PHS 542: Integrated Mathematics and Physics (3 semester hours)

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Catalog description: Mathematical models and modeling as an integrating theme for secondary mathematics and physics. Enrollment by teams of mathematics and physics teachers encouraged.

Course objectives:

(1) To learn techniques for coordinating algebra and pre-calculus courses with physics by exploring models that are common to both disciplines.
(2) To develop student activities that support math-physics coordination.
(3) To initiate and promote an ongoing dialogue between math and physics teachers that illuminates mutual interests and concerns and fosters collaboration.
(4) To collaborate to establish a common language and set of representational tools that math and physics teachers can both use with their students within their respective disciplines.
(5) To develop classroom research techniques whereby teachers can develop an understanding of the modeling methodology.

Course content:

Utilizing the Modeling Method of instruction, abstract mathematical concepts such as *variable, function* and *rate* will be used in development of mathematical models of physical situations.

Emphasis will be placed on use of technology, which allows for less emphasis on the process of data-gathering, and shifts the focus to data interpretation, model identification and generalization.

Math and science standards will be examined to identify and extend possible alignments. Discovering the commonalities these standards have can point to ways that science instruction can improve student performance on mathematics standard-based assessments, and vice versa.

An emphasis will be placed on the underlying structure of student learning as a means of guiding modeling instruction.

Suggested prior course:

For physics teachers, a Modeling Workshop is recommended.

Basic Classes of Models:
(Notice that these mathematical models are called *functions* by mathematicians.)

1) Linear model: Rate of change = constant ($\dot{Q} = k$). Common representations are graphs and equations for straight lines (e.g., velocity, acceleration, force, momentum, energy).

(2) Quadratic model: Change (in rate of change) = constant ($\ddot{Q} = k$) . Usual representations are graphs and equations for parabolas (e.g., accelerated motion, kinetic and elastic potential energy).

(3) Exponential model: Rate of change is proportional to amount ($\dot{Q} = kQ$). Representations include graphs and equations of exponential growth and decay (e.g., population growth, radioactive decay).

(4) Harmonic model: Change (in rate of change) is proportional to amount ($\ddot{Q} = kQ,\ k < 0$). Usual representations are graphs and equations of trigonometric functions (e.g., waves and vibrations, harmonic oscillators, situations in electricity and magnetism such as simple AC circuits and LC circuits).

If we wish to consider two-dimensional situations, we can combine one or more of the above model classes to form complex models:

(5) vector valued models, represented by graphs and parametric equations (e.g., vectors in 2 dimensions, uniform circular motion, the unit circle, projections from a vector point of view). Punctuality and active participation in class and group activities are crucial to the learning experience. Homework will be assigned from time to time but the emphasis will be on cooperative learning experiences and collaborative curriculum development activities.

All participants will be encouraged to subscribe to the modeling listserv so that the discourse established during the course can continue once the school year begins. Teachers will be supported in their efforts to disseminate what they have acquired as a result of their participation in this course. Their efforts will form a foundation for future participants in this course.

"Top Ten Reasons" to enroll in PHS 542: Integrated Mathematics and Physics (with apologies to David Letterman)

10. This course aims to establish a community of secondary teacher - leaders to support the integration of mathematics and physics. We will develop a forum within which physics and math teachers can talk with each other, and find ways to mutually reinforce one another's efforts.

9. Finding a common language and set of representational tools for use with our students is crucial to this enterprise, and will be an ongoing focus of discussion.

8. Physics courses are typically weak in the mathematical analysis of the models they develop. There is very little time to analyze the functional properties that are identified, and rarely are they generalized to non-physics contexts. This collaboration is a golden opportunity for mathematics classes, who are crying out for non-trivial applications, to step in and make use of the groundwork (grunt-work?) that is already being done in the physics laboratory.

7. Physics students learn to look at rate of change in a narrow kinematic context. With a little coordination, this concept of change of rate will be generalized and applied to a broader range of processes.

6. Science is about discerning and representing structure. Mathematics has been called the "language of structure". Such a coincidence of interests should be exploited whenever possible, as there are never enough instructional minutes to do the job.

5. Technology tools will allow us to place less emphasis on the gathering of data, and focus our efforts on analysis and deployment of the resulting models.

4. Math and science standards will be examined for areas of alignment that can be mutually exploited and reinforced.

3. Assessment of integrated learning (both formative and summative) will be discussed, critiqued and extended as often as possible throughout the course, and in listserv discussions during the ensuing school year.

2. The listserv will facilitate ongoing dialogue between participants and instructors, and will support and encourage the efforts of teachers who disseminate what they have learned in this course at their school site or district.

1. Refreshments will be served daily to fuel the intellectual engagement and dialectic that will inevitably result from consorting with a group of motivated educators.

This course is a golden opportunity for math and physics teachers to multiply their effectiveness by cooperating with one another. It will be a win-win proposition for all comers. Don't miss out on a groundbreaking opportunity to be at the cutting of educational reform in your discipline.