Syllabus: Modeling Workshop in Mechanical Waves & Sound

Last held June 11-29, 2018 at Arizona State University. Held every 3 years in June at ASU.

ASU catalog description: PHS 594: Modeling Workshop in Mechanical Waves (3 credits). Teaching mechanical waves and sound in high school physics using model-based methods and science practices. Prerequisite: PHS 530/PHY480 or a mechanics Modeling Workshop of at least 2 weeks.

Course hours: 8:00 – 3:30 M-Th, 8:00-12:00 F (3 weeks)

COURSE DESCRIPTION:

1. Overview

Teachers will work through coherent model-centered materials for high school mechanical waves to develop a deep understanding of content and how to teach it effectively. In this workshop there is less emphasis on why we believe that modeling is superior to conventional instruction, since we assume that teachers coming back to take a follow-up course have come to accept this as true. In the Mechanical Waves workshop, we assume that teachers understand and have classroom experience with Modeling Instruction. To develop familiarity with the Mechanical Waves materials necessary to fully implement them in the classroom, teachers work through the activities, discussions and worksheets, alternating between student and teacher modes, much as they did in the first Modeling Workshop in Mechanics.

2. Course Teaching Methods

Students will participate actively in "student mode": discussion, working in teams, setting up and carrying out experiments, collecting data, analyzing and interpreting data, whiteboarding and presenting results to peers. At times students will participate actively in "teacher mode": discussing most effective approach with various types of students; comparing ideas about pedagogy with other teachers; identifying student naïve conceptions, misconceptions, frequent conceptual errors and reasoning dead-ends; exploring ways of adapting workshop approaches and lessons to specific classroom situations.

3. Description of Units\Text and Required Reading

Unit 1: **The Oscillating Particle**. In this unit we develop the model of an oscillating particle, its causal force model, the restoring force, along with its kinematical model, simple harmonic motion. We will develop graphical and mathematical representations by experimentally studying the motion of masses oscillating vertically on springs. Energy considerations are also studied.

Unit 2: **Mechanical Waves in 1-Dimension**. We connect a string of particles together with springs to help develop the model of a wave being a disturbance propagated through the connected particles as they oscillate. We move on to study the behavior of transverse and longitudinal pulses as they move and reflect. After establishing pulse behavior we use standing waves on a string to experimentally develop the wave velocity equation relating frequency and wavelength. We finish by experimentally developing the relationship of the velocity of waves on a string and the linear density of the string along with the relationship of the velocity and the tension in the string.

Unit 3: **Sound**. The model of sound being a pressure wave caused by longitudinally oscillating particles is developed. We study the concept of resonance and factors necessary for it in tubes, on strings and on rods. We use MBL microphones to study beats, harmonics, pitch and loudness. We finish the unit with the Doppler Effect.

Unit 4: **Mechanical Waves in 2-Dimensions**. We study reflection, refraction, diffraction and two-slit interference. This unit makes use of ripple tanks to develop two dimensional behaviors. To be honest, the oscillating particle model is not taught as a factor in these behaviors. Due to the difficulty of studying these behaviors fully using coupled particles, we will use light.

In each unit we will use Java applets, practicums, MBL probes, many demonstrations and deployment activities.

STUDENT LEARNING OUTCOMES: At successful course completion, 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 mechanical waves and sound (see above),
- experienced and practiced instructional strategies 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 scientific practices recommended by the National Research Council in "A Framework for K-12 Science Education." 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 for ~90 hours (studio format) in summer, and you are required to do at least 45 hours of work outside of class, including reading, worksheets, lab reports, and writing. Assignments are listed in the course itinerary; their links to student learning outcomes are evident in the itinerary.

ASSIGNMENTS, GRADING POLICIES AND PERCENTAGES:

A. Attendance:

You are expected to attend all days of this course. If you miss 2 classes (12 contact hours), your maximum grade will be a B; if 3, you can earn no higher than a C. Please be on time and ready to go! Report any expected absences to the course instructor as soon as possible.

ASU credit-seeking students who miss course time are to complete and write a reflection for all activities missed, design an activity modified or developed for pilot use in the classroom this coming year, and present results to the course instructor and peers when appropriate.

B. Assignments:

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 are required to turn in these assignments, which will be graded as "satisfactory" or "unsatisfactory" for purposes of awarding CEUs.

Students enrolled for credit will contract for a letter grade on the 2nd class day. **Contracting for a letter grade is not a guaranteed grade. Work must be completed at ASU standards and meet all class requirements.**

- Keep a course notebook in which all labs, activities and demonstrations are placed. Keep a course notebook. Teachers have found this notebook to be a valuable resource as they use the curricular materials in their own classes. Consequently participants are expected to record notes pertaining to **everything** that they do. When participants return home and do the labs and activities they are not going to remember many of the details that came out in discussions and activities so they are expected to place them in your notebook as they work. (50% of course grade)

- Labs are performed in "student mode". All labs should include notes from the prelab discussion, the purpose, the data, evaluation of data with all graphs (with curve fits if not linear), equations of linearized graphs, manipulations of units of the slope, statement of what the slope represents, statement of the relationship and the general equation for the lab. For each lab add the necessary comments that will help you guide your students through successful lab experiences.
- You should also take notes on demonstrations and the concept they are designed to illustrate.
- Any activities such as practicums that we do should have the question to be solved along with the data and calculations needed to solve it.
- Basically, the expectation is that notes on everything we do will be in your notebook.

- Formally write up two of the four paradigm labs at 80% level or higher. (15% of course grade)
- Participate actively and thoughtfully in whiteboarding sessions, the discussion of readings, activities, and the worksheets. (10% of course grade)
- Turn in two problem sets of Wave problems of the level found in an honors or AP-1 course. (10% of course grade)
- You will be asked to take a University of Maryland Wave Diagnostic Test and then read two articles by the authors of the test. You will be expected to write a three-fourths to one-page *reaction* (not a synopsis) in which you offer your views about the ideas discussed in the reading assignment. We will go over the test in class. (5% of grade)
- At the end of each unit we would like you to read the teacher's notes. Then turn in a one page reflection on the storyline and the activities in the unit. The materials have recently undergone extensive revisions and we are looking for comments that will help make them better. (10% of course grade)

C. Grading scale:			
	99-100 A+	93-98.9 A	90-92.9 A-
	87-89.9 B+	**83-86.9 B**	**80-82.9 B-**
	77-79.9 C+	**73-76.9 C**	**70-72.9 C-**

Points awarded for each assignment are not summative. The percentage earned for each category will be calculated and then weighted according to the designated percent of the course grade. For example if the participant earns 220 points for the notebook; 220/250 = 88%, 88 x 0.5 = 44 pts. If the teacher earns 92 out of 100 on the "String" lab, 92/100 = 92%, 92.4 x 0.075= 6.9 pts. Summing up all of the points calculated in this manner will yield a score out of 100 from which the grade is determined using the percentages above.

- **Keep a course notebook. (250 points: 50% of course grade)**

225-250 pts = A	200-224 pts = B	175-199 pts = C
Participant records all labs, activities and demonstrations. All labs include the pre-lab, data, evaluation, conclusion and post-lab class discussion. Entries include additional suggestions for implementation.	Participant is missing a few activities and demonstrations. Most of each lab has the required components but is lacking complete notes. Entries include few suggestions for implementation.	Participant is missing more than a few activities and demonstrations. Labs are missing required components but is lacking complete notes. Entries include no suggestions for implementation.

- **Participate actively and thoughtfully in lab whiteboarding sessions, discussion of readings, activities, and problem-solving whiteboarding. (30 points: 10% of course grade)**

27-30 points	24-26 points	21-23 points
Is a prompt and regular attendant; stays until the completion of the session;	Is a prompt and regular attendant; arrives late or leaves early only with the prior	Is usually but not always prompt and regular attendant; participates most of the time in

participates in group activities and discussion by asking questions and offering ideas during whiteboarding. Completes all worksheets for the course.	notification of the instructor; participates in group activities and discussion by asking questions and offering ideas during whiteboarding	group activities and discussion; listens when others talk but infrequently participates in whiteboard discussions

- **Turn in two problem sets of waves problems of the level found in an honors or AP-B course. (100 points each, 10% of course grade)**

Four problems worth 25 points each, most questions have multiple parts.
▪ ½ credit if there is no setup for the calculations ▪ One point deduction for incorrect or missing unit ▪ One point deduction for a computational error where the setup is correct. ▪ If an answer to a question is done correctly but used an earlier answer that was incorrect, there is no deduction.

- **Formal write-up for two paradigm labs (approximately 100 pts per lab 10% of course grade)** You were given a sample rubric for lab write ups. The grading scale is the same as the course scale.

- **Read the teacher notes for each unit and turn in a one-page reflection on the storyline and the activities in the unit. (40 points each: 10% of course grade)**

Rubric is for each individual paper.

Assessment Item	**36-40 points**	**32-35 points**	**28-31 points**
Discussion	Well written; easy and interesting reading; thoughts are fully elaborated and illustrate what is meant; examples are provided as appropriate; discusses what they liked and didn't like and explain why; suggestions are offered to improve the course.	Reasonably well written; easy and interesting reading; points are made, but not always elaborated; discusses what they liked and didn't like but didn't always explain why	Fairly well written; confusing to reader; key points are made, but not often elaborated
Spelling, Punctuation and Grammar	No punctuation errors; no spelling errors; no grammatical errors	3 or fewer errors in these areas	5 or fewer errors in these areas
Format and Appearance	Uses size 12 font or smaller, 1.5 line spacing or hand written. Legible if hand written.	Fails to meet one of the guidelines for appropriate font size, line spacing or legibleness	Fails to meet two guidelines for appropriate font size, line spacing or legibleness
Script Length	One page or over	Close to one page	Much less than one page

- **Take a University of Maryland Wave Diagnostic Test and then read two articles by the authors of the test. (20 points: 5% of course grade)**

Assessment Item	**18-20 points**	**16-17 points**	**14-15 points**
Discussion	All statements are relevant to the topic or bear on the question at hand; it is obvious the articles were read	Fairly good use of logic. Paper illustrates less thought was put into it	Some discussion but not a great deal of thought put into it
Punctuality	Test was done before we went over it in class	Test was 80% complete before we went over it in class	Test was less than 80% done before we went over it in class
Spelling and Punctuation	Insignificant number of punctuation errors; no spelling errors	No spelling errors, and only a few punctuation errors	A modest number of spelling and punctuation errors
Format and Appearance	Uses size 12 font or smaller, 1.5 line spacing or hand written. Legible if hand written.	Fails to meet one of the guidelines for appropriate font size, line spacing or legibleness	Fails to meet two of the guidelines for appropriate font size, line spacing or legibleness
Script Length	One page or over	Close to one page	Much less than one page

Arizona Board of Regents, ASU, and Department of Physics policies:
Each student is expected to spend a minimum of 45 hours per semester hour of credit.
Pass-fail is not an option for graduate courses. https://students.asu.edu/grades-grading-policies
"B" grade means average; 3.0 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".

Academic dishonesty policy: Please refer to http://provost.asu.edu/academicintegrity. Students who suspect a policy violation are encouraged to discuss their concerns with their course instructor. ASU has a grade of "XE" which can become part of a transcript and permanent academic records and explicitly means that the student failed a course because of academic dishonesty.

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:
No textbook. 3-ring binder (preferably 1.5 inches thick); 6 tab inserts. You will also need a 9" x 12" quad-ruled lab notebook. 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 activities and readings assigned. (Buy at ASU bookstore or Staples for ~$15).

REQUIRED READING:

M. Crofton and others, Modeling Instruction in High School Physics Teacher's Manual in Mechanical Waves. (Units 1 – 4).

Michael Wittmann, "The Object Coordination Class Applied to Wavepulses: Analyzing Student Reasoning in Wave Physics", International Journal of Science Education 24:1, 97-118 (2002)

Michael C. Wittmann, Richard N. Steinberg, Edward F. Redish, "Understanding and Affecting Student Reasoning About Sound Waves"

SUGGESTED READING:

Fernand Brunschwig, "Teaching Physics: Inquiry and the Ray Model of Light". Available in pdf at http://modeling.asu.edu Click on "resources for the modeling classroom". Scroll down to the section called 'other instructional resources".
http://modeling.asu.edu/Projects-Resources/BrunschwigF_RayModel-Light.pdf

Bruce Sherwood, "Answer to Question #21", American Journal of Physics 64, 840-842 (1996)
Available at http://matterandinteractions.org/Content/Articles/Refraction.pdf (Confusing, though)

Thomas L. O'Kuma, David Maloney, and Curtis J. Hieggelke, Ranking Task Exercises in Physics. See http://www.compadre.org/psrc/items/detail.cfm?ID=3686

RECOMMENDED MEDIA:

Tacoma Narrows Bridge Collapse: (many resources can be obtained by a web search)
A video: http://www.youtube.com/watch?v=j-zczJXSxnw (6 min.)
K-12 teachers guide by AAPT: http://aapt.org/Store/upload/tacoma_narrows2.pdf
Detailed account: http://www.wsdot.wa.gov/tnbhistory/Connections/connections3.htm
Mechanisms for collapse: http://www.wsdot.wa.gov/TNBhistory/Machine/machine3.htm

Mechanical Universe: http://www.learner.org/resources/series42.html - program_descriptions
Lesson 17: Resonance; Lesson 18: Waves (each is 29 minutes; video on demand – free)