

2011 CU Diversity & Excellence Grant - Final Report

CU Research at the Speed of Light: A Faculty-Outreach Partnership to Engage Underrepresented Students with Electromagnetism

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Introduction: During the week of June 13-17, 2011, Professor Juliet Gopinath (Department of Electrical, Computer and Engineering Engineering), in collaboration with CU Science Discovery (directed by Dr. Stacey Forsyth), organized and taught a 15-hour course on electromagnetism for underrepresented students. This course was developed in response to the growing demand for students trained in science, technology, engineering and mathematics (STEM) fields, and the striking disparities among students in terms of their interest and performance in these areas. Many students, especially female and minority students, lack interest in STEM fields, and those from lower income families are less likely to be exposed to STEM career opportunities and may not have opportunities to participate in STEM enrichment activities.

The goals of this program were to heighten students' interest in science and technology, expose them to current optics research on the CU campus, and promote interest and participation in STEM fields. Professor Juliet Gopinath runs a research group focusing on lasers and their applications, and has a natural interest in engaging underrepresented minority and female students in STEM fields. The course provided an introduction to electromagnetism, covering topics ranging from the basics of waves to the visible, infrared, and microwave portions of the spectrum, and explored two applications of the basic concepts: robotics and holography. Sixteen students (ages 13-17) attended the course: eight from the Trinidad Upward Bound Program, three from the Casa de la Esperanza MESA Program in Longmont, and five from the general public (representing Boulder (2), Louisville (1), Arvada (1) and Albuquerque (1)). Thirteen boys and three girls participated. A photo of the class with Prof. Gopinath is shown in Figure 1.

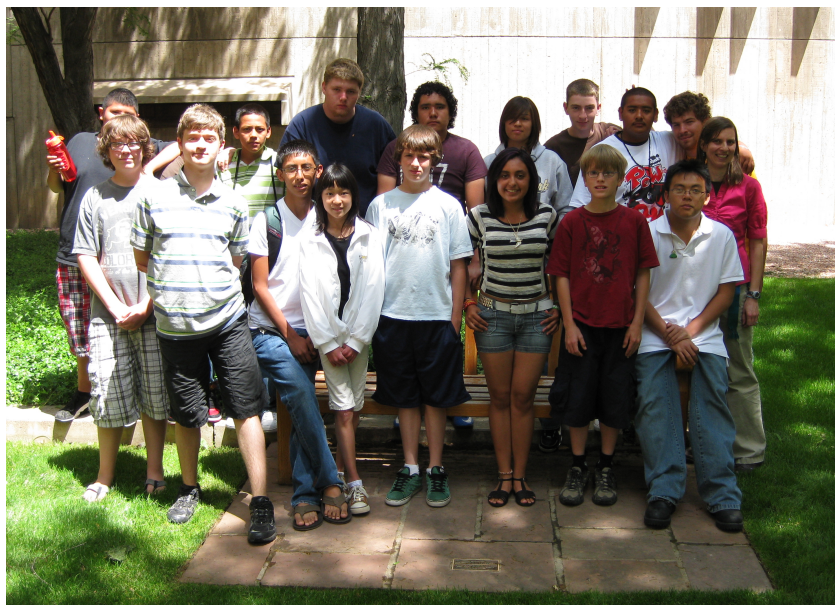


Figure 1. Class photo of students with Professor Juliet Gopinath. Eight of the students came from the Trinidad Upward Bound program and three from the Longmont MESA program.

Course Content: The course was taught from 9 to noon from June 13 – 17, 2011. Each day, Prof. Gopinath gave an introduction to the topics to be covered, as illustrated in Figure 2, and the students completed three to four hands-on activities. A summary of the main topics covered in the course is given below.

Monday: *Waves.* Slinkies™ and interferometers were used to provide a basic understanding of waves and some of their properties. The concepts learned established a foundation for subsequent activities.

Tuesday: *Imaging, Color, and Fiber Optics.* We explored the visible portion of the spectrum and learned how light creates different colors than pigments, how to make a pinhole camera, how fiber optic cables work, and completed a unit on polarization in the optics teaching lab.

Wednesday: *Applications – Robots and Holograms.* We focused on applications of electromagnetism. The students were introduced to robots that have light sensors and a light source to help them navigate around objects. The students used the interference of light to make holograms, and toured Professor Robert McLeod's optics lab, which focuses on polymer processing.

Thursday: *Infrared Light.* The students were introduced to liquid crystals and made mood patches, experimentally determined transmitters and absorbers of infrared light, and experienced what the world might look like if you could see in the infrared, using an infrared camera. In addition, the students learned about the inside of a microscope and used one to look at plant cells from microscopy researcher, Professor Carol Cogswell.

Friday: *Radio and Microwaves.* The students measured the speed of light with marshmallows. They learned about Faraday cages and how they affect car radios. They also made a wireless connection between a TV and a VCR.



Figure 2. Professor Juliet Gopinath teaching the class about electromagnetism.

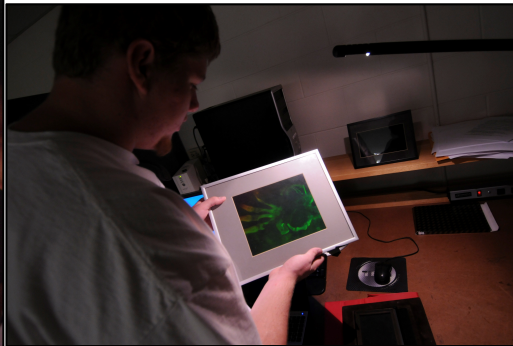
Evaluation

The students were very enthusiastic about the class, especially the three female students. Prior to the class, the majority of students (12) had never visited a working science or engineering laboratory. According to a post-course survey, the most successful units were the holography and robotics units; the students enjoyed making and viewing their holograms, as you can see in Figure 3, and programming a scribbler robot. Although we did not statistically analyze the data, the pre/post survey comparison suggested that the course positively impacted students' interest in technology (average on a 5-point scale shifted from 3.33 to 3.75),

interest in designing new things (3.73 to 4.19), self-assessed knowledge of what scientists do (3.00 to 3.44), interest in science and engineering (3.97 to 4.23), and belief that learning about science is important (4.07 to 4.44). When asked what should be changed for next year's class, the only suggestion (heard from three students) was, "Add more time." The others thought it was excellent as it was; in one student's words, "I don't really have any suggestions – that's how awesome camp was!"

Funding and Resources

Funding from the Diversity & Excellence grant provided \$1,850 toward student scholarships and paid for course materials and supplies (\$1,150), including hologram supplies, kaleidoscope kits, a scribbler robot, glass fibers, battery holders, light bulbs, etc. The CU Dept. of Electrical, Computer, and Energy Engineering (ECEE) donated space and additional resources for the course (materials, supplies, and photography support). Professor Juliet Gopinath donated her time to prepare and teach the course, and numerous faculty, graduate students, and professionals volunteered to assist with the course (see acknowledgements below). Science Discovery staff promoted the course, recruited the students, provided additional scholarship funds and provided an undergraduate Teaching Assistant for the course.



Acknowledgements

Course material was developed in collaboration with Professor Martha Baylor (Professor at Carleton College). Numerous graduate and undergraduate students and professionals volunteered to run course activities including: Donald Conkey, Ginni Grover, Matthew Hayman, Benjamin Kowalski, Kendra Krueger, Zefram Marks, Jeremy Nash, Thomas O'Neill, Jonathan Pfeiffer, Neil Severson, Adam Urness, and Ramzi Zahreddine (all of ECEE); Jennifer Harlow, Leigh Martin, Robert Niederriter, and Daniel Weingarten (from Physics); Alan Pattee (JILA); Tia Reinschmidt and Dola Saha (Computer Science); and Mehdi Mehrpartou (HP). Professor Dirk Grunwold of the CU Computer Science department donated scribbler robots and allowed curriculum from CS Unplugged to be used for the course. The CU ECEE department donated space in the Capstone lab for the course and allowed use of the optics teaching lab for the polarization, holography and microscopy units.