UNIVERSITY OF WISCONSIN
OSHKOSH

Secondary Education 521, 2-3 credits

Modern Physics for Teachers

Pre-requisites:	Bachelor's degree in science, science education, or equivalent; certification to teach secondary school science (grades 10-12) or enrollment in an approved alternative license program; General Physics 171-172 or equivalent; permission from the instructor
Instructor:	Dr. Mark Lattery, Professor of Physics (lattery@uwosh.edu), Department of Physics and Astronomy
Curricular context:	*Next Generation Modeling Courses* (www.uwosh.edu/physics/ngmc)
Course format:	Online
Project paper:	Earn 3 credits for a classroom applications project and paper

Modern Physics for Teachers is a physics teacher professional development course that surveys the special theory of relativity and non-relativistic quantum mechanics. Key topics include: Lorentz transformation and compressed-axes representation, relativistic energy and momentum, free and bound particles, scattering, and the hydrogen atom. Teachers examine research-based methods to teach modern physics and learn to address common student learning difficulties.

Course readings

- *Modern Physics for Teachers Course Materials* (shared on Google Drive)
- *Deep Learning in Introductory Physics* (Lattery, Information Age Publishing, 2017)
- *Next Generation Science Standards: For States, By States* (NAP, 2013)
- Tipler, P. & Llewellyn, R. (1999). Modern Physics (3rd edition). NY: W. H. Freeman and Company.
- Cummings, K., Laws, P., Redish, J., & Cooney, P. (2004). *Understanding Physics* (8th Ed) NY: Wiley.

Required resources

- American Modeling Teachers Association (instructor access)
- Pivot Interactives (student access)
- Vernier's *Logger Pro 3* *(free 30-day trial)*
- PhET Interactive Simulations

Additional software

- Microsoft Office 2007 or higher (Word and Excel)
  Google Chrome browser (version 63 or later)

- [Windows Media Player]
- [QuickTime Player]
- [Adobe PDF Reader]

Course fees

$50 (Access to the AMTA modeling materials and Pivot Interactives)

Advisory panel

Peter Bohacek, *Pivot Interactives*, *Henry Sibley High School*, Minnesota
Scott Hertting, *Neenah High School*, Wisconsin
Jeffrey Elmer, *Badger High School*, Wisconsin
Trish Loeblein, *PhET Interactive Simulations, Colorado*
Terry Schwaller, *Shiocton High School*, Wisconsin
Matthew Vonk, *Pivot Interactives,* UW River Falls, Wisconsin
Edward Wyrembeck, *Howards Grove High School*, Wisconsin

Design considerations

As teaching professionals, finding time for professional development is challenging. Thanks for taking on this challenge! Every attempt has been made to provide great learning opportunities while keeping the course load reasonable. The course consists of labs, reading and writing assignments, discussions, and one final assessment.

Curricular context

This course is a *Next Generation Modeling Course* (NGMC). NGMCs are graduate-level professional development courses for science teachers. The courses are short (four weeks during the summer or eight weeks during the regular school year) and taught online. All NGMCs assume a basic knowledge and understanding of educational theory, science-teaching methods, and science education standards. For more information about the curricular context of this course, please visit the *Next Generation Modeling Courses* website.

Course goals

Professional development courses for physics teachers are currently in high demand in the United States (AAEE 2010, NCES 201[illegible], AIP 2014). To fill this need, NGMCs set three goals for practicing physics teachers:

- strengthen subject-matter content knowledge in physics

- deepen understanding of (1) common student misconceptions and learning difficulties; (2) research-based methods of science teaching and learning; (3) learning theories in science education; and (4) national and state standards

- increase engagement in discussion about the goals and methods of physics teaching through participation in state and national science teaching organizations, local special-interest groups, and classroom action research

Each course activity provides an explicit alignment to the *Next Generation Science Standards* (NGSS Lead States, 2013).

Professional development outcomes

By the end of the course, teachers will be able to:

- engage in all aspects of the scientific modeling process, including experimental design, data collection, data analysis, model evaluation, and model revision (Lattery 2017, and references therein)

- apply modern classroom technology and model-centered teaching strategies for the introductory physics classroom

- discuss and critically evaluate problems, concepts, and issues in the physics education literature (e.g., student learning difficulties, alternative student conceptions, and student learning progressions)

- identify and use resources available through local, state, and national physics teaching organizations for ongoing professional development

Additionally, teachers enrolled the *Plus-1 Credit option* will be able to develop and carry out a classroom action research project that leads to lesson and curriculum improvement.

Course level

This course is a rigorous graduate-level course designed for practicing secondary physics teachers. This course provides:

- a graduate-level treatment of pedagogical content knowledge
- an undergraduate treatment of subject matter relevant to the high school physics curriculum

Laboratory and homework activities are designed with a dual purpose: (1) to strengthen teacher's knowledge of the content matter, and (2) to broaden teachers' understanding of alternative student conceptions and student learning difficulties. These dual goals require a depth/level of coverage of physics concepts that is both different than, and in some respects beyond that of, conventional undergraduate physics courses.

Dual-enrollment certification

NGMCs are designed for physics teachers seeking to meet High Learning Commission (HLC) requirements to teach algebra-based general physics (Physics 171-172 or equivalent) for university or college dual-enrollment credit. Please note that by 2022, all dual enrollment instructors must have a master's degree in the discipline (physics), or a master's degree in another area plus 18 graduate-level credits in the discipline. According to HLC criteria, graduate courses "in the discipline" can be either traditional courses or methods courses: (*underline mine*)

HLC... recognizes that dual credit faculty members who have obtained a Master of Education degree but not a master's degree in a discipline... 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 (Determining Qualified Faculty Through HLC's Criteria for Accreditation and Assumed Practices, 2016).

NGMCs fall naturally into the second category of courses above ("methods courses for the teaching of that discipline"); i.e., these courses address problems and issues in physics education, with particular attention to physics content. Please note the becoming a dual enrollment instructor requires a partnership with a local university/college physics department. Consult your local department for additional requirements.

Course components and grading

1. *Laboratory* (45%). Laboratory assignments include:

   a. Lab worksheets (45%). Contains concepts to review and activities to introduce you to a target physical case. Lab worksheets are completed individually and in a 3-4 member small group. With few exceptions, labs are implemented using Vernier's Logger Pro, Pivot Interactives and PhET Simulations

   b. Post-lab worksheets (45%). Contains a summary, additional activities, and quantitative and qualitative problems to solve. Post labs also include worksheets from the AMTA Modeling Materials.

   c. Lab Discussion (10%). Small-group collaboration on data collection and analysis.

2. *Reading and reflective writing (RW)* (45%). Reading and writing assignments include:

   a. Reflective Writing exercises (50%). During the course, you will keep a journal on the textbook reading (e.g., selected chapters from Cummings, et al. 2004.) For each reading, you will complete a journal entry using the Reflective Writing (RW) technique of El-Helou and Calvin (2018). Journal entries are typically 2 or more pages and can be handwritten. A RW rubric can be found in the Google shared folder

   b. Teacher reading discussions (50%). Teacher readings include peer-reviewed journal articles in science teaching, science education research, and science technology. These readings bridge the course content with classroom implementation. Following each reading, teachers will participate in a large-group (whole class) discussion. A discussion rubric can be found in the Google shared folder.

3. *Final written assessment* (10%). A short synthesis paper on a topic of the teacher's choosing that integrates the main concepts and themes of the course.

4. *Plus-one credit option project paper* (30% of total grade)

Final grades are determined by the following scale
A (92-100), A- (90-91), B+ (88-89), B (82-87), B- (80-81), C+ (78-79), C (72-77)

Per the University of Wisconsin Oshkosh *Office of Graduate Studies* policy, grades for graduate courses below a C are given a failing grade.

Time commitment

The amount of time required to complete the course (including homework, labs, readings, and discussions) is dependent on your subject-matter content background. Most teachers spend between 32-48 hours total for study and review—spread out evenly over the course. (This range does not include direct contact with the instructor and colleagues, and pre-course preparation.) The official total time commitment is governed by UW System Administrative Policy 165. Course activities that count as contact hours include all required small- and large group discussions on homework, laboratory, and teacher readings.

Course policies

1. *Assignment deadlines.* Assignments are due midnight in your time zone for the listed day/date. Assignments are expected to be completed on time unless prior arrangements have been made. Late points are taken off for late assignments. Unfortunately, no credit can be given for contributions to large-group discussions after discussions are listed as "Closed".

2. *Academic integrity.* Academic cheating, copying, plagiarism, handing in another person's work, and other examples of academic dishonesty will not be tolerated. All material submitted must be your own work. Any incident of academic or other misconduct will be reported to the Dean of Students for further disciplinary action.

3. *Special accommodations.* If you have any condition, such as a physical or learning disability, which will make it difficult for you to carry out the work as outlined, or which will require academic accommodations, please notify the instructor before the *first* day of class.

Weekly schedule

The course covers 8 topics: 1 topic per week for 8 weeks (during regular school year) or 2 topics per week for 4 weeks (during the summer). Below is a topic schedule for the course during the regular school year.

Weekday	Day	*Activity*	*Format*
Mon	1	Lab Worksheet	Online lab, small group discussion
Tues	2	Reflective Writing	Written homework, individual
Wed	3	Post-lab Worksheet	Online lab, small group discussion
Thurs	4	Teacher Reading	Written homework, individual
Fri	5	Teacher Discussion	Large group discussion
Sat	6	Teacher Discussion	Large group discussion
Sun	7	Open	Open

For the summer course, the first topic is covered Monday through Wednesday and the second topic is covered Thursday through Saturday.

Canvas learning management system

Canvas is the UW Oshkosh learning management system. In this course, *Canvas* is used exclusively for small- and large-group discussions and posting grades. All file sharing between the instructor and teacher occur using the course Google shared folder.

Course content *(tentative)*

Modern Physics for Teachers is a professional development course with a focus on both physics teaching and learning, and subject-content matter. Example readings and topics given below.

Topic	Topic title	Physics teaching and learning	Physics content
Foundations of quantum mechanics			
1	Photoelectric effect and the Millikan oil drop	Inductive vs. conventional labs, problems and issues in teach PE effect	Lenard PE data, Einstein's photon hypothesis, work fn, stopping potential
2	Quantum wave interference	Simulations/games on two-slit interference, alternative student interpretations	Geometric optics, light reflection and refraction, image formation
Applications of quantum mechanics			
3	Quantum bound states	Classroom experiments on the "particle in a box", evaluation and comparison	Analysis spectra of CdTe quantum-dot solutions, deB hypothesis, S. waves, Born
4	Quantum tunneling	Alternative student misconceptions in quantum mechanics	Analysis of nuclei half-lives (Ra, Rn, Po, and Rb), step potential, barrier potential
5	Hydrogen atom	Debates in the education literature on teaching of Bohr's model	Analysis spectra H gases, Balmer's formula, alternative interpretations
Einstein's relativity			
6	Relativity and simultaneity	Teaching Galilean/Einsteinian relativity, Student beliefs about simultaneity	Michelson-Morley experiment data (null result), alternative interpretations
7	Length contractions and time dilation	Problems and issues in teaching relativity at the secondary level	Analysis of historical Frisch & Smith muon-lifetime experiment, time dilation
8	General relativity or quantum spin (stacked unit)	Uses of models and analogies to teaching GR, student conceptions of Stern-Gerlach	Conceptual development of GR and Stern-Gerlach experiment

Course materials

All course materials are contained in the course Google Drive (*click below*):

dropbox
  private (homework assignments deposit) *Google link sent by email.*
  public (supplemental materials introduced through online discussions, etc.)

course materials
  course information (syllabus, student directory, misc)
  readings (research articles and diagnostics—from beginning to advanced)
  reflective writing (steps, rubric, articles)
  resources (AMTA materials, PhET sims)
  videos (instructor videos, lab videos)

  00 tutorials
  01 introduction to modeling
  etc. (*see below*)

About the course

Focus on scientific models and modeling

NGMCs highlight *model-centered methods of science instruction* (Lattery 2017, and references therein). Each new topic begins with a phenomenon and works toward an empirically accountable and explanatory conceptual model. This approach emphasizes collaboration, peer discourse, and the use multiple representations. The goal of a model-centered course is both an understanding of the nature of science and the subject-matter.

Online discussions

Small- and large-group discussions are facilitated through the *Canvas* learning-management system. Most discussions are *asynchronous*. Small-group discussions occur as you complete lab/post-lab worksheets. Large-group discussions occur after teacher readings. Discussion grades are based on quantity and quality of submissions.

Use of classroom technology

NGMCs employ a mixture of virtual laboratory activities based on Pivot Interactives and Vernier's Logger Pro, traditional problem-solving activities (based on Halliday, et al., 2018), and worksheets (based on Arizona State University modeling method and PhET Simulations). Asynchronous small- and large-group discussions are used extensively. Reflective Writing (Kalman, et al. 2019) prepares teachers for large-group discussions of the physics education literature and related problems/issues in classroom implementation. NGMCs are designed to expose teachers to research-based practices in teaching and encourage them to adopt research-based materials (e.g., the ASU modeling instruction) in their own classrooms.

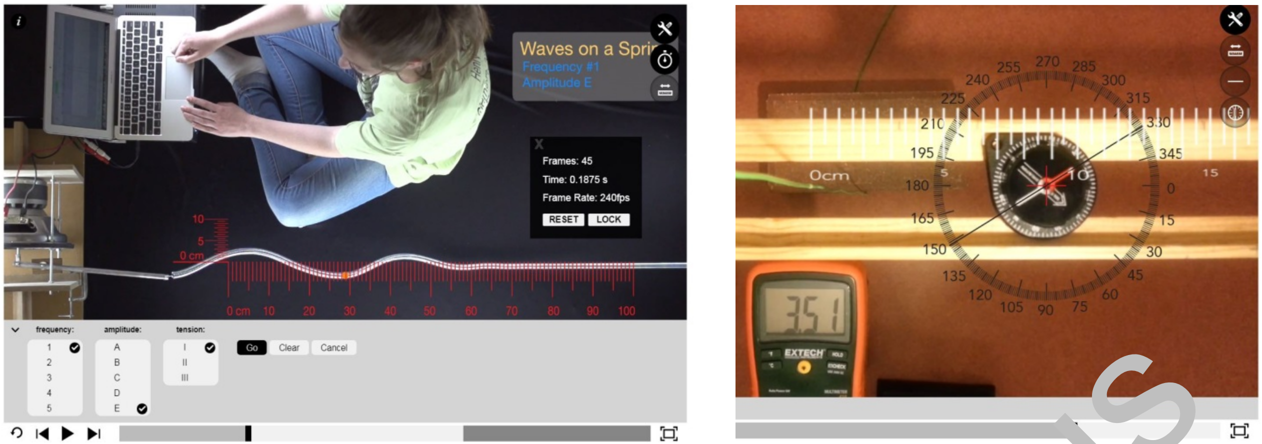

Figure 1. Two examples of Pivot Interactives: (a) waves on a string, and (b) Ampere's law.

Virtual laboratories

Many laboratories are conducted using [*Pivot Interactives*](). Pivot Interactives are not simulations, but inductive investigations of real phenomenon using video analysis tools. As an example, consider the lab, *Waves on a Spring* (Figure 1a). In this activity, teachers explore the relationship between the speed of a transverse wave and several other factors (driving frequency, wave amplitude, and spring tension). The user selects videos for different values of the dependent variables, then measures the wave speed (the dependent variable) with a virtual ruler and stopwatch. A similar example is shown for Ampere's law (Figure 1b). In this case, teachers explore the relationship between the amount of electric current running through a wire (the green wire at the left), the distance of a compass to the wire, the electric current in the wire, and the deviation of a compass needle (a measure of the magnetic field at the compass). Data collection and analyses are conducted in small groups. Individual teachers explore different aspects of the phenomenon, then share and discuss their results using the *Canvas* discussion feature. Many of the same questions that arise in a real lab also arise in a virtual lab, such as how to collect the data to reduce errors. Throughout the process, the non-ideal features of the data challenge teachers to develop explanations and revise their models.

Student and teacher mode

As in most science teacher professional development courses, teachers alternate between “student mode” and “teacher mode”. In student mode, teachers experience the course materials as their students would; in teacher mode, teachers explore extensions to the content and discuss practical issues for classroom implementation. For example, a teacher might examine known student alternative conceptions in a content domain, connections to the history of science, and specific research-based strategies to address these conceptions. Learning is reinforced by conventional HW problems and conceptual problems extracted from the physics education literature.

What this course is not…

This course is NOT…

1. *a traditional lecture-lab course.* As an online professional development course for physics teachers, both the style and format of the course will be different than a traditional lecture-lab course.

2. *an independent study course.* This course is highly collaborative. A significant part of the course experience is working together with your colleagues to meet various challenges. For this reason, course activities (laboratories, reflective writings, post laboratories, and teacher reading discussion prompts) will be posted no more than three days in advance**.** You are, however, welcome to try out any open lab simulations/activities or complete readings ahead of time. Please reserve your questions until we've reached this material together in the course schedule.

3. *a full-length course.* This is a short course, so content goals are narrow. Topics have been carefully chosen to survey major concepts and expose you to instructional materials you can apply and use in your own physics classroom.

4. *a mathematical problem-solving course.* You will solve many conventional, end-of-the-chapter-style HW problems. However, unlike a traditional full-length physics course, mathematical problem solving will not be the primary focus of the course or course assessment.

Questions?

If you have any questions about the course, please do not hesitate to contact Dr. Lattery by email at lattery@uwosh.edu.