

Report by the Physics and Engineering review committee on how to improve introductory physics classes for Scientists and Engineers.

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Success in Engineering is strongly based upon a high level of proficiency in both physics and mathematics. The College of Engineering and the College of Liberal Arts and Sciences science majors need an excellent program in introductory physics. At present there are problems that need to be addressed. The faculty of the Physics department and the College of Engineering formed the present committee to address these problems. Two of us teach the introductory 300 level Physics classes, and two of us are from the College of Engineering.

Our committee suggests a major change in the introductory 300-level Physics sequence.

The situation is as follows. The Physics department currently has two introductory Physics classes for scientists and engineers which are calculus based, which is a national standard for these majors. Currently these classes are Phys 313 and Phys 314, which are taken in sequence. The first class is supposed to cover vectors, motion, mechanics, rotation, oscillations, waves and thermodynamics; the second semester class should cover electricity, magnetism, basic circuits, E-M waves, and light. Currently in both of these classes faculty are unable to cover all of these topics, particularly in Phys 313. This problem comes from two sources. First, although some of the students are well prepared to be able to handle the mathematics from the beginning of the semester, many students are not. Second, while some students are able to go at a high speed during the semester, many more students cannot handle this volume of material in a single semester. Because of this about 33% of the Phys 313 students drop out. At the same time advanced students are frustrated that the instructor has to go very slowly for the poorly prepared students.

In summary, the main issue is that the Physics Department is not servicing all of the different levels in preparation for our enrolled students. In addition, we are not covering the curriculum these classes are assigned. If we are able to find a way to deal with this we will do much better in educating our students and getting more of them into the next stage in their engineering or science degrees.

We propose that the Physics 313 and 314 classes be reorganized. Currently each class is 4 credit hours, with an additional, separate, 1 credit hour associated lab (Physics 315 and 316.) The proposed new sequence would be three classes: Physics 303, 304 and 405, of 3 credit hours each. Physics 315 and 316 would remain as they are. At the same time to service the well prepared students who can handle the higher rate and are better prepared in mathematics, we would keep one section of either Phys 313 or 314 each semester. These students would be expected to take the associated labs, making a five credit hour

package. Students will need to pass a placement exam to take this two course sequence instead of the three course sequence. The topics to be covered in these five classes are outlined in tables 1 and 2.

What this plan accomplishes is that we separate the students who are weak and need more time to learn and spread the topics over three semesters. The material covered per credit hour remains almost the same and the one extra credit hour in the three course version of this sequence is to help these students catch up on their preparation. Some advanced students may find that a five credit hour version of this class is a lot of material to cover in one semester and may therefore also prefer the less compacted sequence. The strongest students will still have the option of taking the Phys 313 and 314 two class sequence in the Fall and Spring semester. This is useful since there will always be students who can find even an advanced subject such as Physics easy. Thus all topics will get covered as they ought to be, in three semesters for the weaker students or those wishing more time, and in two for those who are capable and willing to go at a faster pace. The Physics department had an external review in the Fall 2007 semester and they suggested that the large class sizes in the 300 level physics classes, currently 90 to 100 students, should be reduced if possible; this proposed change will help implement this class size reduction, see comments attached at the end of table 2.

As a historical note we should point out that many state schools in northern states changed their introductory Physics classes to this sequence of three semesters about 15 years ago. Their goal was the same as ours: to help poorly prepared students get up to speed in problem solving and learning the difficult subject more gradually. Spreading the subject matter over more time and semesters has been shown to be very helpful.

Going to the new sequence of introductory Physics classes would cost more by needing additional faculty to cover these extra classes. In table 3 this old physics faculty and new faculty load needs are laid out for comparison. It is a reasonably low request for new personnel although not a zero.

This plan was circulated among the engineering and science departments and was praised by many as a step that would dramatically help. See table 4.

Attached please find the curriculum change forms that would permit us to implement this plan. We ask that this be considered for implementation in Fall 2009, but the extra faculty to cover this load would not be needed until Fall 2010 due to turning on of the new three classes in sequence.

Table 1: Course Content of Physics 313 & 314

Physics 313: 4 Credits			
Physics 313	Topic	Pre 2008	After 2009
1	Measurement	2 days	reading
2	1D motion	4 days	2 day
3	Vectors	2 days	reading
4	2D and 3D motion	4 days	3 days
5	Forces I	4 days	3 days
6	Forces II	4 days	4 days
7	KE, work	4 days	4 days
8	PE, conservation of energy	4 days	4 days
9	cm, linear momentum	4 days	4 days
10	Rotation	4 days	4 days
11	rolling, torque, angular momentum	4 days	4 days
12	equilibrium, elasticity	4 days	4 days
13	Gravity	4 days	3 days
14	Fluids (some faculty skip)	2 days	3 days
15	Oscillations	4 days	3 days
16	waves I	3 days	2 days
17	waves II	2 days	2 days
18	temperature, heat, 1st law	skip	3 days
19	kinetic theory	skip	3 days
20	entropy, 2nd law	skip	3 days
	Totals	59	59

Physics 314: 4 Credits			
Physics 314	Topic	Pre 2008	After 2009
21	electric charge	4 days	3 days
22	electric fields	4 days	3 days
23	Gauss's law	4 days	4 days
24	electric potential	4 days	3 days
25	Capacitance	4 days	2 days
26	current, resistance	3 days	2 days
27	Circuits	4 days	4 days
28	magnetic fields	4 days	3 days
29	currents=> magnetic fields	4 days	2 days
30	Induction	4 days	3 days
31	AC	4 days	4 days
32	Maxwell	2 days	3 days
33	EM waves	4 days	2 days
34	Optics	4 days	4 days
35	Interference	3 days	2 days
36	Diffraction	3 days	2 days
37	Relativity	Skip	3 days
38	photons, matter waves	Skip	4 days
39	matter waves II	Skip	4 days
42	nuclear physics	Skip	2 days
	Totals	59	59

- The column 2009 and after is the material which should be covered in 313 or 314 if we go by the curriculum catalog description which dates from 1960. It is a lot of material and in reality this material has never been covered by the current faculty. The Pre 2008 column represent what was actually done before 2008. Since the

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curriculum catalog description is not correct we either have to change the course description or bring it into agreement, we choose to do the later, but to offer a slower version of the Introductory Physics class (303, 304 and 405) for less prepared students.

- In a semester there are 60 meeting days of which one is for a midterm exam, there is also a 3 hour final exam in addition to these 60 meeting days.

Table 2: Proposed Course Content of New Physics Classes 303, 304, & 405

Physics 303: 3 Credits			Physics 304: 3 Credits			Physics 405: 3 Credits		
Chapter	Topic	What should be Done	Chapter	Topic	What should be Done	Chapter	Topic	What should be Done
1	Measurement	1 days	15	Oscillations	3 days	14	Fluids	3 days
2	1D motion	2 days	16	waves I	2 days	18	temperature, heat, 1st law	3 days
3	Vectors	2 days	17	waves II	2 days	19	kinetic theory	3 days
4	2D and 3D motion	3 days	21	electric charge	3 days	20	entropy, 2nd law	3 days
5	Forces I	3 days	22	electric fields	3 days	33	EM waves	2 days
6	Forces II	4 days	23	Gauss's law	4 days	34	Optics	4 days
7	KE, work	4 days	24	electric potential	3 days	35	Interference	3 days
8	PE, conservation of energy	4 days	25	Capacitance	2 days	36	Diffraction	2 days
9	cm, linear momentum	4 days	26	current, resistance	2 days	37	Relativity	3 days
10	Rotation	4 days	27	Circuits	4 days	38	photons, matter waves	4 days
11	rolling, torque, ang. momentum	4 days	28	magnetic fields	3 days	39	matter waves II	4 days
12	equilibrium, elasticity	4 days	29	currents=> magnetic fields	2 days	42	nuclear physics	3 days
13	Gravity	3 days	30	Induction	3 days	43	Particle physics	3 days
			31	AC	3 days	44	Astrophysics	2 days
			32	Maxwell	3 days			
	Total:	42 days		Total	42 day		Total	42 days

A semester has 45 meeting days, this will leave 2 days free for two exams and one extra day for either contingency due to needing to go slower, an off days due to snow or a day for review before the final. In addition to these 45 meeting days there is a 3 hour final exam.

Additional Information for Table 1 and 2:

- Presently, Physics 313 and 314 classes each have a lab 315 and 316 that are not mandatory. The plan is to have two labs associated with these three classes which are optional.
- We propose that students coming out of 303 could take 304 and 405 concurrently. So 304 will have a pre-requisite of 303 and 405 would have a pre-requisite of 303 and a co-requisite of 304.
- The plan is to keep one section of 313 and 314 in the morning for advanced students, and to make two sections each of the new classes per semester one in the afternoon and one in early evening. This will reduced the class sizes from 90 to 60 students for the first semester and 60 down to 40 students for the 2nd and 3rd semester.
- It should be noted that the number of chapters covered per credit hour is the same but the material is at a slower speed by spreading it over more time, this should help weaker students succeed and allow us to get more engineering degrees out.
- This new set of Introductory Physics classes for engineers and scientists will allow the students to get exposure to advanced topics in Physics such as Quantum Mechanics, this will benefit EE majors.

Table 3: Faculty Load comparison for old and new Physics sequence. The numerical value is fraction of a Physics Professor in a range.

	OLD		NEW	
Physics 111/131/151	0	0.5	0	0.5
Physics 195/196/395	0.75	1	0.75	1
Physics 213/214	2	2	2	2
Physics 210	0.5	0.5	0.5	0.5
Physics 313/315	2	2	0.5	1
		Physics 303/304/405	2.25	2.5
Physics Major Classes	2	2	2	2
Physics 502	1	1	1	1
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Physics Faculty	(8.25	9)
	(9	10.5)

Table 4: Feedback from the Faculty in Engineering and Sciences

Department of Aerospace Engineering

- This is a potentially positive move.

Department of Electrical and Computer Engineering

- This is potentially a positive move.

Department of Mechanical Engineering

- The first course in Physics (303) needs to retain the topics of Temperature and Heat, as that may still remain a prerequisite course to Thermo I.
- The topics of Gravity and Fluid could be moved to the second course (304?), in order to make room for Heat and Temperature, and 304 could be made a prerequisite to Fluid Mechanics. In turn, the topics of Wave I & II could be moved to the third course (405? Mandatory for ME?).

? Reply from Physics: Currently the 313 classes do not get to Temperature, Heat and Thermodynamics this revision will allow the 313 class to do what it is suppose to for advanced students and for slower students they will have to take the 405 class to get Temperature, Heat and Thermodynamics which can be taken right after 303.

Department of Industrial & Manufacturing Engineering

- Concerns expressed regarding issues with transfers from programs with different structure (such as Butler with 4-hr, etc.)

? Reply from Physics. Since one section of 313 and 314 is being preserved for advanced students there is the ability to credit transfer match to that class, but we suggest that these students get a high grade to count and to make sure they cover the topics in 313. Having these new classes will allow student to credit transfer match to 303 if their class did not cover all the necessary topics.

- The IE and MfgE curricula can be modified to accept new Physics structure but depends on how other engineering depts. deal with prerequisites (AE 223, ECE 282, & ME 398).

Department of Biology

- The modifications and added options seem to be a cogent and effective means to remedy the challenges [in introductory Physics] outlined in the report.