

Memo

TO: Undergraduate Programs Committee, Charles E. Schmidt College of Science

FROM: Christopher Beetle, Chair, Curriculum Committee, Department of Physics

DATE: March 21, 2012

SUBJECT: Revisions to Undergraduate Physics Programs

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This memo concerns a proposal from the Department of Physics to make several changes to its undergraduate programs. This proposal would change both individual courses and programs as a whole. The accompanying forms detail the course changes. This memo focuses on the overall picture and the proposed changes to programs.

It has become clear over the past few years that our current programs, which were revised extensively roughly five years ago, can be improved in several ways. The specific objectives of the following proposal are to

- (a) eliminate redundancies in course content,
- (b) ease incoming transfer students' transition from the State College system,
- (c) offer more upper-division elective credits to undergraduate majors,
- (d) promote earlier and deeper engagement of undergraduate majors in research, and
- (e) offer majors more professional skills training for careers inside or outside academia.

The proposal comprises six specific measures, which are listed below.

The main focus of this proposal is the Bachelor of Science with Major in Physics (**BSP**) degree program. However, the proposed changes will also affect the Bachelor of Arts with Major in Physics (**BAP**), the Minor in Physics (**MP**), and the Bachelor of Arts in Education with Major in Physics Education (**BAE**) programs. The last of these is offered by the Department of Teaching and Learning within the College of Education. An accompanying memo from that Department indicates their support of this proposal.

The specific measures we propose are as follows:

1. Replace the advanced mathematics requirement of Matrix Theory (MAS 2103, 3 ϕ ¹) for BSP and BAP candidates with the student's choice of either Differential Equations I (MAP 2302, 3 ϕ) or Engineering Math I (MAP 3305, 3 ϕ). Extend this requirement to students in the MP program as well. Recommend the same change to the BAE program. Change prerequisites as needed on all undergraduate physics courses to reflect this.

¹ The ϕ symbol denotes one credit-hour throughout this memo.

Most other universities in the Florida system require Differential Equations rather than Matrix Theory. This change will therefore ease the transition for students transferring either to or from FAU.

Extending this mathematics requirement to all four degree programs will enable us to set prerequisites for our upper-division courses more consistently. Despite the addition of this math course, there will be no net increase in total credits required for MP and BAE students due to the elimination of General Physics III under proposal (2) below. In fact, the substitution yields a net loss of one required, lower-division credit in both programs. In addition, students in the MP generally have taken a Differential Equations course because they typically major in Mathematics or another science that requires that material. The suggested change to the BAE program will therefore require students in that program to be prepared similarly to all other students in their upper-division physics courses.

Finally, from an overall, curricular viewpoint, the Differential Equations course will make up part of the material that was intended to be covered in General Physics III. The remainder can be covered adequately in Survey of Modern Physics. This is discussed in more detail in connection with the second proposed measure that follows.

2. Combine General Physics III (PHZ 2106, 4c) and Survey of Modern Physics (PHY 3101C, 4c) in a single, 4-credit, upper-division course.

Both of these courses currently focus on topics in modern physics, albeit at different levels of mathematical sophistication. In principle, General Physics III was intended to offer a more heuristic approach, together with a lower-division introduction to more sophisticated mathematical modeling. It was meant to offer a bridge from lower-division work in General Physics I and II to the level of sophistication required in Classical Mechanics and Electromagnetism in the upper division. In practice, however, General Physics III has overlapped much more strongly with Survey of Modern Physics than originally planned. More importantly, no other university in the Florida system requires, or even offers, a course comparable to General Physics III at this time. While this certainly could be perceived as a strength of our current programs, it has presented a difficulty for incoming transfer students, particularly those from the State College system, whose entry to upper-division work can be delayed by the need to take General Physics III. In the end, the Department considers the cost of combining these courses to be small compared to the benefit.

Combining these courses will have only a minor impact on the set of topics to which students can be exposed in our programs. The modern physics topics will be covered in Survey of Modern Physics, which already is a required course in all four programs listed above, and the mathematical modeling will be covered by switching the emphasis of the advanced mathematics requirement from matrices to differential equations. Meanwhile, this change will ease logistical problems for all of our majors.

General Physics III is currently a required course in all four degree programs listed above, so this proposal will result in a reduction of four required lower-division credits in each. For MP and BAE students, three of these will be replaced by requiring Differential Equations under proposal (1) above. For BSP and BAP students, all four of these lower-division credits will be replaced by newly required upper-division courses under proposals (4) and (5) below.

3. Require BSP students to complete 6 credits of approved elective courses in physics at the upper-division level or higher. Eliminate Statistical Physics (PHY 4523, 3c) and Quantum Mechanics II (PHY 4605, 3c) as required courses in the current program to accommodate this change.

It has become increasingly clear that our undergraduate majors would value having more flexibility in their curricula. They also have requested greater availability of elective courses on advanced topics of interest to them, such as relativity theory and biological physics.

This proposal aims to satisfy both of these requests. Parts of the material currently covered in Statistical Physics (PHY 4523, 3 ϕ) and Quantum Mechanics II (PHY 4605, 3 ϕ) will be incorporated in courses that continue to be required for BSP candidates under this proposal. The remainder of the material will continue to be available to interested students in elective courses. Meanwhile, existing elective courses on other topics can be offered more often than they are currently, depending on student demand.

For compatibility with the curricula at other State Universities, and in light of the guaranteed transferability of undergraduate credits in the Statewide Course Numbering System, it will be necessary to change the titles of a couple courses, as well as their numbers, as a result of this proposed measure. Roughly speaking, what currently is called Thermodynamics (PHY 3503, 4 ϕ) will be replaced by Thermal and Statistical Physics (PHY 3523, 4 ϕ), and will include more statistical physics than it currently does. What currently is called Statistical Physics (4523, 3 ϕ) will be replaced by Condensed Matter Physics (PHZ 4400, 3 ϕ), which will be offered as an elective. The slight change of content associated with a single course number (PHY x523) is necessary to remain compatible with the intent of the Statewide Course Numbering System. The change of numbering, and the corresponding broadening of course content will affect students in programs other than the BSP only indirectly. However, the content change is entirely reasonable in all cases, and students in all other programs will continue to have encountered all relevant prerequisite material in their programs.

4. Introduce a sequence of four 1-credit Undergraduate Seminar (PHY 3930, 3931, 4932 and 4933, 1 ϕ each) courses. Require BSP candidates to take each, for a total of four credits.

New course proposals describing these courses are included in this package. The syllabi cover diverse topics, including (a) an introduction to research currently going on in the Department of Physics, (b) practice preparing applications for undergraduate research internships and/or graduate schools, (c) practice in scientific writing and presentation techniques, and (d) an introduction to various methods of scientific computing. In the last case, the specific content will rotate from year to year between Maple/Mathematica, MatLab, and numerical methods in C or Fortran, depending on the expertise of the instructor and the needs of the students. The courses PHY 3930 and PHY 4932 will meet together in the Fall, as will PHY 3931 and PHY 4933 in the Spring, with third- and fourth- year students sharing a classroom. Syllabi for the fourth-year courses (PHY 4932 and 4933) will include an additional requirement to collaborate with and assist junior students on in-class assignments.

The rationale for offering these courses is threefold. First, they offer a formal environment in which to introduce undergraduate physics majors to ongoing research within the Department. The main objective of this measure is to foster greater undergraduate participation in that research. Second, the courses will offer some genuine coaching in various professional skills (writing, speaking, scientific computing, and professional development) that have proved difficult to emphasize in our lecture-based courses. Third, by uniting third- and fourth-year undergraduate majors in a classroom, the Department hopes to foster a greater sense of community among our students and to forge mentor-mentee bonds between junior- and senior-level students.

This addition will directly affect only students in the BSP program. They will be expected to take one of these seminar courses during each of the four semesters they typically will be enrolled in upper-division courses at FAU. The Department will establish contingencies to waive these requirements in

rare cases, for example, of transferring students who might spend less than four full semesters doing upper-division work at FAU. Students in other programs will of course be welcome to take these courses, but they will not satisfy physics elective requirements in those programs.

5. Require students in the BAP program to take Thermal and Statistical Physics (PHY 3523, 4 ϕ) and Quantum Mechanics I (PHY 4604, 4 ϕ). Eliminate the current requirement of eight credits of electives from an approved list.

The current approved list of electives includes Quantum Mechanics I (PHY 4604, 4 ϕ), Thermodynamics (PHY 3503, 4 ϕ), and Statistical Mechanics (PHY 4523, 3 ϕ). The inclusion of the last of these seems to be an error. It has the preceding course as a prerequisite. Removing it from the approved list leaves only two approved courses for two required elective slots. So this measure is really just tidying up the catalog entry.

6. Remove Physical Electronics (PHY 3722, 4 ϕ) from the list of approved electives for the MP program.

Physical Electronics is a laboratory course that complements theoretical work done in other courses. Minors in Physics are only required to take one 4-credit elective course, and the Department feels it is important that these credits should come in one of the theory courses.

Tables 1 through 6 on the following pages summarize the overall effects of the above measures on the degree programs offered by the Department of Physics and by the Department of Teaching and Learning in conjunction with the Department of Physics. In total, the lower-division requirements BSP and BAP programs are reduced by 4 credits, and their upper-division requirements are increased by 4 credits. Meanwhile, the lower-division requirements of the MP and BAE programs are reduced by 1 credit, while their upper-division requirements are unchanged. The total body of material covered in each program will remain substantially the same.

I will be happy to answer any questions or concerns regarding this proposal. My contact information can be found on the first page of this memo. Thank you for your time and attention.

Sincerely,

Christopher Beetle
Chair, Curriculum Committee
Department of Physics

Course Information		Current Programs				Revised Programs			
Title	Credits	BSP	BAP	MP	BAE	BSP	BAP	MP	BAE
Chemistry or Biology I & II with Labs (CHM 2045+L & 2046+L) or (BSC 1010+L & 1011+L)	8	✓	✓	✓	✓	✓	✓	✓	✓
Calculus I, II & III (MAC 2311, 2312 & 2313) or (MAC 2281, 2282 & 2313)	12	✓	✓	✓	✓	✓	✓	✓	✓
Differential Eq. (MAP 2301 or 3305)	3					✓	✓	✓	✓
Matrix Theory (MAS 2103)	3	✓	✓						
General Physics I & II with Labs (PHY 2048+L & 2049+L)	10	✓	✓	✓	✓	✓	✓	✓	✓
General Physics III (PHZ 2106)	4	✓	✓	✓	✓				
Modern Physics (PHY 3101C)	4	✓	✓	✓	✓	✓	✓	✓	✓
Classical Mechanics (PHY 3221)	4	✓	✓	E	E	✓	✓	E	E
Electromagnetism I (PHY 3323)	4	✓	✓	E	✓	✓	✓	E	✓
Electromagnetism II (PHY 3324)	3	✓				✓			
Thermodynamics (PHY 3503)	4	✓	E		E				
Thermal and Stat. Phys. (PHY 3523)	4					✓	✓		E
Statistical Mechanics (PHY 4523)	3	✓	E						
Quantum Mechanics I (PHY 4604)	4	✓	✓	E	E	✓	✓	E	E
Quantum Mechanics II (PHY 4605)	3	✓							
Physical Electronics (PHY 3722C)	4	✓	E	E	✓	✓	✓		✓
Undergraduate Lab (PHY 4811L)	2	✓				✓			
Undergraduate Seminars (PHY x93y)	4					✓			
Mathematical Methods (PHZ 3113)	3	✓				✓			
Physics Electives (various)	(various)	—	4¢	4¢	8¢	6¢	—	4¢	8¢
Total Credits	lower	37	37	34	34	33	33	33	33
	upper	38	20	8	20	42	24	8	20

Table 1: Summary comparison of the current and proposed physics curricula. Check marks (✓) indicate required courses. When a program requires one or more electives to be taken from a stipulated list, those courses are marked with an (E) in this table. These introductory, lower-division courses are required for students in all physics degree programs (BSP, BAP, MP, and BAE). Eliminating General Physics III (PHZ 2106, 4¢) permits the introduction of a differential equations course common to all programs.

Current Physics Core	Proposed Physics Core
General Physics I with Lab (PHY 2048+L, 5¢)	General Physics I with Lab (PHY 2048+L, 5¢)
General Physics II with Lab (PHY 2049+L, 5¢)	General Physics II with Lab (PHY 2049+L, 5¢)
General Physics III (PHZ 2106, 4¢)	
Calculus and Analytic Geometry I (MAC 2311, 4¢) or Calculus for Engineers I (MAC 2281, 4¢)	Calculus and Analytic Geometry I (MAC 2311, 4¢) or Calculus for Engineers I (MAC 2281, 4¢)
Calculus and Analytic Geometry II (MAC 2312, 4¢) or Calculus for Engineers II (MAC 2282, 4¢)	Calculus and Analytic Geometry II (MAC 2312, 4¢) or Calculus for Engineers II (MAC 2282, 4¢)
Calculus and Analytic Geometry III (MAC 2313, 4¢)	Calculus and Analytic Geometry III (MAC 2313, 4¢)
	Differential Equations I (MAP 2301, 3¢) or Engineering Math I (MAP 3305, 3¢)
Either General Chemistry I w/ Lab (CHM 2045+L, 4¢) and General Chemistry II w/ Lab (CHM 2046+L, 4¢) Or Biological Principles w/ Lab (BSC 1010+L, 4¢) and Biodiversity w/ Lab (BSC 1011+L, 4¢)	Either General Chemistry I w/ Lab (CHM 2045+L, 4¢) and General Chemistry II w/ Lab (CHM 2046+L, 4¢) Or Biological Principles w/ Lab (BSC 1010+L, 4¢) and Biodiversity w/ Lab (BSC 1011+L, 4¢)
34 lower-division credits	33 lower-division credits

Table 2: Comparison of the current and proposed *Physics Core* curricula. These introductory, lower-division courses are required for students in all physics degree programs (BSP, BAP, MP, and BAE). Eliminating General Physics III (PHZ 2106, 4¢) permits the introduction of a differential equations course common to all programs.

Current BS in Physics	Proposed BS in Physics
Matrix Theory (MAS 2013, 3¢)	(see Physics Core)
Survey of Modern Physics (PHY 3101C, 4¢)	Survey of Modern Physics (PHY 3101C, 4¢)
Classical Mechanics (PHY 3221, 4¢)	Classical Mechanics (PHY 3221, 4¢)
Electromagnetism I (PHY 3323, 4¢)	Electromagnetism I (PHY 3323, 4¢)
Electromagnetism II (PHY 3324, 3¢)	Electromagnetism II (PHY 3324, 3¢)
Thermodynamics (PHY 3503, 4¢)	Thermal and Statistical Physics (PHY 3523, 4¢)
Statistical Physics (PHY 4523, 3¢)	
Quantum Mechanics I (PHY 4604, 4¢)	Quantum Mechanics I (PHY 4604, 4¢)
Quantum Mechanics II (PHY 4605, 3¢)	
Physical Electronics (PHY 3722C, 4¢)	Physical Electronics (PHY 3722C, 4¢)
Undergraduate Laboratory (PHY 4811L, 2¢)	Undergraduate Laboratory (PHY 4811L, 2¢)
	Undergraduate Seminar I (PHY 3930, 1¢)
	Undergraduate Seminar II (PHY 3931, 1¢)
	Undergraduate Seminar III (PHY 4932, 1¢)
	Undergraduate Seminar IV (PHY 4933, 1¢)
Mathematical Methods for Physics (PHZ 3113, 3¢)	Mathematical Methods for Physics (PHZ 3113, 3¢)
	Two elective courses approved by the Department. (6¢)
3 lower-division, 38 upper-division credits ⇒ 75 total	42 upper-division credits ⇒ 75 total

Table 3: Comparison of the current and proposed *Bachelor of Science with Major in Physics* curricula. The lower-division math course is now part of the Physics Core. This makes room for the Undergraduate Seminar courses. The Department will continue to offer both Quantum Mechanics II (PHY 4605, 3¢) and a second-semester statistical physics course as electives, alongside other options, subject to student demand.

Current BA in Physics	Proposed BA in Physics
Matrix Theory (MAS 2013, 3¢)	(see Physics Core)
Survey of Modern Physics (PHY 3101C, 4¢)	Survey of Modern Physics (PHY 3101C, 4¢)
Classical Mechanics (PHY 3221, 4¢)	Classical Mechanics (PHY 3221, 4¢)
Electromagnetism I (PHY 3323, 4¢)	Electromagnetism I (PHY 3323, 4¢)
Quantum Mechanics I (PHY 4604, 4¢)	Quantum Mechanics I (PHY 4604, 4¢)
	Thermal and Statistical Physics (PHY 3523, 4¢)
	Physical Electronics (PHY 3722C, 4¢)
One elective among the following courses: (4¢) Thermodynamics (PHY 3503, 4¢) Statistical Mechanics (PHY 4523, 3¢) Physical Electronics (PHY 3722C, 4¢)	
3 lower-division, 20 upper-division credits ⇒ 57 total	24 upper-division credits ⇒ 57 total

Table 4: Comparison of the current and proposed *Bachelor of Arts with Major in Physics* curricula. The lower-division math course is now part of the Physics Core. This makes room for a second elective. However, Statistical Mechanics (PHY 4523, 3¢) appears erroneously in the current list. Eliminating it from that list effectively makes the other two courses required.

Current Minor in Physics	Proposed Minor in Physics
Survey of Modern Physics (PHY 3101C, 4¢)	Survey of Modern Physics (PHY 3101C, 4¢)
One elective among the following courses: (4¢) Classical Mechanics (PHY 3221, 4¢) Electromagnetism I (PHY 3323, 4¢) Thermodynamics (PHY 3503, 4¢) Physical Electronics (PHY 3722C, 4¢) Quantum Mechanics I (PHY 4604, 4¢)	One elective among the following courses: (4¢) Classical Mechanics (PHY 3221, 4¢) Electromagnetism I (PHY 3323, 4¢) Thermal and Statistical Physics (PHY 3523, 4¢) Physical Electronics (PHY 3722C, 4¢) Quantum Mechanics I (PHY 4604, 4¢)
8 upper-division credits ⇒ 42 total	8 upper-division credits ⇒ 41 total

Table 5: Comparison of the current and proposed *Minor in Physics* curricula. The only changes are the requirement of an additional introductory math course as part of the Physics Core and the name and number change of one of the elective courses.

Current BAE in Physics Education	Proposed BAE in Physics Education
Survey of Modern Physics (PHY 3101C, 4¢)	Survey of Modern Physics (PHY 3101C, 4¢)
Electromagnetism I (PHY 3323, 4¢)	Electromagnetism I (PHY 3323, 4¢)
Physical Electronics (PHY 3101C, 4¢)	Physical Electronics (PHY 3101C, 4¢)
Two electives among the following courses: (8¢) Classical Mechanics (PHY 3221, 4¢) Thermodynamics (PHY 3503, 4¢) Quantum Mechanics I (PHY 4604, 4¢)	Two electives among the following courses: (8¢) Classical Mechanics (PHY 3221, 4¢) Thermal and Statistical Physics (PHY 3523, 4¢) Quantum Mechanics I (PHY 4604, 4¢)
20 upper-division credits ⇒ 54 total	20 upper-division credits ⇒ 53 total

Table 6: Comparison of the current and proposed *Bachelor of Arts in Education with Major in Physics Education* curricula. The only changes are the requirement of an additional introductory math course as part of the Physics Core and the name and number change of one of the elective courses.