

Stories from Laser Camp: Outreach Activities for Kids

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ABSTRACT

Often in the ever-expanding community of Optics and Photonics, what we do remains a mystery to the outside world. The technology created by our community permeates the lives of every citizen yet is taken for granted due to unfamiliarity. At Three Rivers Community College (TRCC), we have taken steps to rectify that situation. The college's Laser and Fiber Optic Technology program (LFOT) and the TRCC student chapter of SPIE run many outreach activities, the most successful of which is Laser Camp. This paper will present a comprehensive overview of Laser Camp from the students' aspect with testimonials, discussion of the optics themed activities and provide a view of the SPIE members' journey.

Keywords: Laser Camp, Outreach, TRCC, K12

1. INTRODUCTION

Laser Camp runs for three days, the first at TRCC, followed by one at a local laser industry (TRUMPF, Inc. for the past few years), then again at TRCC. At Laser Camp, local high schools are invited for a day of fun with optic-themed activities. The students learn basic physics properties of light and optics through challenges run by SPIE chapter members. By having SPIE members volunteer for Laser Camp and other activities such as Optics Day, Astronomy Day, and Junior Laser Camp, they develop teaching tools to better develop optic-themed activities. With minimal guidance, our SPIE chapter members take the social and technical skills learned in the classroom and develop the curriculum for teaching the workshops. At the end, the visiting students evaluate the workshops. This feedback is used to improve the workshops from year to year.

Laser Camp is supported by a number of organizations. EASTCONN, one of Connecticut's six educational service centers, provides the transportation from the high schools to Three Rivers and purchases many of the supplies. Funding through The CT College of Technology Regional Center for Next Generation Manufacturing (NSF/DUE ATE # 0903209) grant and the Center for Research on Interface Structures and Phenomena (NSF/MRSEC DMR05-20495) grant make many of these activities possible. Other funding for supplies and food comes from an outreach grant from SPIE.



Figure 1. 2009 group photo of campers

2. PROCESS

The journey through Laser Camp is an interesting one for the student volunteer. It starts with his/her commitment. Once the student has committed to help, they must meet with Professor Judy Donnelly to determine what role they will have. For volunteers, Professor Donnelly usually recruits from the TRCC chapter of SPIE or from the TLC program. TLC is a program at TRCC for high-risk students. The program gives them an opportunity to come to college by providing them with an outstanding support system. These students are usually eager to help. They have the option to be an escort in the hallway during the event or to assist with one of the activities. For students in the LFOT program or members of the SPIE chapter, the opportunity for involvement increases. These students are usually given the opportunity to assist with or run an activity. For the students who are ambitious enough to run an activity, their work has just begun.

The authors have run numerous sessions during our time at TRCC. Our first step would always be to pick an activity to run. Once we had our assignment, we were free to develop the curriculum under the guidance of Professor Donnelly. Since time management is crucial, we must determine the average age of the attending students, how many groups will be attending the session, and how many students will be in each group. Once this is determined, we were able to set up a schedule for the event.

After we have our schedule, we set to work making a material list for the activity. The day before, we would consult our list and consolidate all the materials. If time permitted, we would also set up our assigned room after the last class had finished the day before. This was usually preferable so that the following morning would run as smooth as possible.

The morning of Laser Camp we make sure all the volunteers know what the time tables look like for group turn over and the necessity of time management because all the students do have to make it to the cafeteria for lunch. Then any last minute group volunteers are given assignments to make each activity run smoothly. Upon arrival of the students each is given a list of activities they can choose from for the day. Once every student has chosen their activities the groups are then randomly mixed between schools and students. Then the chaperone leads them to the activities location via tour guides. Recently, we haven't been letting students choose. We make 5-6 schedules (depending on the size of the group) and randomly assign them to students. One of the goals of Laser Camp (from EASTCONN's point of view) is to get students from different schools working together.



Figure 2. 2010 TRCC SPIE chapter volunteers

3. ACTIVITIES

Laser Camp is filled with activities for students of all ages. Each activity has a general theme that is taught to entice the students to ask more questions while learning the basic concepts of each activity. Some activities are more hands on than others, while some are to just show how things in the world work. Depending on the age group each activity can be tailored to fit the educational level of the student. This allows similar activities for K-12 with the ability to have the same volunteers help out interchangeably. At Three Rivers Community College we've completed numerous Laser Camps with the same 7 activities for different age groups. Some of our activities are:

- Mirror Challenge
- Fiber Optics
- Spectroscopy
- Phosphorescence, Florescence, Luminescence
- Laser Engraver
- Holography
- Polarized Light Art
- Pinhole Cameras

3.1 Mirror Challenge

The Mirror Challenge activity challenges students to use a laser and mirrors to steer the laser beam to hit a bull's-eye target with points associated with areas within the target. This challenge is started off with a basic walk through of safety of using a laser, even though the HeNe laser we use is low power. Then we teach the students about the law of reflection, that the angle of incidence will equal the angle of reflection. For younger groups we might also state the angle the light goes in is the angle it comes out. This is where you can introduce more tools to be used such as protractors, string, and more mirrors. We place each target on the table and then a laser is fixed and unplugged. We allow three tries for each round with a total of three rounds. Each try has a target total of 100 points/ round. 300 points is the max point total, with, if needed, a sudden death round to break a tie. Each try is determined by when the students think they have a bull's-eye. When they are confident of their alignment, we plug in the laser and see if it hits the target. If they don't get the 100 points they can gamble to get a higher score but if they don't receive a higher target score they lose the points for that round. Each round we introduce another mirror into the game. For the younger students this will be more difficult but still a fun activity.

For the older students we give them protractors and a piece of twine just long enough to reach one mirror at a time. We ask at what angle did the first mirror hit and what angle will it leave to drive home the law of reflection. And at this point they should be able to use a protractor to get near the bull's-eye each time even if we move the bull's-eye target each round to make it harder for them. Most groups use the protractor and string effectively enough to determine a correct beam path, and take the gamble to increase their score. When all rounds are done we add up the total scores and pass out a prize to the winning group and a smaller prize to the defeated groups. Usually it's a full size chocolate bar for the winning groups and small bite size ones for the other participants.

3.2 Fiber Optics

The Fiber Optic activity informs students about how fiber optics are made and used in today's ever changing world. As with all of our activities, the students are given a basic safety introduction. We show them how fiber should be handled safely, the importance of proper eye protection, and how to properly discard of fiber pieces. After the safety talk, we would usually do a quick question session to make sure they had been paying attention. Now we were ready to begin. Using a large core plastic fiber, we are able to demonstrate to the students how light can be propagated through a fiber. We usually shine a low power laser pointer down the cable while twisting it show how light travels through the cable even when bent. We explain the different types of fiber, fiber cables, different connectors, and each student is invited to try stripping a glass fiber and splicing the ends together with a fusion splicer.

The students enjoy when we send a modulated signal through the air into a receiver and the music plays at the speaker attached to the receiver as if from magic. We begin with a modulated HeNe laser and ask the students to block the beam with their hands. Students quickly learn that a free space beam is not a very good option for communication in cluttered spaces. The next demonstration uses an IR source and receiver connected by a long plastic fiber, which eliminates the problem of something blocking the beam. As a variation, we can combine the mirror challenge with the HeNe laser and detector: how many mirrors can you bounce the signal from and still be able to detect it? With the IR demonstration, we can challenge the students to see how long the fiber can be before the signal disappears.

Most students like to watch a short video of how optical fiber is made. OFS has a great video online on the making of fiber optics, and we can show the remains of a fiber pre-form and some of the initial “drips” from the fiber draw process. Along with the making of fiber we show a short video of fiber optics being laid into the ocean from a huge ship and how the handling of the cables is crucial in order to make this happen. At the end of the session, the students are all given a piece of plastic fiber to take with them.

3.3 Spectroscopy

The Spectroscopy activity teaches students about the light spectrum and how each element has its own light finger print. Students have the opportunity to make their own “scientific instrument” from a cardboard tube, laser cut slit (cut of poster board with the TRCC laser engraver) and diffraction grating slide.

This activity starts off as a quick history lesson with the same type of tools (prism spectrometer) used in the 1800s to catalog the spectral lines of each element. Followed by a quick safety awareness lesson of the elemental spectrum tubes housing and what not to touch. Students construct a homemade spectroscope by gluing a 1 mm laser cut slit to one end of a short cardboard mailing tube and a diffraction grating card to the other end. Sometimes, we use circles cut from a used recordable CD, after stripping off the label with a piece of tape. The final step is to place a sticker on the tube warning, “Do not look into a laser or at the sun.”

Using a spectroscope that has three tubes each with a different aperture on the end shows the spectral emission lines. One aperture has an eyepiece for you to look into. Another has an adjustable slit which a number of element tube light sources can be placed for viewing each elements spectral emission lines. We usually have about three different element light tubes for this part neon, helium, and hydrogen. We shine a light into the last tube on the spectroscope for backlighting of the spectral lines according to wavelength. We allow each student to gaze at each element light source and record the wavelengths they see. We explain how limitations in each student’s eyes due to light sensitivity can affect the accuracy in recording the true elements spectral lines. Some students have difficulty to understand until we show them using the next tool.

The last part of the activity uses an USB Ocean Optics spectrometer with a fiber optic cable with a sensitivity range from UV to IR approximately 300nm -1100nm. The spectrometer uses a diffraction grating housed inside a box that can be connected via USB to a computer. The spectral lines show up in graphical form on the computer screen. Each student gets to use the computer to capture in real time the element light sources’ spectral line widths and compare there results and how accurate they thought they were. This Ocean Optics spectrum analysis software gives students an accurate interpretation of what they were seeing with the wavelengths that they could not see high into the IR wavelengths. The use of computers with most students makes the activity enjoyable and fun to learn. We then give out information on where online they can play flash applets if they want to learn more about emission and absorption lines though out the whole light spectrum.

3.4 Phosphorescence, Fluorescence, and Triboluminescence

The Phosphorescence Fluorescence and Luminescence activity is fun for all ages. Usually titled “Let it Glow”, we demonstrate these properties as they occur in nature and around us. As with all the activities, we begin with safety. The safety talk for this activity session revolves around the different kinds of light; IR, visible, and UV. We explain the dangers of each and discuss the importance of wearing proper protection in the sun.

We usually start the activities with a piece of vinyl that is phosphorescent. We turn off the lights so the student’s may see it glow. We also like to draw on the vinyl with red and blue LEDs and let the students guess why the vinyl is unresponsive to red light. This demonstration is an effective way to explain how a phosphorescence material absorbs energy and gives it off over a long period of time.

We always follow this demonstration with the “secret message” activity. Each student is given a small cup with laundry detergent and cotton swabs. The brand doesn’t matter but the detergent MUST have a whitening agent. The students are invited to write a message with the detergent on a piece of paper or their arm. We then pass out UV flashlights so the student’s may see their “secret messages”. It is at this time that we explain the properties of fluorescence and have the students explain the difference between fluorescence and phosphorescence. To drive the experiment home, we use a UV flashlight to excite fluorescent rocks and phosphorescent stars and moons. I hold up each and let the students guess which property the item I’m holding is displaying. This is a fun interaction with the class.

If time permits, we demonstrate triboluminescence using the sparking lifesaver. We use a dark box, a pair of pliers and Wint-o-Green Lifesavers candy. I invite the students up to my table in small groups. With the lights off, I use the pliers to crush a Lifesaver candy inside the box. By breaking the sugar molecules, the candy gives off UV light. The chemical flavoring reacts to UV light so the candy emits a small blue spark when broken. The students are asked to explain why the spark happens.

To end the session, we pass out a handful of UV beads and a small piece of twine to the students. They are then invited to make bracelets with the beads. Although the beads are not phosphorescent, fluorescent, or triboluminescent, it is a fun activity. As with all of our activities, the student is leaving with a gift, a memento from Laser Camp.

3.5 Laser Engraver

The laser engraver activity is one of the most loved by all of the students. It takes place in the machine lab at TRCC and is run under the guidance of the college laser safety officer. The students are introduced to our Epilog 45W Legend EXT laser engraver. We explain that it produces infrared radiation and that the red dot they see is a low power diode laser that shows the location of the invisible beam. The mirrors that deliver the beam and the focusing lens are pointed out, and we make sure to tell students that the laser is made by Coherent, in Connecticut, and that Three Rivers LFOT graduates have been hired by the company. The safety lesson for this activity focuses on eye protection and the different classifications of lasers. This effectively corrects any misconceptions that the students may have heard about lasers. The most common misconception is that lasers cannot hurt you because they are usually only familiar with low power laser pointers.

After the safety talk, we show the students how we can communicate with the engraver through a computer using Corel Draw. After that, we allow each student to choose an image either from our collection or from the Internet and personalize his or her own wooden key tag. Students enjoy watching the key tag being engraved and then cut by the laser. By giving the student something to take with them, we have helped make the activity fun and memorable.



Figure 3. Key tags made with the engraver

3.6 Holography

Another student favorite is the holography activity. This activity takes place in our senior lab room. We use this room because the darkroom is directly attached. This makes shuffling students to get their films developed efficient without having the glass slides with the light sensitive emulsion layer exposed to stray light. The lab also has a large optical table with vibration isolation bases. We need to have the laser diode on for at least five minutes to stabilize it. The PFG-03 holography plates, JD4 developer, and laser diode are all from Integraf, www.integraf.com.

We start off by allowing the student to choose 1 of the 2 stations with a couple objects that are pre-selected. Shiny objects such as coins, keys or jewelry work best. Once the station is selected we instruct the students on how holograms are made by interference patterns of light and how even the very simple hologram we are creating will be destroyed by vibrations. So for the five-second exposure we stress no movements or talking.

Each station has a stand with a red laser diode without the focusing lens attached so it has a wide beam of light without the use of external optics. The holography film plate rests on three cap screws attached to the optical table and the laser is clamped so that it shines vertically down on the plate. Our “shutter” is a homemade 3-sided box to protect the film while placing it onto the screws in the dark. Once the film is placed on the screws we remove the for the five second exposure, after which we return the box over the film. Each film plate is placed into a light tight box and students are told to move to the darkroom for developing. Passing through the rotating door into the darkroom is one of the high points of making holograms!

The film is developed to OD=2 (we compare to a piece of neutral density film), then rinsed in distilled water, and then bleached and rinsed again in running water. Once developed the student are then instructed to let the slide dry, the slower the better. To speed up the process, we have found that with consistent movement of the air from a cool hair dryer, we can dry them fast enough so the instant amazement of the hologram can be seen within our allotted time slot.

This activity has proven to be the hardest to achieve success but each time we enforce how difficult and complex holographic information is to record and with the smallest disturbance everything can be destroyed. But when the students are successful they leave with a cool homemade hologram and hopefully a deeper appreciation for what light can do.

3.7 Polarized Light Art

The polarized light art activity is one of the most popular. We begin by explaining to the students the concepts of polarization and birefringence. We then pass out to each student two 4-inch squares of polarizing film and let them experiment by looking through the two polarizers while they rotate one of them. Next we provide a 4-inch square of transparency film, a container of glue, and a variety of small cellophane shapes that we cut on our laser engraver. The students are instructed to be creative and glue the cellophane shapes to the transparency film. We explain that we use the transparency so the polarizing film stays clean in case they want to use it for further experimentation. Once this task is completed, the students are then instructed to sandwich the transparency film between the two polarizing films. When the student turns the top polarizing film, the shapes appear in color. This activity needs to be done in a room with windows for the best color effects.

For the Spring 2010 Laser Camp, one of the participating high school teachers found a supplier of slightly damaged wood frames on the Internet. We used a hot glue gun to attach thin polarizing film to the back of the frames and cut circles of laminated polarizing film with our laser engraver. The students attached a small screw eye to the frame and attached the circle to the frame with a piece of string. When completed, students took their “art” home to place in a window. The colors can be observed by looking through the attached polarizing film circle.



Figure 4. Students enjoying the polarized art

3.8 Pinhole Camera

The pinhole camera activity has been one of our most successful activities. The student's are invited to make an operating camera out of discarded containers. This requires some coordination with the students' instructor prior to the day of the event. The instructor ensures that each student arrives with a container suitable for making a camera, usually an oatmeal container since they have worked well in the past.

We start the activity by explaining the concept of a pinhole camera, how to take the picture once the camera is completed, and how the developing process works. Since the spent fixer contains silver, we explain that we cannot just wash it down the sink; it must be collected in a special bottle for hazardous waste disposal. By explaining the disposal process, the student is given a lesson in proper chemical safety.

Once the students are situated with a container, they are each handed a small square of aluminum cut from a soda can. The students are instructed to use a pin to drill a hole in the aluminum using a tool consisting of a sewing needle with the needle's eye stuck into the eraser of a pencil. The holes are checked for roundness and uniformity with a USB microscope. (Looking at a friend's hair or shirt with the USB microscope is an adventure in itself for many students.) After determining that the pinhole is round and uniform, the students make a hole in the container and tape the aluminum to the container so that the pinhole is in the center of the hole. The final step is to attach a piece of electrical tape to the container over the pinhole and fold the other side on itself to make a "shutter". This shutter is placed so that the pinhole may be covered during transportation to and from the parking lot where we usually take the photos.

After all students have the cameras constructed, we escort them to a darkroom to load the film. As each camera is loaded with film, the students are sent off to take their photos. We instruct them that the cameras must be placed on a solid, level surface and that the best photos are of scenery, i.e., trees and sky. Nonetheless, some students will have blurry photos because the cameras were hand held or they will have underexposed photos because they tried to take a photo of a friend against a building. When the student is ready, they lift the shutter for a few seconds, exposing the film to light before immediately replacing the shutter. They bring the camera back to the darkroom where we develop the film. The cameras usually produce striking photos, distorted with a great depth of field and make an excellent take home gift.

4. STUDENT LASER CAMPER TESTIMONIALS

"I learned that a nanometer is one billionth of a meter."

Student, Grade 12, Windham High School, Windham, CT

"I learned that Fiber Optics is a fast growing field."

Student, Grade 11, Plainfield High School, Plainfield, CT

"I learned that by rotating two polarized films, light will either pass or be blocked."

Student, Grade 11, H.H. Ellis Technical High School, Danielson, CT

"I liked the Holography. I found it interesting. I learned today that fiber is better than copper because it is nearly impossible to tap."

Student, Grade 11, H.H. Ellis Technical High School, Danielson, CT

"Today I learned that you could see stresses in transparent objects with polarized films."

Student, Grade 11, Plainfield High School, Plainfield, CT

"Everything I learned was very interesting. I was entertained all day. The hands-on experience was also fun!"

Student, Grade 11, H.H. Ellis Technical High School, Danielson, CT

5. CONCLUSION

Laser Camp has been a huge success for Three Rivers Community College. This outreach event has brought hundreds of students to the college for the sole intent of educating them about the world of optics and photonics. By providing hands on activities, we are able to educate the students while making the learning experience enjoyable. With the generous support of grants and funding through various agencies, we expect Laser Camp to run for many more years.



Figure 5. Fifth grade students attempting to steer the beam during the mirror challenge

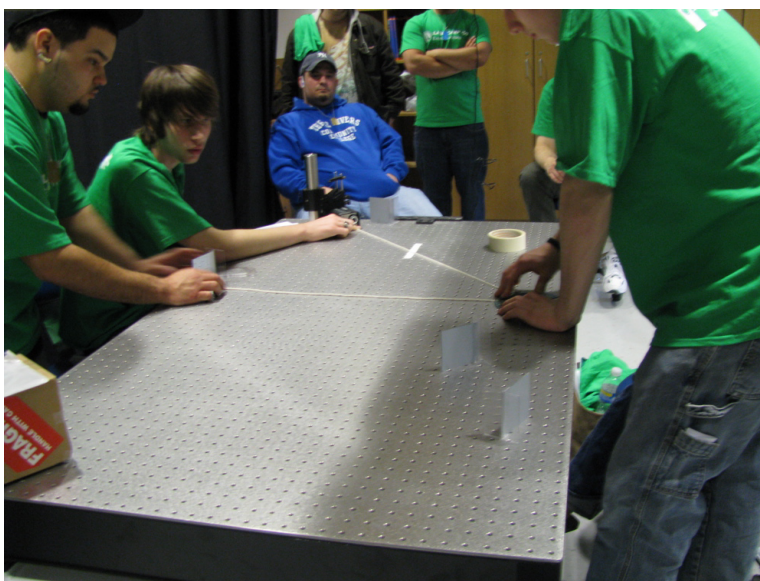


Figure 6. High school students attempt to predict the path of the laser during the mirror challenge