

Pre-College Experience in Physics 2019

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Pre-College Experience in Physics (PREP) is a two-week summer program run through the University of Rochester's Department of Physics and Astronomy. The program hopes to instill a passion for physics and science in general in young women who are entering 9th, 10th, and 11th grade. The program is held in Bausch and Lomb Hall on the University of Rochester River Campus that has classrooms, offices of professors, a library, and laboratories. This commuter program is free of charge, and runs for two weeks in July from 9am to 4pm.

This year's twenty-two participants came from twelve different public and private high schools all over the greater Rochester area. Several of the students were quite new to the area, while others had grown up in Rochester. The students had varying academic backgrounds, particularly in science and math. Those with more experience in science had taken biology and chemistry, but certain students entered the program having taken only Earth Science. Concerning math, most had only taken classes through Algebra 1, and none of them had taken calculus. As a prerequisite, none of the students had taken a physics class before; however, several students were looking forward to taking physics in the fall.

Our goal was to provide each of the students with an enjoyable, hands-on experience with science, particularly physics, in an environment more relaxed than most high schools. Since the students had varied backgrounds in math and no prior experience in physics, our lessons were concept-oriented, focused more on the students' understanding of physical phenomena than the math behind it. That said, in order for the girls to gain confidence in using equations, mathematical problems were provided. Both instructors were always available for aid, and the problems were often reviewed on the board. While our syllabus was ambitious, the students met every challenge with an encouraging level of interest. We were surprised and thrilled by the intelligent questions asked throughout the program and the students' interest in every topic.

A typical day at the PREP program centered around a particular topic in physics—be it astronomy, circuits, or quantum physics—that was introduced to the girls through lecture and supplemented through fun activities, labs, and demonstrations. In addition, University of Rochester professors met with the girls to talk about their research and life experiences. Though most speakers study in a field related to physics, a variety of departments were represented. As the speakers were primarily women, the PREP participants were able to

ask questions not only about research but also about the challenge of becoming a scientist in a male-dominated field. The professors both spoke honestly to the young women and encouraged them to follow their dreams, whatever they may be. Additionally, the girls visited several STEM-related locations on or near the University of Rochester campus: the Department of Biology, the Institute of Optics, the Center for Advanced Brain Imaging and Neurophysiology, and the Laboratory for Laser Energetics. Students also spent time with an admissions counselor to learn about the process of applying to college.

One of the most integral components of the PREP program was the lunches held with undergraduate students. During these events—three during the two weeks—the girls got a chance to have lunch with female undergraduates doing research in a variety of STEM fields. For example, one of the undergraduate participants works in the fabrication of quantum nanochips while another helps to develop immunotherapies to treat late-stage pancreatic cancer. Though the PREP students had a wide spread of interests, almost everyone was able to find a corresponding undergraduate to speak with. These discussions not only allowed the students to see science at work and get a feel for what their futures may be like but also allowed them to connect with role models in a comfortable setting.

The PREP program focuses significantly on particle physics. Though this was a subject that few of the girls had encountered before, many were fascinated by the possibilities and importance of particle physics. They not only were given a lecture on the topic but also received a chance to see particle tracks up close in a cloud chamber, build model particle detectors of their own, and speak to a professor deeply involved in this area of physics. Professor Regina Demina spoke to the students about the four fundamental forces, the standard model of particles and the CMS (Compact Muon Solenoid) detector at CERN. Overall, particle physics proved to be a highlight of the program, challenging the students and exciting them with all of the connections that the smallest things in the universe have to everyday life.

Hands-on projects were a consistent favorite throughout the program. For the first project, the students worked in partners to make, from basic materials such as paper, grocery bags, and string, a device that would protect an egg from a drop of several meters onto hard concrete. Enthusiasm was high, and the girls implemented a variety of techniques to save their eggs. The following week, the students split into groups of three or four to create Rube Goldberg machines. For this project, the students had to involve a minimum of six reactions, with the final step being a marble landing in a bowl. The reactions that occurred throughout the structure were governed entirely by Newtonian mechanics, so the girls needed to use their knowledge of physics, as well as their creativity, to create a successful device. At the end of the project, they were asked to explain how each Rube Goldberg machine worked and produced answers of surprising complexity, directly citing the laws of

classical physics they had learned just days before. Many students cited this as their favorite part of the program, loving the creativity and collaboration involved.

Later in the program, each student was individually tasked with researching a historical woman involved in STEM and using what they learned to create a trading card explaining her contribution to science. The purpose of this project was not only to expose the students to the research process but also to provide them with another role model in a scientific field they were interested in. The girls were given a tour of the physics library and shown a display, arranged specifically for the program, on many of the scientists they were researching. On the last Thursday of the program, these cards were proudly presented to parents and guardians in slideshow format. Many parents were thrilled to see the woman that their particular student had picked out and how much they had learned.

The PREP program sets out to instill in young women a passion for science but also teaches them how to solve problems, work in groups, and research topics they care about. Ultimately, we hope they see both the beauty of physics in the world around them and their own potential in the field. Those students planning to take physics have said they feel PREP has more than prepared them for the class and that their experience has boosted their confidence for school in the fall. By the end of the program, all students expressed a fascination with the science they had learned, with one girl even saying “The physics was amazing! Learned more in these two weeks than I ever have about physics!”

Overall, PREP has a great deal to offer young women interested in physics and other STEM fields. Not only is the program flexible to the needs and interests of its participants but it also covers topics not normally taught in a high school physics class such as particle physics, quantum physics, and astronomy. Just as importantly, it gives the students the opportunity to connect with other girls who share the same interests as them and inspire them to follow their dreams.