Education and Outreach: A QuarkNet Story

The Search for the Higgs Boson

Motivation for the study of high school physics

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QuarkNet Overview

- Year 1: Lead Teacher Institute
  - 2 Lead Teachers
  - 8 weeks of Research
- Year 2: Associate Teacher Institute
  - 6-16 Associate Teachers
  - 3 weeks
- Year 3: Follow-up Institute
  - 1 week

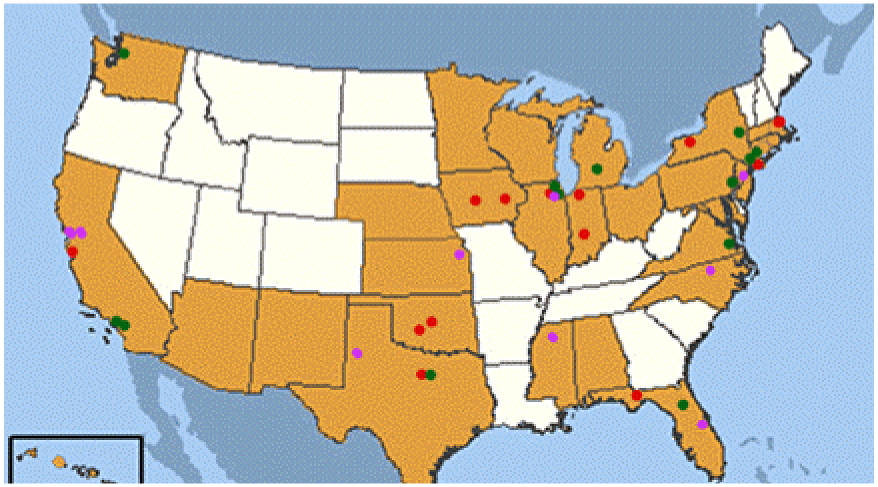
What is QuarkNet, really?

Over five years, QuarkNet will establish 12 centers each year in universities and laboratories participating in hadron collider experiments at CERN in Switzerland and Fermilab in the US. Initially, each center will include two mentor physicists and two high school physics teachers.

QuarkNet will involve 100,000 students from 600 US high schools in:

- Web-based analysis of real data
- Collaboration with students worldwide
- Visits by student representatives to the experiments

QuarkNet: A Distributed Program



1999: ●

14 QuarkNet Centers in 10 states

2000: ●

13 QuarkNet Centers in 9 states

2001: ●

11 QuarkNet Centers in 9 states

Current total: 33 QuarkNet Centers in 17 States

QuarkNet Goals for Teachers

- Actively participate in significant research
- Bring particle physics objectives to the high school classroom
- Infuse inquiry into the high school classroom
- Encourage high school students to do science the way scientists do science

First Week of School

- Introduction of Particle Physics using…
- The story of my summer research
- One motivation for the research is the SEARCH for the HIGGS BOSON

After Kinematics

- Reflection on the application of kinematics concepts to the need to get the colliding protons to great speeds

After Newton’s Laws

- Reflection on the possible source of the forces required to accelerate the protons to high speeds
- Reflection on the possible source of the forces required to make the protons travel in the circular ring

Reflection on Conservation of Energy and Matter

Use complete sentences to answer all of the questions.

1. Write everything you can think of about the nature of matter.

2. Describe the current model for the explanation of the most fundamental particles.

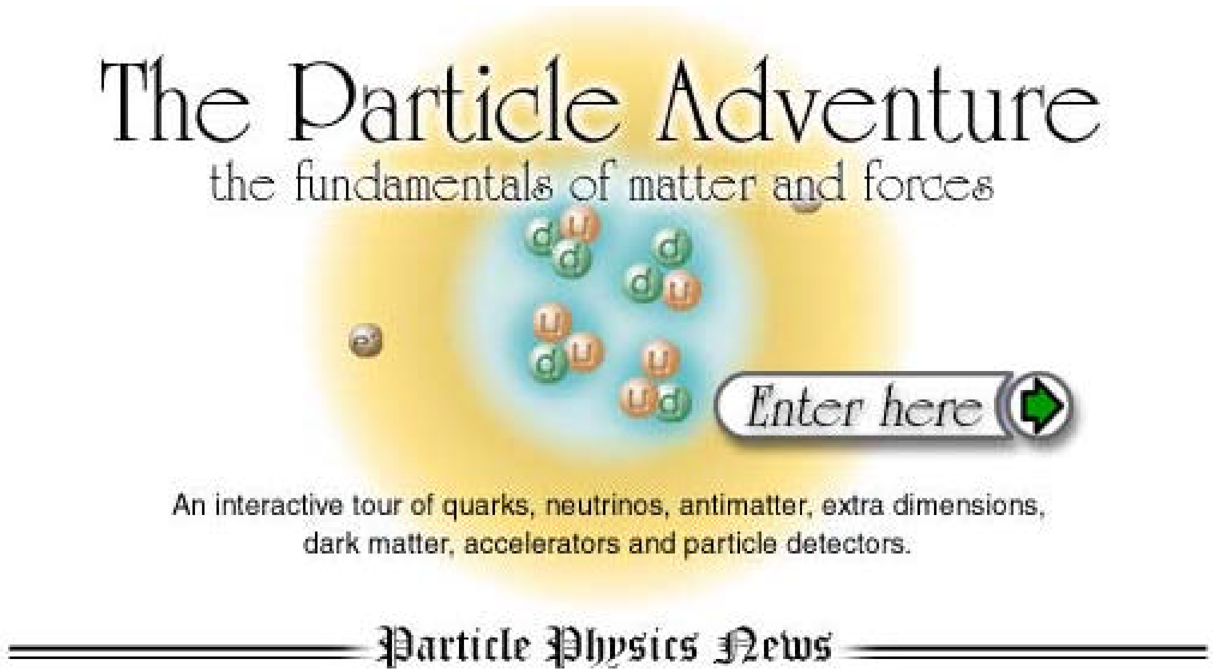
3. What does it mean for something to be conserved? Give several examples of quantities that are conserved. Think of things you studied in chemistry as well as things you have studied in physics.

4. How are conservation principles useful to scientists?

5. What properties are conserved in the interaction of fundamental particles?

Introduction to Particle Physics

http://www.particleadventure.org/

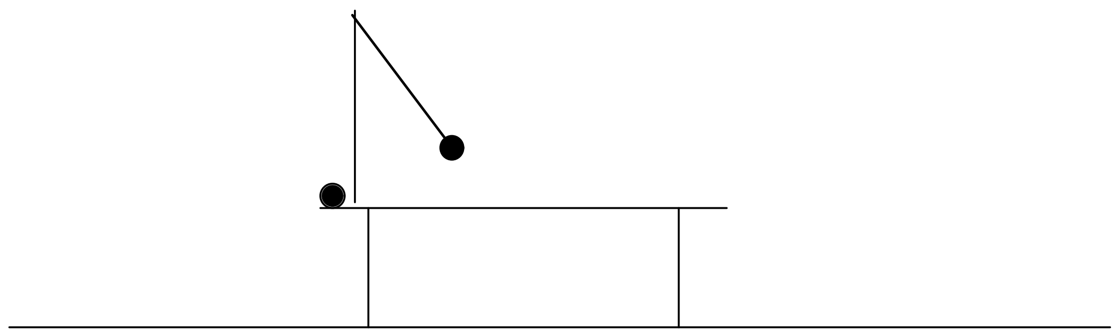


Use of Inquiry

Conservation Laws of Mechanics

Inquiry
Conservation Laws

1. The first purpose of this inquiry is to be able to construct the device illustrated. You must be able to adjust the pendulum so that when released, the bob strikes the object sitting on the table knocking the second object onto the floor.

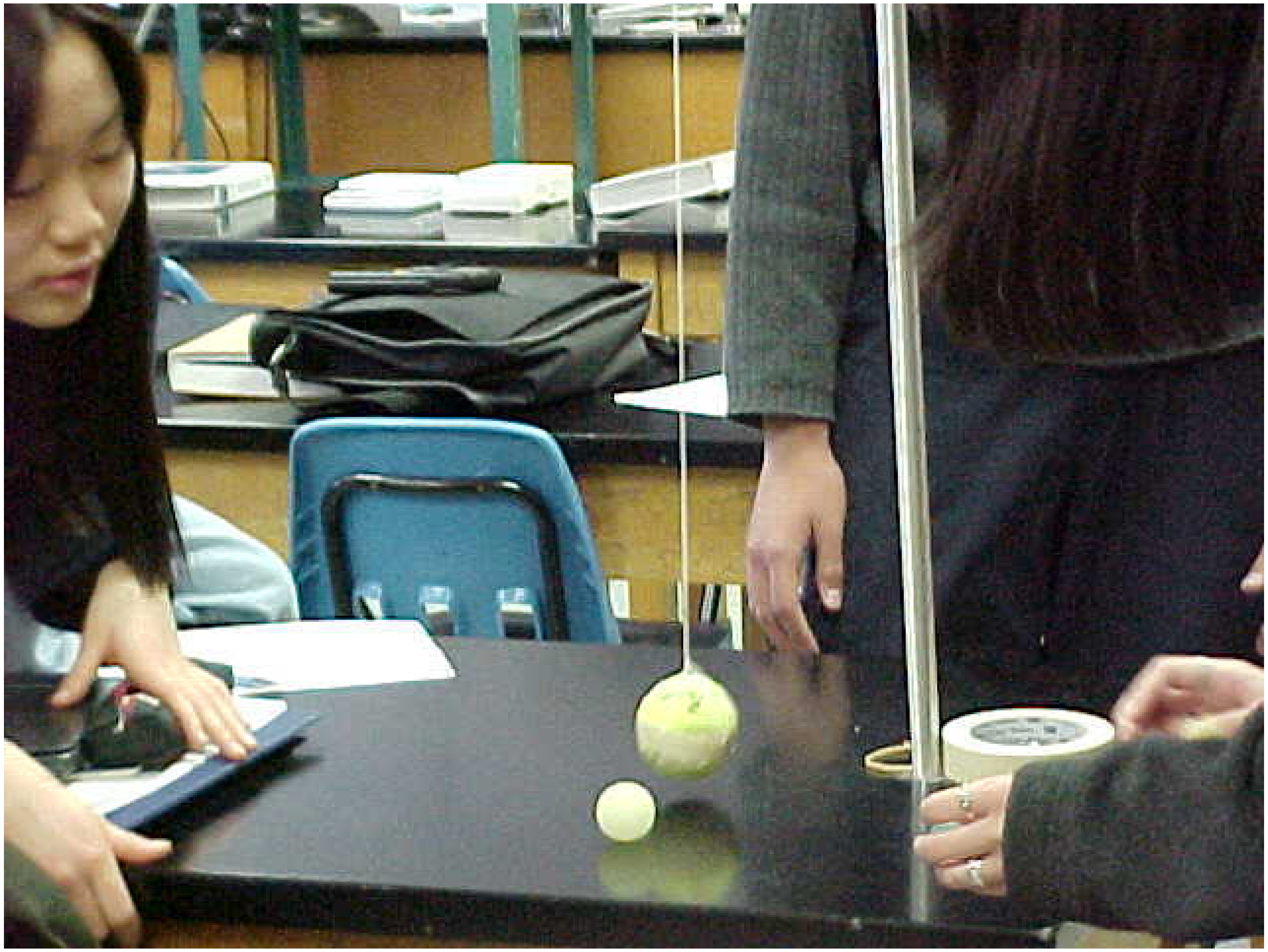


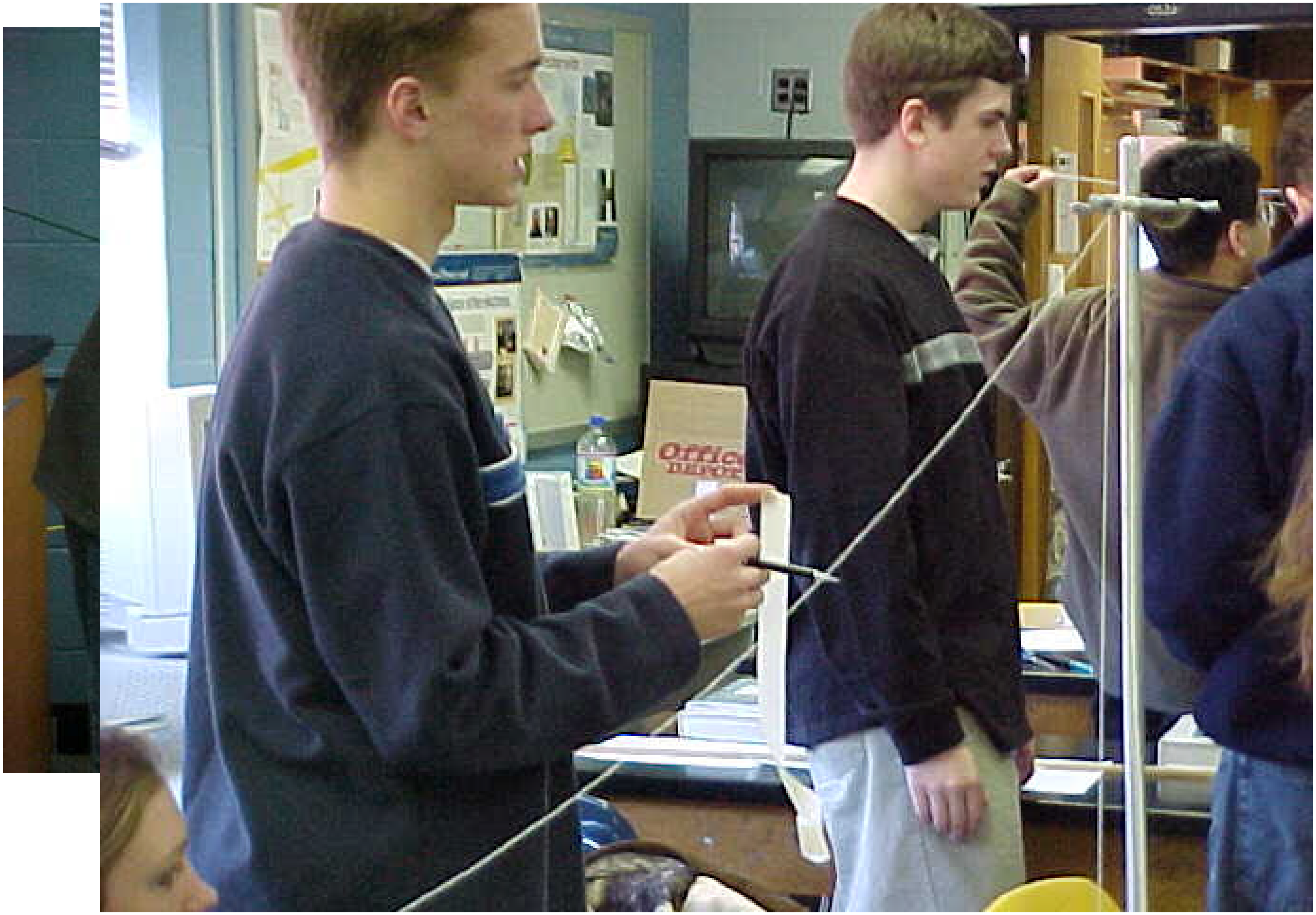
2. The second purpose is for you to devise a way of using your apparatus to hit a pre-set target spot on the floor. You must also devise a way of determining the velocity of each object just before and just after the collision that propels the second object onto the floor. Document your method so that someone else can use your method to also hit a pre-set target spot on the floor.

3. The third purpose is for you do develop a theoretical prediction using physics laws to predict not only the prediction spot but the velocities as well. Your theory must start with first principles and derive equations for determining the each of the required variables. (HINT: think in terms of conservation laws)

4. You must document that your data supports or fails to support your theory.

Student Inquiry at Work

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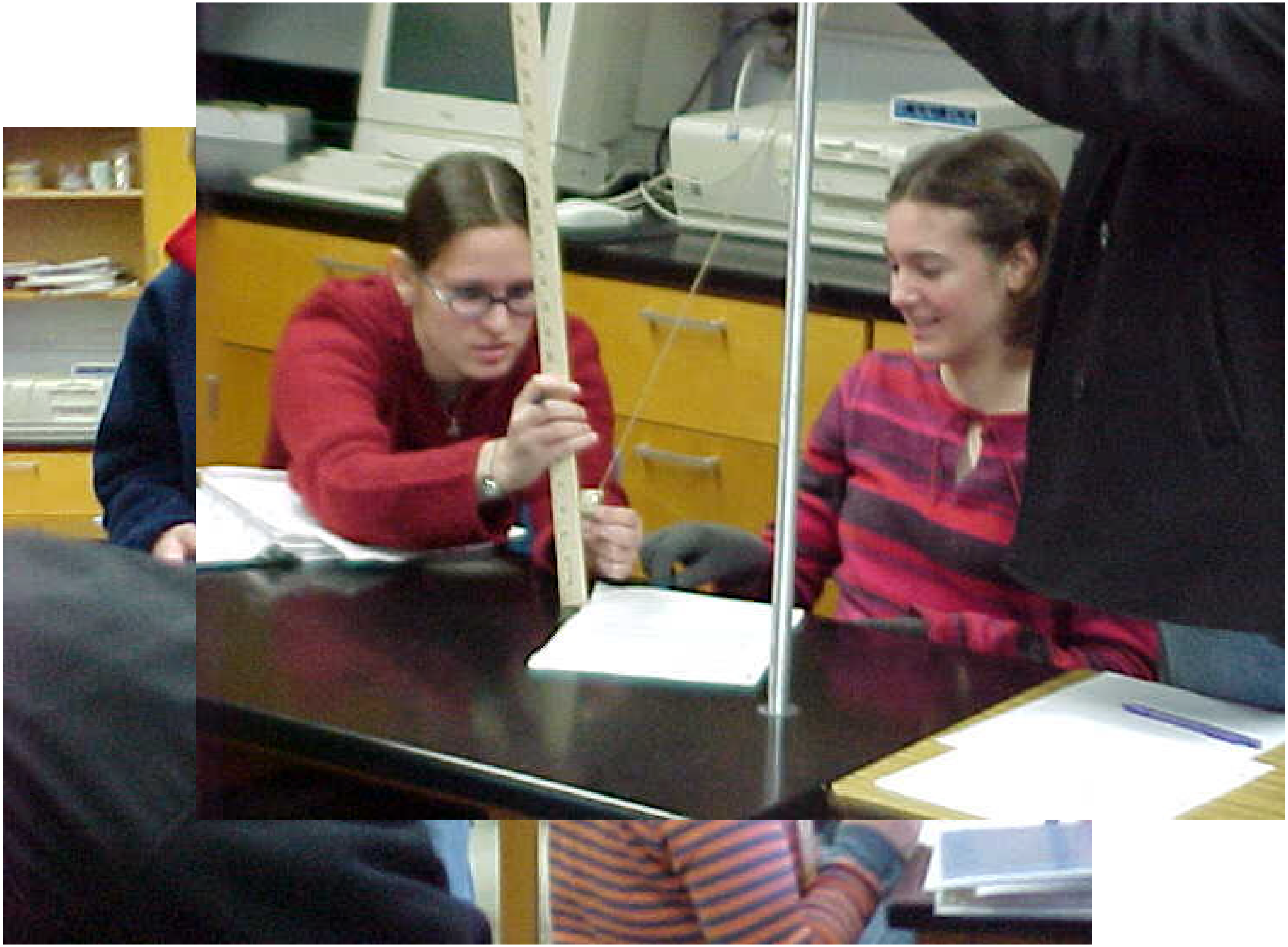

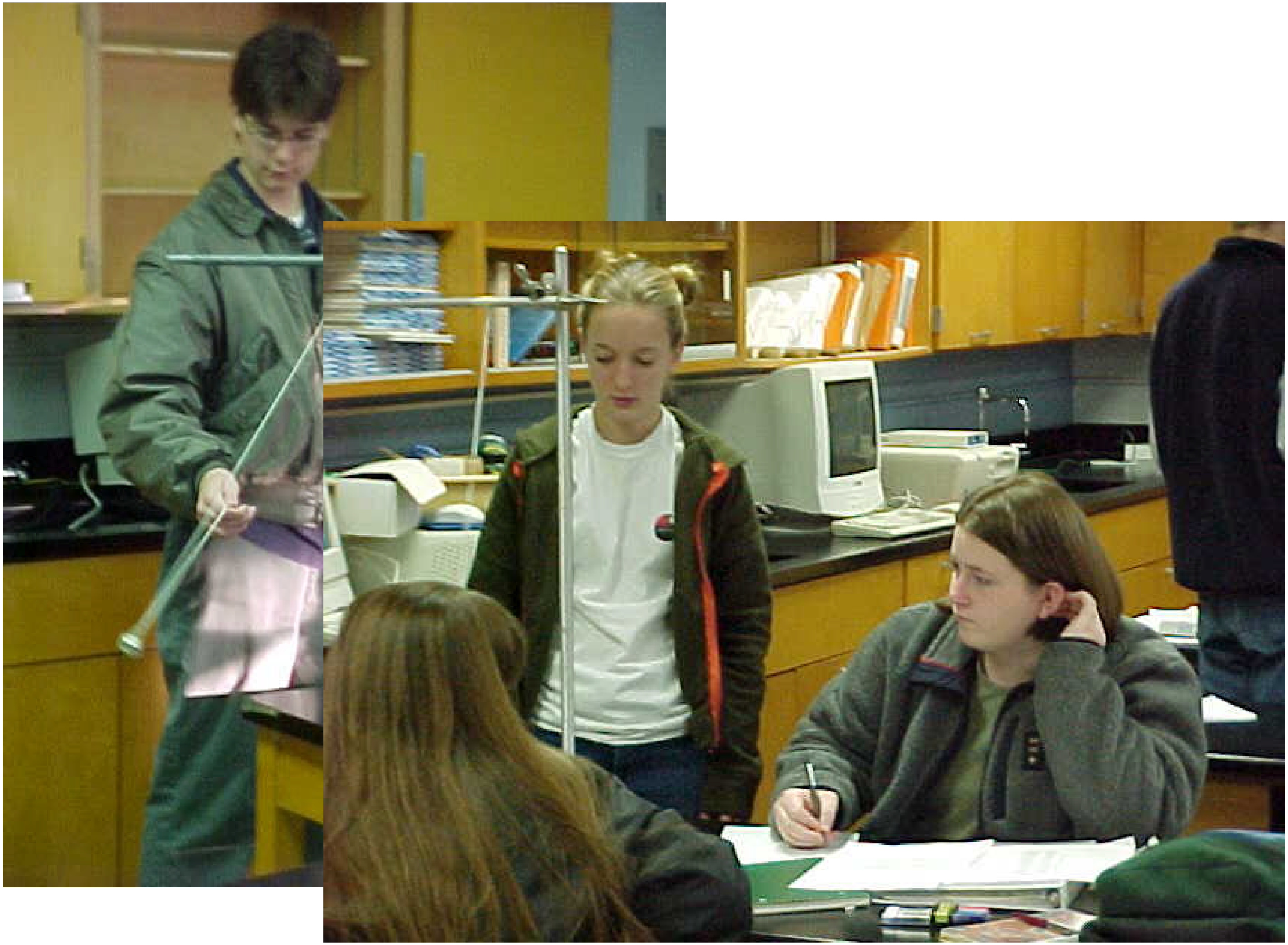

Special Relativity

1. Think about the most famous equation that you associate with Einstein:
2. Write down what each letter stands for.
3. Look in the textbook and find the meaning of the equation and the value for the variable which is constant.
4. When mass is in kg and velocity is in m/s, the unit for energy is J. Look in the front of the book and find the value for the rest mass of a proton in kg.
5. Calculate the rest energy of the proton in J.
6. This is a very small number so scientists like to use a new energy unit to represent this rest energy. This unit of energy is called and electron volt: 1 eV = 1.602×10^{-19} J
7. Determine the rest energy of the proton in eV.
8. Scientists prefer to write powers of ten as multiples of 3 and use the prefixes. Write the rest energy of the proton in MeV (Mega election volts).

Special Relativity

9. Repeat for the rest energy of an electron.
10. Repeat for the rest energy of a neutron.
11. When a fundamental particle is moving, the total energy of the system is the sum of the rest energy and the kinetic energy:

    $E_t = E_o + KE$

12. Determine the KE of a 1.3 GeV proton in eV.
13. Convert the KE of the proton from eV to J.
14. Determine the velocity of the proton.
15. Repeat steps 11 – 13 for a 835 keV electron.
16. Repeat 14 for a 1.0 TeV neutron.
17. Consider your answer to problem 15. Do you see any problem with that solution?

Application of E & M

- Electric forces to accelerate charged particles
- Magnetic forces to maintain the charged particles in a circle
- Continued emphasis on the role of conservation principles in the study of physics

Pulling It All Together

- Final Exam based on HEP

Impact on Student Learning

- Coherent theme across year's instruction
- Increased emphasis on inquiry
- Incorporating more of what scientists do
- Students assumed more responsibility for their own learning
- Increased student interest in science current events