PHS 594: Electricity for Middle/Secondary Teachers

Description: A modeling-modified CASTLE approach to electricity, for inservice science teachers of grade 8 and high school.

Instructor: Richard McNamara

Prerequisite: PHS 534 or PHS 530 (PHY 480). For inservice science teachers of grade 8 and high school. (Please note that the 2004 Arizona Science Standard for grade 8 does not include electricity.)

I. Workshop objectives.

The main objective of the physical science with math modeling workshop and the mechanics modeling workshop was to acquaint teachers with all aspects of the modeling method and develop some skill in implementing it. To that end, you were provided with a fairly complete set of written curriculum materials to support instruction organized into coherent modeling cycles (as described in Wells et. al. (1995)). The physical materials and experiments in the curriculum are simple and quite standard, already available in any reasonably equipped physical science classroom.

In the present course, teachers will use the same process but will develop skills in materials usually covered later in the school year. You will be learning the Modeling-modified CASTLE approach to electricity using materials developed by modeling teachers from around the country. Their work has been arranged into units with a coherent storyline and field tested at ASU for several summers.

II. Preparation and plans for this course.

On the first morning of the workshop, we will discuss the experiences of those participants who have taught mechanics by the modeling method. This will allow "novice" modeling teachers a chance to discuss concerns that have arisen as they taught.

We believe that to develop familiarity with the materials necessary to fully implement them in your classroom, you must work through the activities, discussions and worksheets, alternating between student and teacher modes, much as you did in the 1st Modeling Workshop.

Before you register for this course, please review the 2nd semester materials so that you can

make an informed decision whether to take this course. To do so, you should go to the Modeling Instruction in High School Physics page, click on the [Curriculum materials] link, then on [Participant resources]. Once you have entered the username and password, scroll down to 2nd semester materials, then [Read Me First] link to get an overview of how the materials are organized, then on any of the links to 2nd semester topics. There you will find stuffed (Mac) or zipped (PC) archives of the materials to expedite download. If you are unable to obtain the materials this way, please e-mail Jane.Jackson@asu.edu and give her your full mailing address so that she can mail you a CD-ROM. Please cc to Reba@asu.edu.

Special attention has been paid to the development of coherent teacher's notes. Review of these should give you the best idea of what the development team has decided was a logical development of the key features of the underlying models.

III. Description of the units in the 2nd semester Modeling-modified CASTLE approach to electricity

The original Capacitor Aided System for Teaching and Learning Electricity (CASTLE) was developed by a group of university and high school educators as an alternative approach to traditional instruction in electricity. The original curriculum consists of a simple but robust set of hands-on activities and develops fundamental concepts in a sequence consistent with a more historical progression. Because the original curricular materials were designed to be "teacher proof", the investigations tend to be very structured; they don't leave much room for exploration or for students to articulate their own understanding.

The Modeling-modified CASTLE approach closely follows the original materials, but is less structured, allowing for more open-ended investigations. With more opportunities to whiteboard results and deployments, the modeling version enables students to develop a deeper understanding of the fundamental concepts in electricity, without the heavy emphasis on formulas.

In Unit 1, the fundamental requirements for creating simple DC circuits are investigated. Using compasses, students discover the something is moving through all of the conductors in the circuit and that the flow does not diminish after passing through a bulb.

In Unit 2, students use a capacitor to determine the origin of the moving charge in a circuit. Bulb lighting and compass deflections are used to discover that charge is already present in all the conductors in a circuit. Students see that the capacitor can store energy so as to drive charge around a closed loop. Students are also introduced to an analogy between charge and air rather than charge and water.

In Unit 3, students develop a concept of resistance by examining the effect of different types of bulbs on capacitor charging and discharging times. After determining that the bulbs control the *rate* of charge flow and not the *amount*, the air analogy is again used to develop a kinesthetic sense of resistance. Students are also introduced to the effects of series and parallel combinations of bulbs.

In Unit 4, the air analogy is again used to develop a concept of electric potential/voltage as an electric pressure. After examining the effects of adding more batteries in series on an already charged capacitor and of adding cells in series but with reversed polarity, students develop an understanding of pressure and pressure difference as an explanation for why charge flows, why capacitor charging stops and why a charged capacitor can cause charge to flow with no battery in the circuit.

In Unit 5, the air analogy is studied in more detail. By slowing down transient conditions with a capacitor connected in parallel to various bulbs, students investigate how electric pressure changes in wires not directly connected to a battery. Students also examine the nature of short circuits and how batteries 'die'.

In Unit 6, students are introduced to the voltmeter as a device that measures electric pressure difference and the ammeter as a device that measures flow rate. With devices providing quantifiable measurements of pressure and flow rate, a mathematical definition of resistance is developed.

If time allows, we will also examine additional materials for Unit 6 which is still under development. These materials develop the concept of energy transfer and power in the circuit.

Each participant will receive a CD-R containing the resources for both the 1st semester (mechanics) and the 2nd semester instructional materials.