Proposed New Learning Community for 2004-2005

Background

This learning community proposal comes from Alessandro Massarotti of the physics department and Joe Perez of the math department, with the enthusiastic support of physics program director Mike Horne, math chair Carlos Curley and chemistry chair Louis Liotta. Although it will not start until 2004-2005, it affects the math, chemistry, and physics curriculum starting next year and hence should appear in the new catalog currently being prepared.

As freshmen at Stonehill, chemistry, math, and computer science majors take calculus I and II (MA125-126) and no physics. As sophomores, they continue with calculus III and IV (MA 261-262) and they currently also take general physics (PY 211-212).

With the encouragement of the math and chemistry faculty and their chairs, the physics department is going to list the general physics course as a freshman course (new numbers PY 121-122). The chemistry and math departments have already rewritten their portions of the catalog to require their majors to take the course as freshmen; computer science majors will remain free to take the course in any year.

The shift of the physics course from the sophomore to the freshman year will be accompanied by some significant changes in content. In the fall semester of the current sophomore course (PY 211), the students make a tour of Newtonian mechanics, thermodynamics, heat as molecular motion and, briefly, mechanical vibrations and waves. In the spring semester (PY 212), they see electromagnetic fields, optics, and, briefly, electromagnetic waves and quantum waves. After the shift to the freshman year (PY 121-122), the above-mentioned briefly treated topics will be omitted. The omitted material will be covered and expanded in a new sophomore course (PY 221) which will be part of the following learning community.

LC ___ Waves: From Classical to Quantum

PY 221: Mechanical and electrical examples of damped, forced and resonant oscillations, the mechanical wave equation via Newton's mechanics, the electromagnetic wave equation via Maxwell's equations, travelling sound and electromagnetic waves, geometrical limit of wave optics. In brief, this course covers the physics of mechanical and electromagnetic waves, collectively known as classical waves. Massarotti will teach this course.

MA 261 (Calculus III) Fourier expansions, differential and integral calculus of multivariate functions, differential operators in curvilinear coordinates, divergence theorem and Stokes' theorem. In brief, this course covers the mathematics needed to describe waves of many varieties, and it also includes some mathematical tools not commonly used for classical waves. Perez will teach this course.

LC_____. With the creation of quantum mechanics in the 1920s, physicists conceived of a new and unexpected kind of wave that is neither a Newtonian (c. 1700) mechanical wave nor a Maxwellian (c. 1860) electromagnetic wave. These mysterious de Broglie - Schroedinger waves of probability are the essence of quantum mechanics. These waves determine the structure of atoms and molecules, i.e. they are the deepest foundation of both physics and chemistry. While the mathematics of these quantum waves is similar to the classical waves already studied in PY 221 and MA 261, the physical, chemical, and philosophical consequences are breathtakingly different. In this integrative seminar, to be held in the Spring, the students will have the opportunity to investigate these waves by simply reapplying some skills already learned in the Fall in PY 221 for classical waves and also by applying, for the first time, some other tools from MA 261. The seminar will start with Richard Feynman's famous introduction to the subject (see enclosed copy of Feynman's essay *Quantum Behavior*), it will proceed to some very basic examples (see enclosed copy of Mike Horne's *Free-Particle Amplitudes*), and it will then use a textbook to cover a few select but important topics: Schroedinger's equation, particle in a box, harmonic oscillator, hydrogen atom (see title page and first three chapters of the contents of enclosed sample text). These are samples of the material for the seminar. These samples are all self-contained and hence serve as a seed for the discussion. At the seminar meetings the students will initiate and carry on a discussion of the assigned materials. The instructors will coordinate and moderate these discussions.

Supporting Comments

The proposed PY 221/MA 261 learning community definitely fulfills the general requirements expected of all learning communities, as described in the catalog. First, the problems and issues encountered in quantum physics are emphatically multidisciplinary, for they can't be investigated, or even understood, without having mastered certain topics in mathematics *and* certain topics in classical wave physics. These required topics are the covered in MA 261 and PY 221.

Secondly, the proposed learning community certainly combines major courses, minor courses, electives, and distribution requirements in a very creative way and, in fact, completely solves several longstanding problems in the curriculum. The chemistry department has long wished their B.S. majors could get stronger preparation in quantum physics before taking, as juniors, CH 333 *Physical Chemistry*, and CH 443 *Atomic Structure and Spectra*. But this has not been possible because of severe constraints from their major and their core curriculum requirements as sophomores. Consequently, even when a suitable physics course was offered to service the physics minor, no chemistry majors could take it. The learning community requirement makes the constraints on sophomore chemistry majors even more severe. Similarly, the math department has long

wished there were regularly scheduled and suitable intermediate physics courses, either as electives for their majors or leading to a physics minor. And as a result of these scheduling constraints in other majors, the physics program cannot attract the most natural minors, i.e. math and chemistry majors. Indicative of the difficulty is the fact that there have only been four physics minors in the past decade, and none was a chemistry major.

The proposed learning community solves all of these longstanding curriculum problems: chemistry will require and math will recommend the learning community for their majors (MA 261 is already a requirement in both majors). And, since any student who completes the learning community will need only two more intermediate physics courses to complete a minor, the learning community will attract more physics minors. Please note that this magical solution to the several outstanding curriculum problems is achieved *only because the offering fulfills the learning community requirement*.

Finally, we wish to argue that the learning community will be successful. Massarotti and Perez, who are offering the learning community are both experienced teachers who respect our students' abilities and both are quantum physicists (late in graduate school Perez switched his thesis from a quantum physics topic to a math topic in a similar subject). Massarotti has three years of experience conducting seminars in physics and astronomy prior coming to Stonehill College. Many times in the past 33 years, Mike Horne has taught a course whose content is the same as the seminar of this learning community (without the head start that PY 221 will provide). Every semester for the past decade he has taught a general studies course (PY 196*, Quantum World and Relativity*) that gives even the general, non-science, student an appreciation of quantum waves. He will participate in an advisory role in designing this learning community.