Voltage Demonstration

98-7000

INSTRUCTIONAL GUIDE

Contents

Voltage Demonstrator

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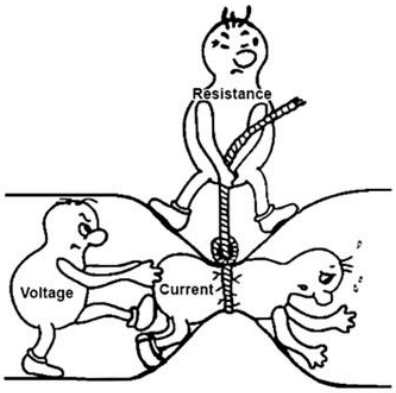
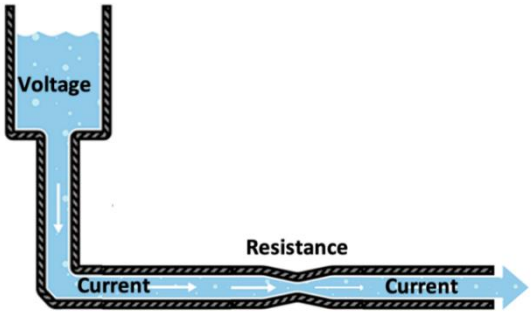
Introduction

FOR THE PHYSICS/PHYSICAL SCIENCE TEACHER…



The World of Physics and Physical Science can usually be described using equations and numbers. However, throughout the Physical Science world, there are concepts that are extremely abstract or just difficult conceptually for students to grasp. When teaching electricity, the three major concepts of voltage, current and resistance are all factors in a conventional circuit, and each has an effect on one another. Students need to understand the basic concepts of electrical circuits before they move onto solving DC (or AC circuits at higher levels). Most science teachers over the years have used analogies to teach the fundamentals of electricity, sometimes represented with cartoons depicting voltage, current, resistance interactions or using water analogies to illustrate the relationships and how voltage may affect current, etc.



One of the most difficult pieces in teaching the electricity section to your students is the concept of voltage. There are numerous analogies throughout the years that attempt to explain what voltage is and its purpose in an electrical circuit. There are simulations as well as numerous diagrams to attempt to explain exactly what role voltage plays in circuits. Using the new "Voltage Demonstrator" highlights the concept of voltage (potential difference) to the front of your classroom.

Voltage is the difference in electric potential between two points, corresponding to the work needed per unit of charge to move a charge between the two points, measured in Volts.

Demonstrations

How to use the "Voltage Demonstrator"

- The "pipe" is analogous to the wire and the "white beads" represent the electrons in the wire/circuit.
- It is also helpful to have a small plastic funnel that can be used to transfer the white beads into and out of the bottles for your demonstrations.
- Each bottle is able to be easily attached to the pipe ends for your demonstrations.
- Standing in front of your class while performing the demos is essential to student understanding… have fun with it!

1. **General Demonstration of Voltage**
   - With the two SMALL bottles attached on either end (one filled with white beads), you can illustrate the concept of voltage by tipping the pipe and allowing the beads to flow freely. Tell students that you must have a potential difference for the current to "flow".

     As the beads flow, it is helpful to slightly/slowly spin the tube to prevent the beads from bunching up and preventing friction effects. *See video

2. **Demonstration of High Voltage/High Current**
   - Example → Lightning (1 million Volts/20,000 Amps) or electric transmission line (~400,000V/700Amps)
   - With the two SMALL bottles attached on either end (one **filled** with white beads), tip the Voltage Demonstrator at a steep angle to represent a large voltage (high potential difference) resulting in a large flow of white beads (electrons/current). *See video

3. **Demonstration of High Voltage/Low Current**
   - Example → Tasers (50,000-1000,000V/~1-2mA) or cauterizers (15,000V/2mA)
   - For this demonstration, you will need to first **remove white beads** from the small bottle until there are just enough to cover the bottom of the bottle (~10% filled with beads). With the two SMALL bottles attached on either end, tip the Voltage Demonstrator at a steep angle to represent a large voltage (high potential difference) resulting in a small flow of white beads (electrons/current). *See video

4. **Demonstration of Low Voltage/High Current**
   - Example → Toaster (120 Volts/10 Amps) or clothes dryer (240V/20Amps)
   - With the two SMALL bottles attached on either end (one **filled** with white beads), tip the Voltage Demonstrator at a shallow angle to represent a low voltage (low potential difference) resulting in a large flow of white beads (electrons/current). *See video

5. **Demonstration of Low Voltage/Low Current**
   - Example → Flashlight (3-6 Volts/10 Amps) or electronic games/toys (3-12V/>1Amp)
   - For this demonstration, once again you will need to first **remove white beads** from the small bottle until there are just enough to cover the bottom of the bottle (~10% filled with beads). With the two SMALL bottles attached on either end, tip the Voltage Demonstrator at a shallow angle to represent a low voltage (low potential difference) resulting in a tiny flow of white beads (electrons/current). *See video

6. **Demonstration of Battery Types → AAA-cell Batteries vs. D-cell batteries**
    - For this demonstration, you will need to **fill the small bottle** with white beads and attach it to one end of the Voltage Demonstrator. Attach the large bottle to the other end. To illustrate the difference between a D-cell and AAA batteries, this demonstration can clear up the misconceptions about why the **SIZES** of the batteries are different yet the **SAME** voltage. For obvious reasons of size/space, AAA and AA batteries are used conveniently in smaller devices but the differences lie in how they function for various applications. The D-cell has a high capacity which means it is capable of operating at the same load for a **LONGER** time period. With the set-up (large bottle and small bottle at either end), tip the Voltage Demonstrator at a shallow angle and allow the beads (Electrons) to flow for an extended period of time. The students will observe that the current flows for a for the same amount of time, but the small bottle gets filled up and the large bottle has a lot more room. *See video

7. **Demonstration of Battery Charging/Discharging**

For this demonstration, return to using the two SMALL bottles attached to either end (one filled with white beads). The Voltage Demonstrator can be utilized as an excellent analogy for what occurs when a fully charged device (such as a student's cell phone) gets used throughout the day and then requires recharging at night when their battery "dies". Tip the Voltage Demonstrator at a shallow angle and allow beads to flow in the tube. As the device is "used" throughout the day, the voltage decreases and eventually there is no voltage (potential difference) to drive the electrons through the circuit. Demonstrate this by lowering the tube SLOWLY while the beads are flowing and bring the tube to horizontal, where the current (white beads) stop moving. Emphasize that when their cell phone or most battery-operated devices are plugged in to recharge at night, the process heats the chemical processes within the battery to bring the voltage back to power the device once again. The demonstration once again emphasizes the importance of voltage driving the current through the device. *See video

Final Notes

It is important to remember that the suggestions for these demonstrations are **merely analogies** for the abstract world that electricity concepts can have on your students. As most science teachers are aware, the Voltage Demonstrator is NOT an actual representation of how Voltage in a circuit works, but it is a further tool for your teaching of electricity. **Electrons do not flow** in a circuit like water or the beads but engage in electron drift, which is usually taught at AP or College-level Physics/Electrical Engineering courses. This device has been designed for General High School Physics and Physical Science/Middle School students dealing with basic concepts in electricity and based on New York State's Regents-Level Physics Curriculum.