TEACHER AND STUDENT NOTES

How Do We Levitate the Train?

Abstract:
Students will be presented with a problem: "What superconducting material is best to use for a maglev train?" Students will discuss strategies for solving the problem, learn how to sift through hundreds of data runs to develop answers, produce graphs that will lead them to their conclusions, present findings to the class, and propose a specific answer to the problem based on data.

Introduction to Research:
As described in the section on the Meissner Effect, a repulsive effect between a superconductor and a magnet can be obtained by exposing the superconductor to such an external magnetic field.

Learner Outcomes:
The student will be able to:

- Identify different factors that affect the maximum current a superconducting wire can carry.
- Use voltage vs. current data (or graphs) to identify when a material is superconducting and when it is resistive.
- Use data to make a proposal about the physical behavior of a material and make an argument about that behavior.

Research Question:
Given a data set about different superconducting materials, which material and conditions would provide the largest current / magnetic field?

Assessment Type:
Performance (presentation), along with argument paper to justify the presentation.

To the Teacher:

Alignment with National Science Education Standards

This project demonstrates elements of the following:

- Teaching Standards:
    - A: Plan an inquiry-based science program.
    - D: Develop communities of science learners.
    - F: Participate in ongoing planning and development of science program.
- Assessment Standards:
    - B: Achievement and opportunity to learn science
    - C: Quality of data matched to decisions and actions taken
    - D: Assessment is fair.
- Content Standards:
    - A: Science as inquiry
    - B: Physical science
    - E: Science and technology
- Program Standards:
    - A: Consistent with other standards
    - B: Developmentally appropriate, interesting, and relevant
    - D: Access to appropriate and sufficient resources
    - E: Equitable student access

Teaching Notes:

Where might this fit into the standard physics curriculum?
This activity should come as part of a unit on superconductivity. Students should understand the basic qualities of superconductivity and how it differs from resistive materials. The materials could also be used after a unit on electric circuits and Ohm's Law without much explanation of the nature of superconductivity. However, by doing so, students might miss out on the important understanding of why some materials are superconducting.

Materials Needed:

- Computer (PC or Macintosh) with connection to printer (one per group of 3-4 students)
- Spreadsheet software (The spreadsheet was written in MS Excel, but a modified version can be used with Open Office 2.0.)
- Presentation materials (markers, presentation space such as large whiteboard or poster paper)
- Copies of handouts and the data sets

Teaching Tips:
Setup for users of MS Excel: Make certain that Excel is installed on all of the computers you intend to use. Download the file labeled "All data runs" into a folder that can be accessed on each machine (or have students do this after the computer is prepared for use).

Setup for users of Open Office 2.0: Make certain that “OpenOffice.org Calc” is installed on all of the computers you intend to use. Download the eight files below to a folder that can be accessed on each machine (or have students do this after the computer is prepared for use):

- Report summary
- Datasheet tests 0_100
- Datasheet tests 101_200
- Datasheet tests 201_300
- Datasheet tests 301_400
- Datasheet tests 401_500
- Datasheet tests 501_600
- Datasheet tests 601_690

Organization of Teams: Teams should probably be as heterogeneous as one can make them, allowing for the fact that advanced physics classes can be less than heterogeneous. These teams should be formed based on the types of students in the class. If there are a number of “computer whizzes,” make sure they are in different groups so that the maximum number of students can benefit from their experience.

Possible Organization of Tasks:

1. Students should read the document “What’s in the data pot, and why does it matter?” It will give them a foundation for the characteristics of superconductors and the quantities to be measured.
2. Students can practice working with the spreadsheet through answering the questions listed in the handout, “What’s in the spreadsheet?”
3. Students, with facilitation of the teacher, should develop a “plan of attack” where a list of variables to be tested is solicited; hypotheses students generate, and the tests to be undertaken are divided among teams. (A transparency handout for this step is included.)
4. Students gather data sets to answer their questions. (A handout students can use to keep track of their investigation is provided.)
5. Students develop presentations about the data sets and give those presentations to one another, as informed by the rubric. (The rubric is provided.)
6. After presentations, students will develop a list of questions that have been answered and those that have not.
7. Students will write a short (one-page) document where each one outlines materials and conditions for the optimal superconducting magnet material, with references to specific trends and data. (An outline for this document is provided.)

Other than the handout, “What’s in the data pot and why does it matter?” teachers need not use any other handouts. The teacher can drive an investigation in any direction that is desired. Teachers that use the Modeling Method of Instruction in physics will find that the handouts work similarly to the method used for laboratory investigations.

Teacher Transparency:
“How Do We Levitate the Train?”

Teacher Handouts:
“Plan of Attack” and Presentation Rubric

Transparency: "How Do We Levitate the Train?"

Factor	Variables to Control	Hypothesis and Reasoning	Group Members to Analyze Factor