

Physics for Third Graders: An Example

About twice a year for the past five years, I have been invited to speak to third-grade students about forces. My visits in the St. Louis area are arranged by the St. Louis Academy of Science, which matches school requests with willing scientists, and have been primarily to the suburban, middle-class Rockwood School District, about 25 miles west of the city.

With my small collection of magnets, I drive to the appointed grammar school. The students usually have just finished a section of their science curriculum on forces, including a hands-on experience with magnets. I ask the students to move their chairs into a half circle around me, and I in turn sit on a student's chair, so that I can easily make eye contact with them. The teacher generally sits at the back of the class and listens in.

I introduce myself and tell the students I want to hear them talk about science. I first ask what they have learned about forces. What is a force? I emphasize the idea of attraction and repulsion as the signature of a force. What are examples of forces? I make a point of telling them that two magnets stuck together and the students stuck on Earth's surface are both examples of attractive forces.

I then mention the Van de Graaff generator. A small St. Louis science museum, the Magic House, has a Van de Graaff generator, and nearly all of the students have visited the museum and had their picture taken with their hand on the top of the generator and their hair standing out from their heads. I ask, Why does your hair do that? The students have no idea, so I ask a series of related questions: What is your body made of? Bones. What are bones made of? Cells. What are cells made of? What are all things made of? After some wrong answers and hints from me, the class arrives at the correct answer—atoms. What are atoms made of? The students groan, but finally I talk about electrons, protons, neutrons, and a planetary model of the atom.

Returning to the Van de Graaff generator, I explain—incorrectly—that at the bottom of the machine electrons are scraped off a surface and put on a belt, which carries the electrons to the top of the machine where they are transferred to the

student's hand. Actually, the generator removes electrons from the top of the generator, but talking about missing electrons would unduly complicate the discussion.

So why does your hair fly out the way it does? After more wrong answers and hints about electrons repelling each other, I explain that repelling objects—electrons—want to get as far away from each other as possible. Where are the electrons? At the end of each strand of hair.

After a brief discussion of static electricity—balloons attracted to walls, for example—I take out of my pocket two magnets that are stuck together. I ask if they will stick together if I place a piece of paper between them. We take a vote. I ask how we decide who is right, and then I do the experiment. What about aluminum foil? Will the two magnets stick together if I place a piece of aluminum foil between them? Most of the students vote no. Again, I ask them how do we decide who is right? I do the experiment. I emphasize that science is not a democracy, it is not the majority but the experiment that decides what is correct.

Next, I place a number of sheets of Mumetal between the two magnets and demonstrate that, with those sheets separating them, the magnets do not stick together. I tell the students that Mumetal is a magnetic shield. How does it work? After more wrong answers, I explain that the sheets of Mumetal act like a magnet with the opposite polarity of the two permanent magnets. (If both permanent magnets have a north-south polarity, then the sheets of Mumetal have a south-north polarity.) The sheets of Mumetal repel both permanent magnets with almost the same force as the two permanent magnets attract one another. The two magnetic forces acting on each permanent magnet almost cancel each other out and there is almost no net attraction.

I begin the last part of my presentation by asking, What is a gravitational shield? What would happen if you had a rug that was a gravitational shield and you sat on it? Have you ever seen or owned a gravitational shield? No, the students tell me. Why is there no such thing as a gravitational shield? After I hint that there is no gravitational repulsion, sometimes a third-grade student gives the right answer. In any case, I end my presentation by repeating how a magnetic shield works, how magnetic repulsion is

an essential part of the process, and how one cannot have a gravitational shield because there is no gravitational repulsion.

Each presentation runs about 20 minutes. I usually do about four, one right after the other, to all the third-grade classes at a given school. I realize that 20 minutes probably will not change a student's view of science; the presentation is really aimed at the teacher. Maybe the teacher will realize that science is not a collection of facts to be memorized, but an investigation into nature, a two-way inquiry between students and teacher, and a cultivation of the students' enthusiasm and curiosity. I have always enjoyed my visits to the third grade, and I hope my positive experiences will motivate other scientists to do something similar in the schools in their neighborhoods.

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When Physicists Volunteer, All Parties Benefit

I commend PHYSICS TODAY for the story celebrating volunteerism in the physics community (September 2004, page 30). As a student in physics and astronomy, I saw that many of my professors considered volunteer work a waste of time, an interruption in the journey to professorships. But as a Peace Corps volunteer in West Africa, where I taught math and physics, I saw just how beneficial the work was to me and to my students.

A handful of teachers or a single person can make a difference teaching and learning through outreach programs. I encourage everyone in academia and industry to find some way to help out fellow educators or students, on the other side of the globe or in a local school.

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Correction

October 2004, page 93—Mario Iona completed his PhD thesis under the direction of Theodor Sexl and Egon von Schweidler, not Roman Sexl as reported. ■