

Proposed Changes to the Physics Major program

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Background/Motivation

The Physics Undergraduate Studies Committee has discussed the addition of computing to the curriculum for at least 10 years. There have been persistent efforts of the part of physics instructors to add computing based tools such as MATLAB and Mathematica to the upper division courses Physics 555, Physics 631, and Physics 621. These efforts have been hampered by the lack of familiarity incoming students have with true computing tools (beyond something like Excel).

In addition, organizations like the American Institute for Physics (AIP) have noted the importance of computing both for Physics bachelors degree students, as well as those intending to pursue a physics PhD. In particular, they find:

- 1) 24% of Physics Bachelors have a job in software 5-8 years after graduation.
- 2) Students rated their preparation in Scientific Software and Scientific programming very poorly, while rating their importance to their current job as very high.
- 3) 75% of PhD recipients rated “Software Development or Modeling” as skills necessary “Some or Most of the Time”.

Clearly, computing skills are a necessary, yet overlooked, part of the undergraduate Physics major. See <http://www.aip.org/statistics/trends/reports/bachplus5.pdf> for more details on this topic.

Other Universities:

We have examined the computing requirements for Physics majors among our nine benchmark institutions. The results of this study fall into 4 basic categories:

- 1) A formal requirement for all majors:
Penn State University, the University of Arizona, the University of Illinois, and the University of Minnesota, all require a computing course as part of their undergraduate Physics Major curriculum.
- 2) A formal requirement for a subset of majors:
The University of Texas requires a computing course in 3 of their 6 options for a B.S. in Physics. The University of Washington Seattle has a technical elective requirement in which computing is 1 of 6 choices from which 2 must be chosen.
- 3) Encouragement, but no formal requirement:
The University of Wisconsin at Madison strongly encourages their physics majors to take a computing course, but there is no formal requirement to do so.
- 4) No requirement:
Among our 9 benchmark institutions, only the University of Michigan and UCLA have no computing requirement in their Physics Major curriculum.

The majority of our benchmark institutions have recognized the importance that computing skills play in the educational experience of their undergraduate physics majors.

Summary of Changes

The changes fall into two categories: the addition of a new prerequisite, and modification of prerequisites for courses that students are already required to take.

The new prerequisite will be for Physics 416: CSE 202, Introduction to Programming and Algorithms for Engineers and Scientists. This is a 4 credit hour course which has a single prerequisite of Math 151. Math 151 is already required for our majors, and all of our incoming students should be able to take CSE 202 in their first year, or in the first two quarters of their second year. Alternate courses offered by CSE would be considered as substitutes subject to approval by the Physics Undergraduate Studies Committee or their designee.

The modification of prerequisites essentially requires that Physics 416 be taken prior to Physics 555, 621, and 631 – which is typically the case for most of our majors already.

The summary of all of these prerequisite changes are as follows:

- 1) Physics 416: Add CSE 202 to the current prerequisite of Physics 133
- 2) Physics 555 (Fields and Waves I): Add Physics 416 to current prerequisites of Physics 261, Math 415 and Math 513
- 3) Physics 631 (Introductory Quantum Mechanics I): Add Physics 416 to current prerequisites of Physics 263, Math 415 and Math 568
- 4) Physics 621 (Statistical Physics I): Add Physics 416 to current prerequisites of Physics 263, Math 254 or Math 263

The primary motivations for these changes is twofold:

- 1) Physics 416 teaches experimental techniques of physics and the statistical analysis of data to students. To do this effectively requires the use of some programming. Since there is no computing requirement for this course presently, the instructor provides some simple programming instruction. However, since the programming skills of students varies greatly, the course instructor is usually forced to spend significant time training students in this important skill. A formal programming class prior to this course will allow the instructor to focus on the core aspects of data analysis which Physics 416 is intended to deliver.
- 2) The upper division courses of Physics 555, Physics 631, and Physics 621 are taken in the 3rd and/or 4th year by the overwhelming majority of our students. By adding Physics 416 as a requirement for these courses, this effectively requires students to take Physics 416 by the end of their second year, which is when Physics 416 was originally intended for students in the first place. Since computing will still be used in Physics 416, this ordering, plus the requirement of CSE 202, will give each student two formal programming experiences by the end of their second year. This will enable instructors of the upper division courses to integrate complex computer programming examples into their curriculum, without having to spend valuable time teaching programming techniques as well.

Impact of the Changes

Looking at graduates of the ASC Physics Major program for the years 2006 through 2007, which includes approximately 70 students, we determined that approximately 70% had taken CSE 202 or an equivalent course. As a result, the addition of CSE 202 as a required course would on average impact approximately 30% of our ASC physics majors.

The ASC Physics Majors choose among 6 different options when planning their major program: A:Advanced, B:General Sciences, C:Biophysics, D:Pre-med, E:Secondary Education, and F:Personalized. The total minimum number of hours to graduation remains at 181 credit hours for our students, even with this change. A sample curriculum for the Advanced Physics Major option A is attached as an appendix to this document.

Finally, an important result of both the CSE 202 requirement, as well as the prerequisite modifications, will be the impact on student readiness for research. If the proposed changes are approved, ALL of our ASC Physics majors will have two significant classroom computing experiences prior to the summer of their second year. Conversations with many faculty in the Physics department indicate that students who are already prepared with computing skills are at a significant advantage when they seek research employment with physics faculty. Research experience is a significant contributor to any physics student's success, whether they intend to seek employment immediately after graduation, or if they intend to go on to graduate work in physics. These changes will make students more attractive candidates for research positions.

Process/Recommendation

The changes were discussed in a series of Physics undergraduate studies meetings, through the spring and fall of 2007. The committee formally voted on the changes on January 8th, 2008, and unanimously approved them. A presentation of the proposed changes was made to the full faculty on January 24th, 2008, and approved at that meeting as well.

The changes were also discussed extensively with a broad collection of undergraduates at a Society of Physics Students (SPS) meeting on September 25th, 2007. The purpose of this meeting was to discuss the possible computing requirement as well as solicit student comments. The response was overwhelmingly favorable. In addition, a smaller meeting involving just the leadership officers of both SPS and Sigma Pi Sigma (the national honor society of Physics students) was held to discuss the changes. This group of 6 students was also very supportive of these changes. Finally, we should note that there are 3 student representatives on the Undergraduate Studies committee (only one of whom is in the previously mentioned leadership group), and they expressed strong support for these changes as well.

This addition of CSE 202 as a requirement has been discussed with the Chair of CSE, Prof Bruce Weide, and he has indicated that the additional students should not pose any problem from a staffing perspective. A copy of the letter of concurrence from CSE is attached to this proposal.

SAMPLE FOUR-YEAR PROGRAM

Bachelors of Science – Physics – Option A

The Physics Department offers 6 options to complete a Bachelors of Science in Physics. Option A is the program designed for those interested in pursuing graduate study in Physics. All other options require less Physics but may have specific other technical electives. Please consult the on-line handbook for details.

YR	AUTUMN	WINTER	SPRING
1	MATH 151 (5 hrs) Calculus and Analytical Geometry I PHYS 131 (5hrs) Intro. Physics; Particles and Motion GEC	MATH 152 (5 hrs) Calculus and Analytical Geometry II PHYS 132 (5hrs) Intro. Physics; Elec. and Magnetism GEC	MATH 153 (5 hrs) Calculus and Analytical Geometry III PHYS 133 (5hrs) Intro. Physics; Waves and Quantum CSE 202 (Proposed)
2	MATH 254 (5 hrs) Calculus and Analytical Geometry IV PHYS 261 (4 hrs) Dynamics of Particles and Waves, I PHYS 295 (1 hr) Undergraduate Seminar GEC	MATH 415 (4 hrs) Ordinary and Partial Differential Equations PHYS 262 (4 hrs) Dynamics of Particles and Waves, II GEC GEC	MATH 568 (3 hrs) Introductory Linear Algebra PHYS 263 (4 hrs) Dynamics of Particles and Waves, III PHYS 416 (4 hrs) Meth. Of Exper. Phys GEC
3	PHYS 555 (4 hrs) Fields and Waves I PHYS 631 (4 hrs) Intro. to Quantum Mechanics I MATH 513 (3 hrs) Vector Analysis GEC	PHYS 656 (4 hrs) Fields and Waves II PHYS 632 (4 hrs) Intro. to Quantum Mechanics II GEC	PHYS 657 (4 hrs) Fields and Waves III PHYS 633 (4 hrs) Intro. to Quantum Mechanics III PHYS 517 (4 hrs) Intro. Electronics GEC
4	PHYS 621 (4 hrs) Statistical Physics I PHYS 596 (3 hrs) Senior Seminar, Writing and Speaking GEC	PHYS 622 (4 hrs) Statistical Physics II PHYS 616 (4 hrs) Advanced Physics Lab GEC	PHYS 664 (4 hrs) Theoretical Mechanics GEC GEC

*A minimum of 191 total hours is required for graduation in the College of Arts and Sciences. The sample program above illustrates the physics and math courses. The remaining hours are comprised of courses chosen to complete the General Education Curriculum (GEC) of the College. The number of hours in the core program, GEC, and remaining free electives are indicated below the sample curriculum.

COURSES IN RED ONLY OFFERED ONCE PER YEAR

Credit Hrs in Core Courses	113
Credit Hrs in GEC	65
Free Electives	3
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Total Hours in Program	181