Syllabus

PHS 530/PHY 480: Methods of Teaching Physics I
Modeling Instruction in Mechanics (3 credits)

Minimum content prerequisite: Two semesters of college physics (trigonometry-based)

June 8 to July 14, 2020 remote learning offered by Arizona State University
Instructor: Jeff Steinert  Co-leader: Melissa Girmscheid  Instructional Trainee: Kirticia Jarrett
Zoom meetings 8:30 to 11 am AZ Time (PDT) MTWThF. No class Friday, July 3.

Note: On April 1, 2020, ASU notified employees that all summer courses that begin in June must be remote learning, to practice social distancing because of Covid-19. The essence of the course description, student learning goals, ASU & ABOR policies (including academic dishonesty and disability) remain the same, as much as possible. Details for 2020 course differ as noted in red.

Clientele: The course is valuable for in-service and preservice chemistry and physics teachers, physics graduate students who intend to teach college or high school, and teachers who are preparing for the Arizona physics certification test. It is useful for biology, earth science, and environmental science teachers and faculty, since physics is a foundation of these sciences and since ASU offers no comparable graduate disciplinary methods courses in these other sciences.

It satisfies the Higher Learning Commission dual credit faculty expectations. Page 5 of “Guidelines: Faculty Qualifications” [http://download.hlcommission.org/FacultyGuidelines_2016_OPB.pdf](http://download.hlcommission.org/FacultyGuidelines_2016_OPB.pdf) states:

“HLC also recognizes that dual credit faculty members who have obtained a Master of Education degree but not a Master’s degree in a discipline such as English, Communications, History, Mathematics, etc., may have academic preparation to satisfy HLC’s expectations. In this context, the curricula of graduate degrees in the field of Education, when inclusive of graduate-level content in the discipline and methods courses that are specifically for the teaching of that discipline, satisfy HLC’s dual credit faculty expectations.”

PHS 530, Methods of Teaching Physics I, is inclusive of graduate-level content in physics education research that forms the basis of a physics discipline and methods course that is specifically for the teaching of physics. It is included in the ASU Master of Natural Science (MNS) degree, an interdisciplinary terminal science education degree for high school and two-year-college teachers of physics and chemistry (often the same person, especially in rural schools).

COURSE DESCRIPTION:
A. Objectives: The workshop is a Methods of Physics Teaching course that thoroughly addresses most aspects of high school and community college physics teaching, including integration of teaching methods with course content, as it should be done in the classroom. The course incorporates up-to-date results of physics education research, best practice curriculum materials, use of technology, and experience in collaborative learning and guided inquiry. Participants are introduced to the Modeling Method as a systematic approach to the design of curriculum and instruction. Content of the entire first semester course in physics (mechanics) is organized around a set of basic models to increase its structural coherence. Participants are supplied with a complete set of course materials and work through activities alternately in roles of student or teacher.
B. Course plan and rationale: Since “teachers teach as they have been taught,” the workshop includes extensive practice in implementing the curriculum as intended for high school and community college classes. 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 to develop a deep understanding of content and how to teach it effectively. To these ends, they read, discuss, and reflect on related physics education research articles. (This also provides in-depth remediation for under-prepared teachers.) Altogether, the Modeling Instruction Workshop in Mechanics provides a detailed implementation of the Next Generation Science Standards and 2018 Arizona Science Standards. The course begins with a discussion of participants’ goals for the course and the greatest content- and instructional-related teaching challenges they face in their classrooms. Teachers are given a manual of sample course materials. To develop familiarity with the materials necessary to fully implement them in the classroom, we find that teachers must work through the activities, discussions and worksheets, alternating between student and teacher modes. This constitutes the rest of the course. Each unit in the course manual includes an extensive Teacher Notes section and practicums, microprocessor-based sensors, demonstrations, and deployment activities are employed throughout. Teachers are required to reflect on their practice and how they might apply the techniques they learn in the course in their own classes.

C. Description of the units: The Mechanics Modeling Instruction materials are organized into nine units that employ guided-inquiry, student-designed experiments to develop descriptive and explanatory models. These models are then deployed to analyze and predict the behavior of physical phenomena.

In Unit 1, students learn the fundamentals of experimental design, data collection, and mathematical modeling. These skills are a prerequisite for the analysis of the results of the paradigm labs in each of the succeeding units of study.

In Unit 2, Constant Velocity motion is investigated and the Constant Velocity kinematical model developed and deployed. Students use graphical representations from the dune buggy paradigm lab to derive mathematical representations of the motion and interpret and analyze them using graphs, motion maps, and verbal descriptions.

In Unit 3, the study of motion is extended to situations involving Constant Acceleration and the Constant Acceleration kinematical model is developed and deployed. Students use graphical representations from the ramp paradigm lab to derive mathematical representations of the motion (kinematic equations) and interpret and analyze them using graphs, motion maps, and verbal descriptions.

In Unit 4, the Free Particle (\(\sum F=0\)) causal model for Constant Velocity motion is developed and deployed. Students use free-body diagrams and mathematical relationships to interpret and analyze situations in which objects are motionless or moving at constant velocity. Newton’s First and Third Laws of Motion are derived from study in this unit.

In Unit 5, the Constant Force (\(\sum F=\text{constant}\)) causal model for Constant Acceleration motion is developed in the Force and Acceleration paradigm lab. Deployment of the model aids students in extending the use free-body diagrams and mathematical relationships to interpret and analyze
situations in which objects are accelerating, adding to their understanding of the causes of constant velocity motions developed in Unit 4.

In Unit 6, the Constant Velocity and Constant Acceleration kinematical models are combined with the Free Particle and Constant Force causal models to describe and explain projectile motion. Students use graphical representations from their video analysis of the flight of a projectile to develop the combined mathematical relationships that govern projectiles and deploy them to interpret and analyze related physical phenomena. Likely not included in 2020.

In Unit 7, the Uniform Circular Motion kinematical model and the Central Force causal model are developed from the paradigm lab, extending student understanding of accelerated motion to situations where the direction of the velocity is changing. Students deploy the models to interpret and analyze situations in which a central (centripetal) net force acts to accelerate an object that is turning in a partial circle or completing multiple revolutions. Newton’s Universal Law of Gravitation is included in this unit. Definitely not included in 2020.

In Unit 8, the Energy Storage and Transfer model is developed through a series of paradigm labs that illustrate how forces acting over a distance can change the energy stored in a system and that changes in the system may transfer energy from one account (kinetic, gravitational, elastic, or thermal) to another. The Law of Conservation of Energy and the Work-Energy Theorem are derived from the graphical representations from these paradigm labs and deployed to interpret and analyze closed systems that may or may not be isolated from the effects of unbalanced external forces.

In Unit 9, the Collision kinematical model and the Impulsive Force causal model are developed from the “Explosion” paradigm lab and its extension. The Law of Conservation of Momentum is derived from student analysis of these experiments and the models are deployed to interpret and analyze closed systems that may or may not be isolated from the effects of unbalanced external forces.

STUDENT LEARNING GOALS: At successful completion of this course, students will have
• improved their instructional pedagogy by incorporating the modeling cycle, inquiry methods, critical and creative thinking, cooperative learning, and effective use of classroom technology,
• deepened their understanding of content in the Mechanics Modeling Instruction Curriculum (see above),
• experienced and practiced research-informed instructional methods of model-centered discourse, Socratic questioning/whiteboarding, use of standardized evaluation instruments, coherent content organization,
• strengthened coordination between mathematics and physics,
• increased their skill in all eight science and engineering practices included in the Next Generation Science Standards (NGSS) and 2018 Arizona Science Standards. Models and theories are the purpose and the outcomes of scientific practices. They are the tools for engineering design and problem solving. As such, modeling guides all other practices.

LISTING OF ASSIGNMENTS: This course meets synchronously for 65 hours (via Zoom in the online format) during June and July, and students are required to do 70 hours of work outside of class in preparation for the next class, including performing experiments and collecting data,
completed worksheets, reading, and participating in asynchronous online discussions. Additional longer-term assignments will include completion of problem sets and writing lab reports. Assignments will be listed in the course calendar, found on the “Canvas” online learning platform.

**GRADING POLICIES AND PERCENTAGES:**

**A. Attendance:** Students are expected to virtually attend all days of this course. If you miss more than 10% of the contact hours, your maximum grade will be a B; if more than 20% of the contact hours, you can earn no higher than a C. Please be on time and ready to go! Report any expected absences to the instructor as soon as possible. ASU credit-seeking students who miss course time are to complete and write a reflection for all activities missed.

**B. Grading policy:** Students will contract for a letter grade on the second day of class. **Contracting for a letter grade is not a guaranteed grade. Work must be completed at ASU standards and meet all class requirements.** Within grade categories, additional requirements are assigned for the graduate level course, beyond those for the undergraduate course.

All participants, whether seeking ASU credit or not, are expected to do activities and homework, as described below for a “C” grade. (Non-credit participants should email the instructor, specifying which days they intend to participate, at the start of the course.)

<table>
<thead>
<tr>
<th>PHS 530 graduate</th>
<th>PHY 480 undergrad</th>
<th>Minimum Requirements (additional assignments are required for the same grade in the graduate course as in the undergraduate course):</th>
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<tbody>
<tr>
<td>C</td>
<td>C</td>
<td>PHY 480 and PHS 530: Synchronous class attendance and engaged participation in class activities. Discussions, whiteboard presentations, log of activities/ and teacher notes in the lab book, completion of assigned readings and reflections, worksheets, tests, etc. Reflections and Lab Writeups submitted to Canvas.</td>
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<tr>
<td>B</td>
<td>B</td>
<td>PHY 480: All of the above plus a two-page typed paper reflecting on specific differences in instructional practices between a Modeling classroom and a traditional classroom, based on your experiences. PHS 530: All of the above plus a two-page typed reflection paper discussing how Modeling Instruction differs from your current practices and changes you plan to incorporate or issues you will have to deal with in implementing Modeling Instruction in your classes.</td>
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<tr>
<td>A</td>
<td>A</td>
<td>PHY 480: All the above plus 1 activity (lesson plan) modified or developed for classroom use. Lesson plan must be in a Modeling format (pre-activity discussion, exploration, post-activity discussion) and lead to constructing a model or using a model to solve a problem (3 page minimum). PHS 530: All the above plus 2 activities (lesson plans) modified or developed for pilot use in the classroom next school year. Lesson plans must be in a Modeling format (pre-activity discussion, exploration, post-activity discussion) and lead to constructing a model or using a model to solve a problem (3 page minimum for each lesson plan).</td>
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Grade Breakdown

- **Online Class Participation (30%):** Participate actively and thoughtfully in discussions of readings, group problem-solving and whiteboards, and other online activities.
- **Lab Notebook (10%):** Keep a course notebook to provide evidence that labs have been effectively done and notes pertaining to future use of models/modeling in your classes have been carefully made. A 9” x 12” quad-ruled computation notebook works well. Teachers have found this notebook to be a valuable resource as they use the curricular materials in their own classes. Consequently, you are expected to record notes pertaining to everything we do. When you return to your own classroom and do the labs and activities, you will not remember all the details that came out in discussions and activities. Place them in your notebook as you work. For all labs, record notes from the pre-lab discussion, record and evaluate data (include any graphs you make), and summarize the findings of the “class” in your lab notebook (summarize means write the relationship, the equation if applicable, the general equation and what the slope represents). Include notes that will help you when you are doing the lab with your students. Most teachers benefit by writing down good questions asked during whiteboarding sessions. Take notes on demonstrations and the concepts they are meant to illustrate. Your attention to these details while you are present in class will be evident during the online class sessions and in your level of participation in the asynchronous discussions.
- **Lab Writeups (20%):** Students perform paradigm labs each unit in “student mode”. You will be expected to submit formal lab write-ups for selected labs to Canvas. For details on the expected format for a lab report, please see “Writing the Physics Lab Report”, “Laboratory Investigations in Physics”, and “Physics Laboratory Write-up Checklist” in the first section of the Modeling Instruction in High School Physics lab manual.
- **Reading Reflections (15%):** You will be asked to read sections in Arons’ book and articles from physics education research. You are expected to write a one-page reflection (not a synopsis) on each night’s assigned reading, and submit it to Canvas. These reflections should include your reaction to ideas discussed and how they apply in your classroom.
- **Paper (10%):** A two-page paper describing how the Modeling Method of instruction differs from your current practice and/or issues impacting implementation of Modeling Instruction in your classes. This is required if you contract for a B or higher.
- **Lesson Plans (15%):** Submit lesson plans for two activities (PHS 530) or one activity (PHS 480) modified or developed for pilot use in your classroom this school year. Lesson plans must be in the same format as modeling teacher notes and lead to constructing a model or utilizing models to solve a problem. A lesson plan template will be provided. Notebooks containing Lab Writeups and Reading Reflections will be collected and evaluated as listed in the agenda. We believe they will be a valuable resource as you use the curricular materials in your classes. This is required if you contract for an A.

**C. Grading scale:**

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<tr>
<th>Grade</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>A+</td>
<td>97-100</td>
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<tr>
<td>A</td>
<td>93-96.9</td>
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<tr>
<td>90-92.9 A-</td>
<td>87-89.9 B+</td>
</tr>
<tr>
<td>B</td>
<td>83-86.9</td>
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<tr>
<td>80-82.9 B-</td>
<td>77-79.9 C+</td>
</tr>
<tr>
<td>C</td>
<td>73-76.9</td>
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<tr>
<td>70-72.9 C-</td>
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**D. Policies of Arizona Board of Regents (ABOR), ASU, and Department of Physics:**

* ABOR: Each student is expected to work a minimum of 45 hours per semester hour of credit.
* Pass-fail is not an option for graduate courses. [https://students.asu.edu/grades](https://students.asu.edu/grades).
* 3.0 grade point average (GPA) is minimum requirement for MNS & other graduate degrees.
* Incomplete: only for special circumstances. Must finish course within 1 year, or it becomes “E”.
* An instructor may drop a student for non-attendance during the first two class days (in summer).
* An instructor may withdraw a student with a mark of "W" or a grade of "E" only in cases of disruptive classroom behavior."
* The ASU Department of Physics is critical of giving all A's, because it indicates a lack of discrimination. A grade of "B" (3.0) is an average graduate course grade, and obviously not all students do above-average work compared to their peers. Some of you can expect to earn a "B", and those who are below average but do acceptable work will earn a "C".

E. Academic dishonesty policy: Academic honesty is expected of all students in all examinations, papers, laboratory work, academic transactions and records. The possible sanctions include, but are not limited to, appropriate grade penalties, course failure (indicated on the transcript as a grade of E), course failure due to academic dishonesty (indicated on the transcript as a grade of XE), loss of registration privileges, disqualification, and dismissal. For more information, see http://provost.asu.edu/academicintegrity.

F. Disability policy: Qualified students with disabilities who require disability accommodations in this course are encouraged to make their requests to the instructor on the first class day or before. Note: Prior to receiving disability accommodations, verification of eligibility from the Disability Resource Center (DRC) is required. Disability information is confidential.

REQUIRED INSTRUCTIONAL MATERIALS:

Materials (Summer 2020): First-time participants can buy an AMTA membership for only $25 by the first day of their workshop, and they will have immediate access to materials. Returning workshop participants will get a discount on membership renewal, paying only $50 on or before the first day instead of the regular $75.

Please buy a bound lab notebook. A 9” x 12” quad-ruled computation notebook works well. This size will allow you to easily tape or paste in data you collect and graphs you produce from the labs you perform during the workshop, as well as your reflections on the activities and readings assigned during the workshop.

REQUIRED READINGS: Check the course website for links to readings, or ask the instructor if you cannot download.


RESOURCES FOR REMOTE TEACHING, THAT ARE RESEARCH-INFORMED:
https://www.physport.org/recommendations/Entry.cfm

https://www.facebook.com/groups/320431092109343 (Eugenia Etkina’s Facebook group, called "Exploring and Applying Physics". In spring 2020 she posted numerous suggestions. She founded ISLE and PUM, which are super-compatible with Modeling Instruction.)

https://www.islephysics.net/pt3 (Eugenia Etkina’s 200 videotaped experiments, with questions.)
https://www.pivotinteractives.com (especially 2 dozen research-based vISLE: most are FREE.)
**Course itinerary (15 days, ~ 90 contact hours; 26 days, ~ 65 contact hours)**

**Week 1 (Face-to-face version)** Online course will have 26 days at 2.5 hour each day. Because we have not led this course online in this format, the calendar will be fluid. Units in red will definitely not be fully developed during our online course in 2020.

<table>
<thead>
<tr>
<th>Day</th>
<th>AM –</th>
<th>PM – <strong>Unit 1: Scientific Thinking in Experimental Settings</strong> Pendulum lab, Graphical Methods, lab report format, grading of lab notebook</th>
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<tbody>
<tr>
<td>Day 1</td>
<td>Welcome, Introduction of leaders and participants, Schedules, Workshop description, goals, FCI overview, Pre-testing: FCI.</td>
<td><strong>HW –</strong> Readings: Hestenes, “Force Concept Inventory.” Skip Sections II and III, Focus on Sections I, IV, and V. McDermott, &quot;Guest Comment: How we teach…&quot;</td>
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<td>Day 2</td>
<td>AM - Discussion of reading, clarification of Unit 1 lab; lab write-ups, worksheet/test unit 1, Linearization with Logger Pro.</td>
<td>PM – Whiteboarding, presentation criteria, discuss unit materials <strong>Unit 2: Particle with Constant Velocity</strong>, Battery-powered vehicle lab, post-lab discussion, motion maps, deployment.</td>
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<td>Day 3</td>
<td>AM – Discussion of readings, problems, worksheets/presentations, Intro to Body modeling, Motion sensors.</td>
<td>PM – Unit 2 lesson plan, Whiteboard WS and Test, Introduction to <strong>Unit 3: Uniformly Accelerating Particle Model</strong></td>
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<td>Day 4</td>
<td>AM – Discussion of readings, Timer software, ball-on-rail lab, white board results.</td>
<td>HW – Readings: Mestre, &quot;Learning and Instruction in Pre-College...&quot; Arons, 2.1-2.6.</td>
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**TURN IN NOTEBOOKS FOR ASSESSMENT**
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<th>Week 2</th>
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<td>Day 6</td>
<td><strong>AM</strong> – Discussion of reading, <strong>Unit 4: Free Particle Model-inertia &amp; interactions</strong>, inertia demo (Newton 1), the force concept, force diagrams, statics lab, the normal force demo questioning strategies.</td>
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<td><strong>PM</strong> – Deployment worksheets/WBs, force probes, paired forces, Newton 3.</td>
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<td>Day 7</td>
<td><strong>AM</strong> – Discussion of reading, more deployment exercises. wrap up unit 4 materials, test.</td>
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<td><strong>PM</strong> – <strong>Unit 5: Constant Force Model-force and acceleration</strong>, weight vs mass lab, modified Atwood's machine lab (compare different equipment).</td>
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<td>Day 8</td>
<td><strong>AM</strong> – Discussion of reading, whiteboard results of previous days labs, post-lab extension: derivation of Newton 2, lab write-up.</td>
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<td><strong>PM</strong> – Deployment worksheets/whiteboard, Unit 5 test.</td>
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<td><strong>HW</strong> – Reading: Miyake, “Reducing the Gender Achievement Gap …”</td>
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<td>Day 9</td>
<td><strong>AM</strong> – Discussion of reading, <strong>friction lab</strong>: pre lab and data collection, whiteboard. Discussion of reading.</td>
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<td><strong>PM</strong> – <strong>Unit 6: Particle Models in Two Dimensions (likely not included in 2020)</strong>, combinations of FP and CDP models, deployment.</td>
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<td><strong>HW</strong> – Reading: Arons, 3.1-4, 3.6-13.</td>
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<td>Day 10</td>
<td><strong>AM</strong> – Worksheets/whiteboard, projectile motion lab, explore use of Video Technology.</td>
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<td><strong>HW</strong> – Reading: Hestenes, Wells, &quot;A Modeling Method For High School...” T**URN IN NOTEBOOKS FOR ASSESSMENT</td>
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Week 3

| Day 11 | AM – Discuss Readings, projectile practicum  
|        | **Unit 7: Central Force Model (definitely not included in 2020), uniform circular motion lab.**  
|        | PM – Collect/analyze data; further use of spreadsheets, whiteboard problem sets.  
|        | Day 12 | AM – Complete WBs, Buzz Lightyear circular motion practicum.  
|        | PM – **Unit 8: Energy Storage and Transfer**, Stretched spring lab, work on lab notebooks, graph, whiteboard prep & practice critiques.  
|        | HW – **REFLECTION PAPERS DUE**  
|        | Day 13 | AM – Gravitational potential energy, *elastic potential energy to kinetic energy deployment*, work-kinetic energy theorem.  
|        | PM – **Unit 9: Impulsive Force Model**, *conservation of linear momentum lab*, collect data, plot velocity ratio vs. mass ratio.  
|        | HW – Reading: Swackhamer, “Making Work Work.”  
|        |        | LESSON PLANS DUE  
|        | Day 14 | AM – Lab extension for Conservation of Momentum, deployment worksheets.  
|        | PM – Impulse-Momentum Theorem lab activity, WB worksheets.  
|        | Day 15 | AM – WB presentations of deployment exercises. unit test, FCI and MBT, post-test, door prizes (Thank you, Christine Vernier!), closing remarks.  
|        |        | RETURN PAPERS AND LESSON PLANS