During September, the New England Board of Higher Education (NEBHE) recruited 24 teachers and faculty from high schools and two- and four-year colleges across the country who teach science, technology, engineering, and/or math.

A key component of project PHOTON2 is the development of "alliances." The "alliance" model, developed in Project PHOTON, is based on three different types of partnerships. First, to promote career-based learning within each school, each applying institution must include a team consisting of a science and/or technology instructor(s), and a career or guidance counselor(s). Second, to foster photonics education "pipelines" linking secondary and post-secondary schools, each applicant must collaborate with a local institution (high schools will collaborate with a local college; colleges will collaborate with a local high school) that can act as a regional partner to build photonics technology career pathways. And finally, companies that employ photonics technicians will meet and work with school teams to share information and ideas about industry needs and career opportunities.

PHOTON2 Team from left (standing) Sandy Bell, UConn, Barbara Washburn, STCC; Judith Donnelly, TRCC; Kelli Valieres, UConn; Nick Massa, STCC; Karen Mayo, Stephen F. Austin State University; Fenna Hanes, NEBHE; and seated, Marijke Kehrhahn, UConn.

PHOTON2 offers participants the following:

- A one-semester 4-credit web-based professional development course, "Introduction to Photonics Technology," using the field-tested PHOTON curriculum. The first offering will be in spring semester 2004, the second in spring semester 2005.
- A 2-day regional "Introduction to Distance-Learning" workshop designed to acclimate participants to the web-based learning environment and establish online learning communities.
- A field-tested industry-quality laboratory equipment kit valued at $4000 per institution (half paid by the grant and half by the participating institution).
- Instructional materials designed for use by career and guidance counselors (counselors may also audit the distance learning course).
- Assistance in securing locally-based paid summer externships for teachers and counselors in the photonics industry.
- Participation in a final "Showcase" workshop in 2006.
- Participation in a nationwide online learning community consisting of photonics educators, career and guidance counselors, industry mentors, and professional optics-related societies.

Upon completion of the course, each participating educator (teacher and counselor) will have gained the knowledge and resources needed to implement and introduce photonics technology at their own institutions and engage students in exploring a career in photonics technology. For more information go to www.nebhe.org/PHOTON2.

PHOTON Status Interviews, continued from page 8

Photon alliances and articulation

One community college reported that they have articulation agreements in physics, chemistry, math, biology and photonics with area high schools.

One PHOTON alliance was able to build collaboration among the middle, secondary and postsecondary alliance schools. The curriculum even reaches down to the elementary school, where sections on light are being taught in science classes. The articulation agreement also encourages students to help other students: high school students mentor in the middle school classes, reinforcing their own skills and gaining tutoring experience. Finally, articulation agreements have been established between the high school and the local community college.

As an outreach and recruitment strategy, last spring, one of the Connecticut community colleges conducted a one-day Fiber Optics Workshop for teachers and offered Continuing Education Units. The PHOTON network, in addition to reaching out to local schools, brought educators from as far away as New Hampshire and Maine to the workshop.

Collaboration with industry

A number of schools have received donations of equipment and instructional materials from local companies. These companies have also opened their doors to students, teachers and counselors for field trips. Several schools are also offering customized training for employers in their service area.

Collaboration with industry associations such as the Optical Society of America (OSA) and SPIE, has enabled educators to tap into valuable resources and make contacts with members in their area. One college started a local SPIE student chapter and, for the last two years in a row, has sent a student to the annual SPIE Conference. SPIE has also awarded one of the community colleges a grant to provide tuition for ten high school students to participate in a college-level optics course.

Several participants commented on the fact that implementation of new curricula is a long-term proposition but one worth striving for. One satisfied educator concluded the interview with this comment, "You have always been there for support, both in terms of equipment and training. It doesn't get any better than that." ■

Career Spotlight Dr. Anthony Johnson's Journey to Photonics

Becoming Interested in Optics

I had a strong interest in science in high school and did well in all the sciences. I had a really interesting teacher in physics. My first formal introduction to optics was a summer research program at Bell Labs. I was finishing my junior year in college at Brooklyn Polytechnic and this was my first exposure to real research with lasers—Dr. David Auston was my mentor and eventually became my Ph.D. thesis advisor. I wrote my first technical paper that summer which was published in IEEE. After that summer, I applied for and was awarded the Cooperative Research Fellowship Program at Bell Labs to pursue a Ph.D. in physics.

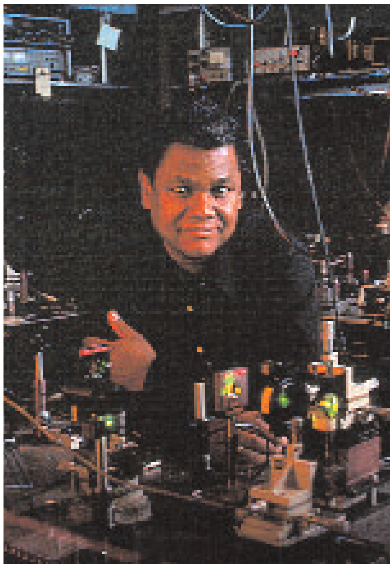
Working in Industry

In graduate school—with the Bell Labs research fellowship—I did all my research for my thesis at Bell Labs itself after I had finished my coursework and passed the qualifying exams at City College of New York, part of CUNY. After completing the Ph.D., I was then hired at Bell Labs as a member of the technical staff. At that time, I really wanted to be in industry. I wanted to go into academia eventually, but I wanted first to build up my research within an industry setting.

While at Bell Labs, not only could I engage in state of the art research, but I was also able to help recruit minorities and women into Bell Labs Research. I had a number of students do summer research with me and this was when I really decided that I wanted to be in academia.

Working in Academia

After 14 years at Bell Labs, I received a phone call with an offer to become chair of the physics department at New Jersey Institute of Technology. Managing my research and entering academe as a department chair, I learned so much about how to deal with people and their different goals. In August of 2003, I moved my lab to the University of Maryland, Baltimore County where I direct a photonics program called CASPR—a career transition which I am very much looking forward to.

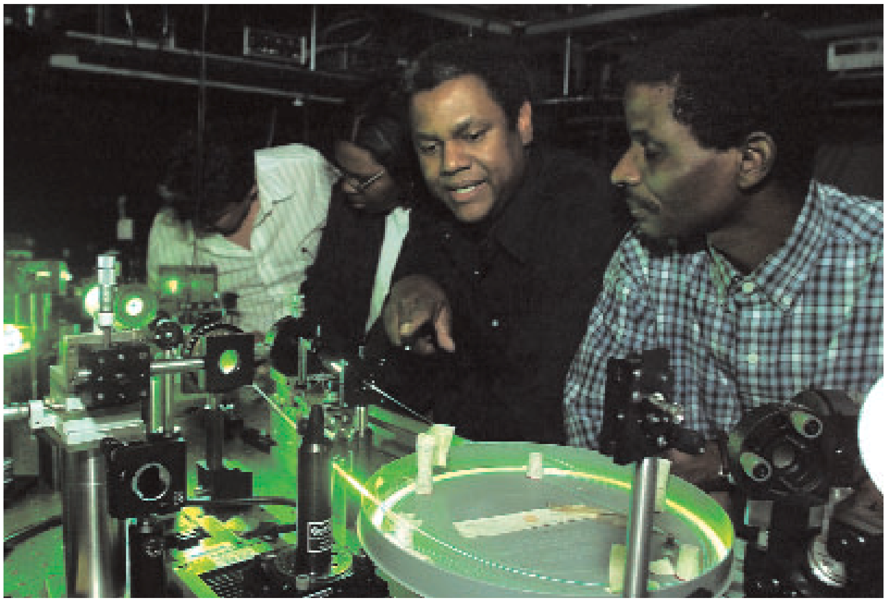


Participating in Professional Societies

My involvement with the Optical Society of America (OSA)—of which I was recently the president—has been very rewarding. Back in the 1980's there was a committee started with Elsa Garmaier for Women in Optics. At one of the evening meetings we decided to make it a committee for Women and Minorities in Optics. Through that avenue, and through an American Physical Society committee on minorities in physics, which I chaired, I feel I have been instrumental in securing a commitment from these organizations to work to broaden participation of minorities in physics and optics. Through OSA, I also do some outreach with countries such as Ghana, Brazil and Senegal.

Mentors

Mentors are key to anyone's success and I have had so many. Mentors need not look like you. Don't limit yourself. Scientists love to talk science! Race goes out the window when you are talking about science. Of course, my parents were always there for me and my pillar of strength has been my wife, who has a Ph.D. in nursing.



Anthony Johnson enjoys mentoring students in his lab.

Career Climate in Optics

We've had this economic downturn. Although telecommunications is down, the field of optics is very broad and there are other areas in photonics that are doing quite well. Internet growth continues, and I believe that the downturn is temporary. For example, in the area of nanotechnology, photonics is needed to image nanostructure. Biophotonics is also taking off. Talent is needed in all of these areas in order to push these forward. Much of the current technology is photonics related. One of our untapped sources, of course, is making sure underrepresented talent is being trained and utilized.

Science in Motion, continued from page 1

Science in Motion participants collimate a laser beam for use in a Michelson interferometer.

to explore the principles of geometric and wave optics. Dr. Massa demonstrated the physical concepts of Snell's Law, Malus' Law and collimation, and guided the teachers as they built a Michelson interferometer. Massa was assisted by Clarion University graduate student Jeff Bellerillo and Indiana University of Pennsylvania Professor James Sherman. Special guest Dr. Ronald Scotti, a science and technology strategist for SPIE, the International Society for Optical Engineering, also assisted the teachers by sharing his knowledge gained over a long career as an optical engineer with Bell Labs and Lucent.

When asked what they found most interesting, participants overwhelmingly expressed their satisfaction with the lab set-ups and the opportunity to work with lasers. One teacher shared, "I didn't realize how easy it is to work with lasers. I never thought this would be something that I could do in my classroom."

During lunch, participants viewed a video "Laser Technology: Changing Daily Life, Forging New Opportunities" produced by the Optical Society of America (OSA). The video can be ordered by visiting the OSA website at www.osa.org. Participants also had an opportunity to tour the EOC labs, which conducts research for the U.S. Navy, the U.S. Department of Defense and industry.

Next steps for the Clarion University Science in Motion consortium will be to add the PHOTON kit and instructional materials to the Science in Motion van and for the teachers to introduce the photonics labs into their classrooms. The long-term goal is to introduce the PHOTON curriculum to the other 10 Science in Motion consortia throughout Pennsylvania. For more information about Science in Motion go to their website at www.science-in-motion.org/.

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For more information, please visit our website:
www.nebhe.org/photon.html

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