PHS 530/PHY 480: Methods of Teaching Physics

(Modeling Workshop I in mechanics)

Note: PHS 530/PHY 480 is a 3-credit course. An identical, but more indepth, 4-credit course, PHS 594, is also held. It has typically 120 contact hours.

The workshop is a *Methods of Physics Teaching* course that thoroughly addresses most aspects of high school physics teaching, including the integration of teaching methods with course content as it should be done in the high school classroom. The workshop incorporates up-to-date results of physics education research, best high school curriculum materials, use of technology, and experience in collaborative learning and guidance.

Participants will be introduced to the Modeling Method as a systematic approach to the design of curriculum and instruction. Content of the entire first semester course in high school physics (mechanics) is reorganized around five basic models to increase its structural coherence. Participants are supplied with a complete set of course materials and work through all the activities alternately in the roles of student or teacher.

Teachers improve their physics content knowledge and are equipped with a robust teaching methodology for developing student abilities to:

- make sense of physical experience,
- understand scientific claims,
- articulate coherent opinions of their own and defend them with cogent arguments,
- evaluate evidence in support of justified belief.

Specifically, teachers learn to:

- ground their teaching in a well-defined pedagogical framework (Modeling Theory), rather than following rules of thumb;
- organize course content around scientific models as *coherent* units of structured knowledge;
- engage students collaboratively in making and using models to describe, to explain, to predict, to design and control physical phenomena;
- involve students in using computers as scientific tools for collecting, organizing, analyzing, visualizing, and modeling real data;
- assess student understanding in more meaningful ways and experiment with more authentic means of assessment;
- continuously improve and update instruction with new software, curriculum materials and insights from educational research;
- work collaboratively in action research teams to mutually improve their teaching practice.

Since "teachers teach as they have been taught," the workshop includes extensive practice in implementing the curriculum as intended for high school classes. Participants rotate through roles of student and instructor as they practice techniques of *guided inquiry* and cooperative learning. Plans and techniques for raising the *level of discourse* in classroom discussions and student presentations are emphasized. Teachers are immersed in studying the physics content of the entire semester, providing in-depth remediation for under-prepared teachers. Altogether, the Modeling Workshop provides a detailed implementation of the *National Science Education Standards.*

The workshop is led by two experienced high school teachers who have participated in at least eight weeks of Modeling Workshops during two summers. Teachers meet daily, 5 days per week, for 3 weeks, for a total of 90 contact hours plus homework.

As of 2004, almost 1400 high school teachers in 48 states use Modeling Instruction. Student enrollments increase, sometimes dramatically, when Modeling Instruction is implemented. We have data on some 20,000 high school physics students, showing that student gains in understanding of the force concept are typically doubled, and sometimes tripled, when Modeling Instruction is used, compared to traditional instruction.

MODELING INSTRUCTION in HIGH SCHOOL PHYSICS @ ASU

Course Description and Syllabus(v1, 2003)

The Modeling Instruction Leadership Workshop is an intensive 4-week course with the following goals:

1. To train lead teachers in the use of a model-centered, constructivist method of teaching high school physics.
2. To help participants integrate computer courseware effectively into the physics curriculum.
3. To establish electronic network support among the participants for the school year as well as to help them to make better use of national resources for physics education.

Syllabus/Agenda

Week 1

Mon Day 1	**(am)** Welcome, Introduction of participants, Schedules, Workshop description, goals, FCI overview, Pre-testing: FCI **(pm) Unit I: Scientific Thinking in Experimental Settings** Pendulum lab, Graphical Methods, lab report format, grading of lab notebook **Readings:** Hestenes, "A Modeling Method for HS Physics Instruction." [or Mestre, on day 1 and Hestenes on day 4. Mestre is easier to start with.]
Tue Day 2	**(am)** Discussion of reading, clarification if Unit I lab. lab write-ups, worksheets/test unit 1, **(pm)** white boarding, presentation criteria, discuss unit materials **Unit II: Particle with Constant Velocity,** Battery-powered vehicle lab, post-lab discussion, motion maps, deployment **Readings:** McDermott, "Guest Comment: How we teach…" Arons, ch 1 (special attn: sections 8, 9, 11, 12)
Wed Day 3	**(am)** Discussion of readings, problems, worksheets/presentations, Intro to *Body modeling,* PAS materials **(pm)** ultrasonic motion detector, Unit II Test **Readings:** Hake, "Socratic Pedagogy in the...", Arons 2.1-2.6
Thu Day 4	**(am)** Discussion of readings, **Unit III: Uniformly Accelerating Particle Model,** Timer software, ball-on-rail lab, white board results **(pm)** Discussion of readings, Motion Detectors**,** post-lab extension: instantaneous velocity, acceleration, motion maps, deployment worksheet/white board **Readings:** Mestre, "Learning and Instruction in Pre-College..."
Fri Day 5	**(am)** Intro to *Graphs and Tracks,* instructional comments, descriptive particle models, more deployment exercises. wrap up unit III materials, test, **free fall w/ picket fence** **Reading:** Arons 2.7-11, Hestenes, Wherefore a science of teaching. (optional)

Week 2

Mon Day 6	**(am)** Discussion of reading, **Unit IV: Free Particle Model-inertia & interactions** inertia demo (Newton 1), the force concept, force diagrams, statics lab, the normal force demo questioning strategies **(pm)** Tension forces, spring scales, force probes, paired forces, **Reading:** Camp and Clement introductory reading
Tues Day 7	**(am)** deployment worksheets/white board, **(pm)** Discussion of reading, more deployment exercises unit IV materials, test **Reading:** Arons 2.16-19
Wed Day 8	**(am)**,**Unit V: CDP Model-force and acceleration**, weight vs mass lab, lab write-up modified Atwood's machine lab (compare different equipment) **(pm)** white board results of previous days labs, post-lab extension: derivation of Newton 2, lab write-up **Reading:** Arons 3.1-4,
Thu Day 9	**(am)** Newton 3, critique activities, deployment worksheets/whiteboard **(pm)** Finish whiteboarding, Unit V test (turn in lab books) **Reading:** Arons 3.5-9
Fri Day 10	**(am)** Discussion of reading, friction lab: pre lab and data collection, white board. Model development **Reading:** Arons 3.15-24

Week 3

Mon Day 11	**(am)** Discuss reading, deployment activities, alternative tests, unit test **(pm) Unit VI: Particle Models in Two Dimensions,** combinations of FP and CDP models, deployment **Reading:** Arons 4.1-5
Tue Day 12	**(am)** worksheets/whiteboard, projectile motion lab, **(pm)** explore use of Video Technology, alternative tests, Test **Reading:** Arons 4.1-5
Wed Day 13	**(am)** Discuss Readings, **Unit VII: Work, Energy, & Power,** Stretched spring lab, work on lab notebooks, graph, whiteboard prep & practice critiques. **(pm)** finish critiques, energy analogy, **Reading:** Energy concept

Thu Day 14	**(am)** discuss readings, Gravitational potential energy, work-kinetic energy lab, **(pm)** Further discussion of working/heating as means of changing internal energy of system. **Reading:** Arons 5.5-6
Fri Day 15	**(am) Unit VIII: Central Force Model**, uniform circular motion lab, collect/analyze data; further use of spreadsheets **Reading:** Arons 4.8-9, Hestenes: Modeling Methodology for Physics ..."

Week 4

Mon Day 16	**(am)** discuss reading, deployment worksheets, instructional comments **(pm)** central force applications, and extensions. **Reading:** Hestenes: Modeling Methodology for Physics Teachers" again!
Tue Day 17	**(am)** circular motion lab practicum. Alternative tests and testing. **(pm) Unit IX: Impulsive Force Model,** conservation of linear momentum lab, 1/2 use air tracks, 1/2 use PASCO carts, collect data, plot r_{final} Vs $r_{initial}$ **Reading:** Arons 5.1-4
Wed Day 18	**(am)** deployment worksheets, instructional comments. FCI posttest, evaluation **(pm)** worksheets/tests on Impulsive force. Turn in notebooks. Closing remarks.
Follow-up Day 19	**(am)** discussion, implementation survey **(pm)** a look at second semester materials w/ modeling approach.
Day 20	**(am)** MBT test, discussion, look at 2nd semester models