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Magnetism and Superconductivity Demonstration for High School Students

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This paper describes a set of demonstrations and hands-on learning experiences devised to introduce basic concepts of magnetism and superconductivity. These have been successfully presented to high school students during 2006 and 2007. A special feature of these experiments is the involvement of the principal author's REU students in the planning and delivery of the modules and the interaction of the undergraduates with high school teachers and high school students. The experiments were conducted in a nano and advanced materials workshop which was part of an annual Engineers Starter Program Camp conducted on our campus every year. The two-day workshop has been attended by over 85 students over the past two years.

The first set of experiments was focused on learning magnetism, drawing magnetic lines of forces, and experiencing the force of magnetic fields. The experiments included drawing magnetic force lines by sprinkling and tapping iron fillings on a plexiglas plate placed over a bar magnet. This provides the students the idea of magnetic lines of forces being emanated from both the poles of a bar magnet. The idea of magnetic lines of force are crucial to facilitate student understanding of the phenomenon of diamagnetism that underlies superconducting levitation – the second experiment the students do.

The second set of experiments were focused on superconductors – including a levitation experiment and a high-temperature superconductor assisted light bulb circuit. The students were first given a demonstration experiment when a superconducting pellet was dipped in liquid nitrogen and then a small magnet was levitated over that. After the demonstration experiment, each student was asked to conduct the experiment himself/herself. The students had fun handling the liquid nitrogen themselves. They also froze some oranges and dropped to the floor which gave them an idea how temperature can transform a soft material into hard and brittle material. The superconductor assisted bulb lighting experiment involved making a microbridge in yttrium-barium-copper oxide (YBCO) superconducting films using a pulsed laser ablation technique. The purpose of making the YBCO microbridge was to increase the normal temperature resistance of the films in the range of 400-500 ohms from the resistance of 4-5 ohms of unpatterned film. This YBCO microbridge was connected to an electric bulb and a battery in series. The bulb did not light up. When the microbridge was dipped in liquid nitrogen, the resistance of the film dropped to zero and bulb was found to light up. As the liquid nitrogen evaporated, the resistance of the YBCO film increased and the bulb stopped lighting up. The students poured the liquid nitrogen themselves, made the bulb light-up and light-off. They also measured the resistance of the YBCO microbridge as a function of time and found the resistance shooting up back to 400-500 ohms.