

Majors curriculum reform – why bother?

Intellectual Goals, relevant for all students – appreciate/understand/acquire:

- Physics as a *living* subject, including *current* frontiers & open questions
- Broadly applicable concepts & connections between different subfields
- Facility with physical reasoning, order-of-magnitude estimates and quantitative results
- Key phenomena/ideas, for example

<i>atomic structure</i>	<i>semiconductors & transistors</i>	<i>stability of matter</i>
<i>CMB</i>	<i>constituents of matter</i>	<i>symmetries & symmetry breaking</i>
<i>statistical errors</i>	<i>perturbations of orbits & atoms</i>	<i>oscillators/resonances/quasiparticles</i>

Structural goals:

- Make efficient use of resources while enhancing breadth of curriculum.
- Retain flexible program, accommodating students with diverse backgrounds and varied career goals.

Concerns and Challenges I:

- Current 100, 200, and 300-level courses incorporate relatively little physics < 80 years old
- Only rather small fraction of majors take 400-level classes -
65% do not take any of 421, 422, 423, or 424*
25% do not take 400 level labs
- Too few majors are exposed to -

condensed matter physics	15 % take 423
stat. mech.	25% take 328)
astro/cosmology	20 % take 311
particle/nuclear physics	15 % take 422
EM radiation	60 % take 323
hydrogen atom QM	55% take 325
- Few students take recommended sequence of courses:
34% of degrees are awarded within 4 quarters of 228

* Out of 360 BS degrees 1997 to 2005 who passed 228 at UW

Concerns and Challenges II:

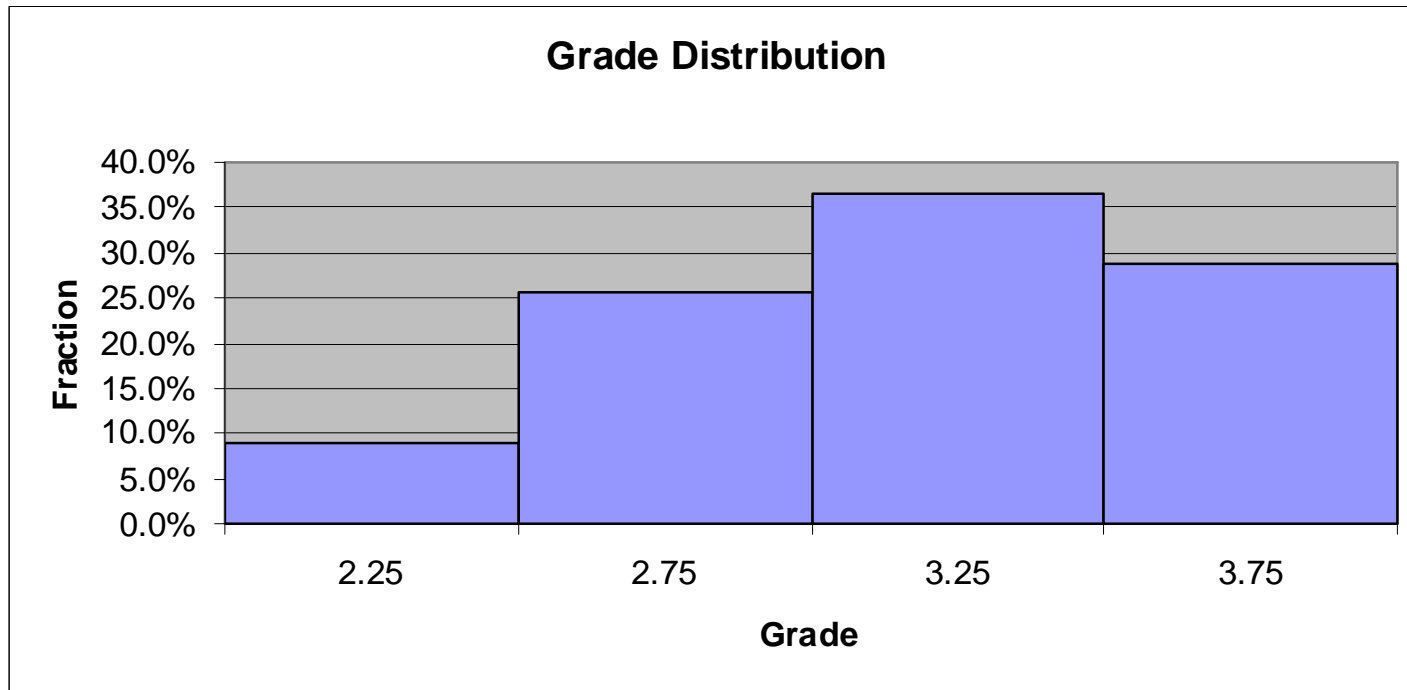
- Not enough emphasis on back-of-the envelope estimates
- Students see very little about current or upcoming experiments
- 12x sequence has little modern physics & basic thermo
Many other universities offer introductory physics with coverage closer to our 11x than our 12x sequence
- Is it a virtue to have the easiest B.S. program of any physical science?

Our GPA requirement is 2.0 in core courses for graduation
Chemistry requires 2.8

We require 2.0 GPA for admission
Mechanical Eng requires 2.5

Students can avoid taking any 400 level courses (except the capstone seminar), about 1/3 take the absolute minimum time

Average Grade Distributions for Phys 321, 322, 315/324, 334 (BS 1997-2005)



⇒ If raise GPA cut to 2.5, lose ~ 10% of students

Proposed core curriculum

	Autumn	Winter	Spring
Yr 2	Math Methods I Statistical Phys Electronics Lab	Math Methods II Quantum Dynamics I Experimental Physics I Intro Comput Phys	Classical Dynamics Particles & Symmetries Experimental Physics II
Yr 3	Electromagnetism Quantum Dynamics II	Kinetics & Early Universe Quantum Dynamics III	Macroscopic E&M Condensed Matter Optics Lab

- “Top-down” design from 3rd year:
less duplication - agreed (and acted upon) syllabi
coverage in first year of basic thermal physics, relativity, and quantum concepts
- Where feasible greater emphasis on applications of basic formalism, especially applications to current (or near current) research topics

“New” in Second Year

- **Mathematical Methods I & II and Classical Dynamics** (This year's 227/228/229) Maxwell's equations, electrostatics already part of 228
- **Statistical Physics** - Mix of current 224 and 328. Do in 2nd year, to allow condensed matter & early universe applications in 3rd year (assumes ≈ 3 weeks of intro physics devoted to thermal physics)
- **Quantum Dynamics I** - First part of multi-quarter quantum sequence focusing on basic principles and fundamental applications (similar to Feynman vol. III, or current 315)
- **Particles & Symmetries** - Introduce constituents of matter & interactions, with major emphasis on discussing recent and proposed experiments, understanding symmetries, scattering cross-sections and rates, order-of-magnitude estimates. Assumes intro physics includes basic relativity.
- **Experimental Physics I & II** - An adjunct to the main second year classes. Students do a couple of experiments per quarter, on phenomena related to quantum & classical dynamics, gain experience with proper data analysis and write-ups.

“New” in Third Year

- **Electromagnetism** - Vacuum E&M including radiation, covariant formulation. Assumes prior exposure to Maxwell's equations (228) and basic relativity in Intro Phys and Particles & Symmetries.
- **Quantum II & III** - Essential QM techniques and applications. Roughly one quarter of exactly soluble systems (hydrogen, coupled spins, periodic potentials), and one quarter of approximation techniques and applications (perturbation theory, variational principle, WKB) plus decoherence and measurement.
- **Kinetics and Early Universe** - Introduce kinetics and apply statistical physics to explore physics of the early universe. Illustrate basic principles in action, discuss equilibration, relevant time scales, phase transitions, departures from equilibrium, relic signatures.
- **Macroscopic E&M** - Focus on material properties (dielectric, magnetic, optical), frequency dependent response. Introduce some more modern applications (left handed materials, optical fibers, non-linear optics).
- **Condensed Matter Physics** - Introduce major principles, including elementary excitations and symmetry breaking. Discuss electron dynamics and transport, semiconductors, quantum Hall effect, etc. Similar to 423, but moved into 3rd year as core course.

Comparison I

Current Course

Content moves to:

224 (Thermal Physics)	Split between 1 st year and new 2 nd year Stat Phys
225 (Modern Physics)	Basic concepts in 1 st year. Replaced by Quantum I and Particles & Symmetries in 2 nd year
227/228 (Elem Math Phys)	<i>No Significant Change</i>
229 (Classical Dynamics)	<i>No Significant Change</i>
231 (Intro Expt Phys)	Experimental Phys I & II, experiments linked to proposed 2 nd year courses
232 (Intro Comput Phys)	<i>No Change</i>

Comparison II

<u>Current Course</u>	<u>Content moves to:</u>
311 (Relativity & Cosmo)	Basic SR in 1 st year, further application in Particles & Symmetries and E&M. Replace with 400 level Rel & Grav
315 (Appl of Mod Phys)	Replace with 2 nd year Quantum I
321/322/323 (E&M)	Replace with E&M and Macroscopic E&M (2 qtrs total). Maxwell's eq'ns and basic electrostatics in Math Methods II
324/325 (QM)	Replace with Quantum II & III, following Quantum I
328 (Stat Phys)	Split between 2 nd year Stat Phys and 3 rd year Kinetics and CM courses
331 (Optics Lab)	<i>No change</i>
334 (Circuits Lab I)	<i>Update</i> and move to 2 nd year Electronics Lab
335 (Circuits Lab II)	Partially moved into 4 th year Applications of Computers

First Year

- Introductory physics should convey that physics didn't end in 1930 --- spend more time on modern physics. Important for both majors and non-majors.
- Many other institutions teach introductory physics with a broader, more modern selection of material than our current 12x sequence.
- One possibility worth considering is T. Moore's *Six Ideas That Shaped Physics*, which has 6 modules:

Conservation Laws Newtonian Dynamics	Relativity Electromagnetism	Quantum Reality Thermodynamics
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Currently being tried in the honors section. Designed for a highly interactive, non-traditional class format. This particular text may or may not be suitable for wider adoption here --- but it exemplifies a choice of material for introductory physics which we believe is desirable.

- Teach some topics, like circuits and geometric optics, in lab not lecture.
- Cannot assume that most majors go through honors section of 12x. (They don't.)

Fourth Year

- Want broad, interesting set of electives, reflecting both student and faculty interests
- Offerings need to be adapted to changes in 2nd and 3rd year curriculum
- Offerings will obviously be resource-limited
- One set of possibilities was in the distributed proposal:

Modern Physics Lab I Senior Seminar I Atomic & Molecular Appl. of Computers	Modern Physics Lab II Senior Seminar II Biological Phys Relativity & Gravitation	Modern Physics Lab III Senior Seminar III Nucl & Particle/QED Intro String Theory
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but more consideration of various possibilities is needed

Comparison III

<u>Current Course</u>	<u>Content moves to:</u>
421 (Atomic & Molecular)	Slightly updated
422 (Nuclear & Particle)	Replace with QED?
423 (Solid State)	Move to 3 rd year Condensed Matter
424 (Math Phys & Class Mech)	Now in 228/229 (or 505)
431/432/433 (Modern Lab)	<i>No change</i>
434 (Appl. Of Comp)	<i>Update?</i>
436 (Nonlinear Dynamics)	<i>Not currently taught, but?</i>
485/6/7 (Honors Seminar)	<i>No change</i>
494/5/6 (Senior Seminar)	<i>No change</i>

Open questions and issues

- Need to develop plan for revised first year courses, including resource needs
- Need buy-in from Engineering for substantive curricular changes in 12X
- Are multiple offerings of 2nd and 3rd year classes needed?
- Which fourth year classes to offer?
- Required courses for degree?
- Do we need “tracks”/multiple degrees (BA)?
- What students do we lose with changes?

But first, we need to hear *if this faculty is enthusiastic about the envisioned curriculum*

Extra input – Double Hump Score Distribution

