PHS 531: Methods of Teaching Physics II

I. Workshop objectives.

The main objective of 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 physics classroom.

In PHS 531 teachers will use the same process but will develop skills in materials usually covered after mechanics. You will be covering either a particle model approach to E & M or 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 story line and field tested in PHS 531 at ASU for the last two summers.

II. Preparation and plans for PHS 531.

On the first day of the workshop, July 6th, we will have a morning session with both groups combined that will include a discussion of the experiences of those participants who have taught mechanics by the modeling method. This "post-mortem analysis" will have the purpose of allowing “novice” modeling teachers a chance to discuss any concerns that have arisen as they taught.

The short duration of the summer workshop and the quantity of material to be covered in each of the content areas requires that you *make a choice* as to which of the content areas you wish to investigate during the workshop (Modeling-modified CASTLE approach to electricity or Particle Model approach to E&M). We believe that to develop the 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 in Mechanics.

If you are not sure which class to choose, review the 2nd semester materials so that you can make an informed choice of the unit on which you wish to work. 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 materials.

2nd Session July 6 – July 29

1. **Particle Model Approach to E&M**
   Unit 1 starts by developing a particle model of matter that accounts for the interactions observed between charged bodies. A quantitative investigation of this interaction produces Coulomb's Law. Then, we explore the concept that charge both produces and responds to an electric field.

   In Unit 2 the parallel between electric and gravitational fields is made to help students get a sense for electric potential. Students map electric potential due to distributions of charge, drawing a parallel to "topographic maps" as descriptors of gravitational potential. Next, we develop the views of field as the storehouse of energy and as the agent that mediates the electric force on charged bodies.

   In Unit 3 the role of the electric field as the agent that acts on charge is extended to conductors. First we examine the transient state due to uneven charge distributions. Later, we examine the role of field in steady state situation. Kirchhoff's junction and loop rules as seen as examples of conservation of charge and energy.

   In Unit 4, we see that *moving* charge both produces and responds to a new kind of field (B). The similarities and differences between electric and magnetic fields are examined in detail.

2. **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.