

# Majors Curriculum: Proposal from the Curriculum Committee

Discussion II – Leading to a “Sense of the Body” on an action item to ensure timely progress (curriculum change is a process and not an event):

*It is desirable that an ad hoc committee be formed to implement a set of 200 and 300-level courses based on the draft curriculum presented to the Department by the Curriculum Committee in June 2006, with the committee to be composed primarily of the faculty members likely to teach those courses.*

# Represents buy-in to a number of general assumptions -

- Our undergraduate majors program can and should be improved
- It is important to have an overall vision/curriculum for the program that guides decisions concerning the Undergraduate Majors
- We can agree on a general curriculum relevant to ALL of our majors, with agreed upon content for all courses (at the ~80% level)
- The June 2006 Proposal from the Curriculum Committee is an appropriate template, but specific details may change
- We need to start planning/acting now on multiple fronts so that detailed plans can be approved well before instruction begins

# Concerns from October Discussion:

- The proposed changes to the introductory 12X sequence

3+ informal meetings have discussed possible ways for incorporating thermal and more modern physics in 12X

Not yet a clear consensus on details, but no argument that changes in the 12X curriculum, consistent with the assumptions made in the proposal, are infeasible

A committee charged to recommend specific changes for next year has been created

Conclusion: this is not a showstopper, details need to be worked out

- The lack of an updated set of requirements

Several alternative sets of B.S. requirements based on the proposed curriculum, along with a possible "applied physics" (2nd track) degree, have now been proposed

Possible to require most, but not all, of the `core' 200 and 300-level classes with only modest increase in the total number of credits

Result in line with most other UW science departments

Conclusion: Again not a showstopper; remaining details to be worked out. Note that much of the proposal concerns moving and re-emphasizing content. Few truly new courses. Good opportunity to add 2<sup>nd</sup> track.

# Credit Hour Requirements

- Current Physics – 86 credits
- Chemistry – 91-94 credits
- Biology – 90 credits
- Biochemistry – 106 credits
- Microbiology – 94 credits
- Earth and Space Sciences – 90 credits

# Current 86 credit plan

Math 124,125,126,324 (calculus)	18 credits
Math 308, 318 or Amath 352	3 credits
Phys 121,122,123	15 credits
Phys 224,225 (thermal, modern)	6 credits
Phys 227,228 (math methods)	6 credits
Phys 321,322 (E&M)	8 credits
Phys 334 (circuits)	3 credits
Phys 315 or 324 (QM)	3 credits
Phys 33X or 43X (adv. labs)	6 credits
Phys 40X, 48X or 49X (research or seminar)	3 credits
Physics or related electives	6 credits
Related science electives	9 credits

≥ 2.0 grade in all physics coursework

# 99 Credit BS Option

Math 124,125,126,324 (calculus)	18 credits
Math 308, 318 or Amath 352 (linear algebra)	3 credits
Introductory physics	15 credits
Statistical physics	3 credits
Math methods and classical dynamics	9 credits
Electromagnetism and radiation	4 credits
Quantum I/II/III	12 credits
3 of Particles, Kinetics, MacroEM, CM	9 credits
Intro computational physics	3 credits
Sophomore labs	5 credits
Advanced labs	6 credits
Physics or related science electives	12 credits
(may substitute 3 credits research/seminar/thesis if GPA $\geq$ 3.3)	

$\geq$  2.0 grade in all major coursework

$\geq$  2.2 grade in 227 & 228

$\geq$  2.3 GPA in physics and math

# The Works – 108 credits

Math 124,125,126,324 (calculus)	18 credits
Math 308, 318 or Amath 352 (linear algebra)	3 credits
Introductory physics	15 credits
Statistical physics	3 credits
Math methods and classical dynamics	9 credits
Electromagnetism and radiation	4 credits
Quantum mechanics	12 credits
Particles & symmetries	3 credits
Kinetics and early universe	3 credits
Macroscopic EM and condensed matter	6 credits
Intro computational physics	3 credits
Sophomore labs	5 credits
Advanced labs	6 credits
Physics or related electives	6 credits
Research or seminar	3 credits
Related science	9 credits

# 92 Credit Applied Track

Math 124,125,126,324 (calculus)	18 credits
Math 308, 318 or Amath 352 (linear algebra)	3 credits
Introductory physics	15 credits
Statistical physics	3 credits
Math methods and classical dynamics	9 credits
Electromagnetism and radiation	4 credits
Macroscopic EM	3 credits
Quantum I & II	8 credits
Quantum III	recommended only
Intro computational physics	3 credits
Sophomore labs	5 credits
Appl. of computers	3 credits
Other advanced labs	6 credits
1 of Particles, Kinetics, CM	3 credits
Physics or related science electives	9 credits
(may substitute 3 credits research/seminar/thesis if GPA $\geq$ 3.0)	

$\geq$  2.0 grade in all major coursework

$\geq$  2.2 grade in 227 & 228

$\geq$  2.3 GPA in physics and math

- Is proposed curriculum overly targeted toward physics graduate school bound students?

Not the intent

Learning something about, for example, the early universe, or semiconductors, or constituents of matter, or other areas of "living physics", as an undergraduate, is especially important for physics students who will not be exposed to any of these things in their subsequent careers

Learning about profoundly useful frameworks, such as statistical mechanics, or generally applicable techniques, such as WKB or numerical methods, as important for students pursuing careers involving applications of physics as they are for physics graduate school bound students

Focus is to get the essential material into 200 and 300 level courses

- Will proposed curricular changes and updated major requirements reduce the number of majors?

Fair concern but difficult to predict

Our guess is that perhaps 15% of our weakest current students would choose a different major under the revised curriculum

The revamped curriculum could also increase the appeal of a Physics major for students who are seriously interested in learning science

Increase efforts to attract strong students at the beginning of their university studies via Discovery seminars, and outreach to high schools

The status-quo involves uncertain academic standards and leads to teaching that, by necessity, often targets the gap in double-humped distributions of students

# Possible Time Line: Should Start Now

2006-07	Agree on general plan, recruit volunteers for new courses.
2007-08	Offer one (or more) sections of 121/122/123 sequence designated for physics majors and students interested in a strong background in physics with revised syllabus
	Design and do paperwork for new 200-level courses
2008-09	Offer all sections of 12X with new syllabus
	Offer new 200-level courses
	Design and do paperwork for new 300-level courses
	Determine the correct role for 11X and design new syllabus
2009-10	Offer new 11X and 300-level courses
	Design and do paperwork for new 400-level courses

# We need to proceed NOW!

By calling for a sense of the body on today's specific proposal -

*It is desirable that an ad hoc committee be formed to implement a set of 200 and 300-level courses based on the draft curriculum presented to the Department by the Curriculum Committee in June 2006, with the committee to be composed primarily of the faculty members likely to teach those courses.*

# We are asking for buy-in to -

- Our undergraduate majors program can and should be improved
- It is important to have an overall vision/curriculum for the program that guides decisions concerning the Undergraduate Majors
- We can agree on a general curriculum relevant to ALL of our majors, with agreed upon content for all courses (at the ~80% level)
- The June 2006 Proposal from the Curriculum Committee is an appropriate template, but specific details may change
- We need to start planning/acting now on multiple fronts so that detailed plans can be approved well before instruction begins

A yes vote today implies you buy-in to the points on the previous slide

If the sense of the body is negative, we should determine how to proceed:

- a) Select a different Curriculum Committee
- b) Use the pre-existing committee structure and proceed by small perturbations

# Informational slides from October Meeting

# Recall the Why ?

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 calculations
- Key phenomena/ideas, for example

*atomic structure*    *semiconductors & transistors*    *stability of bulk matter*  
*microwave bkgd*    *constituents of matter*    *symmetries & symmetry breaking*  
*statistical errors*    *perturbations of orbits & atoms*    *oscillators/resonances/quasiparticles*

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:  
35% of degrees are awarded within 4 quarters of 228  
5% do not complete all 4 required 300 level courses

\* Out of 360 BS degrees 1997 to 2005 who passed 228 at UW; assuming  $\pm 5\%$  error bars

# Concerns and Challenges II:

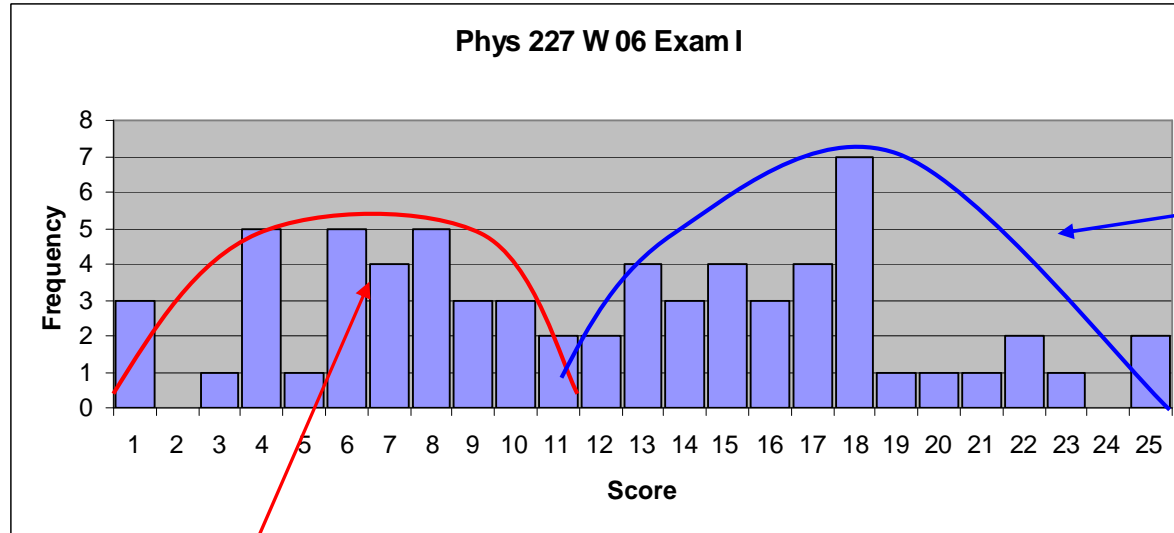
- Not enough emphasis on back-of-the envelope estimates
- Students see very little about current or upcoming experiments
- 12x sequence has little modern physics & basic thermo  
Many other universities offer introductory physics with coverage closer to our 11x than our 12x sequence
- Is it a virtue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

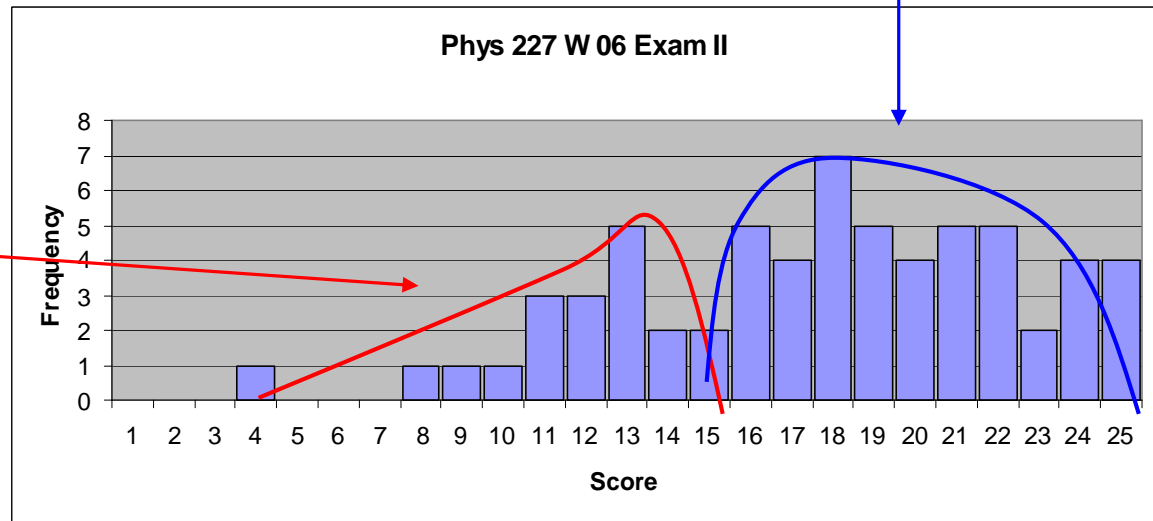
Students can avoid taking any 400 level courses (except the capstone seminar), about 1/3 take the absolute minimum time

# 2<sup>nd</sup> year Classes show – Double Hump Score Distribution

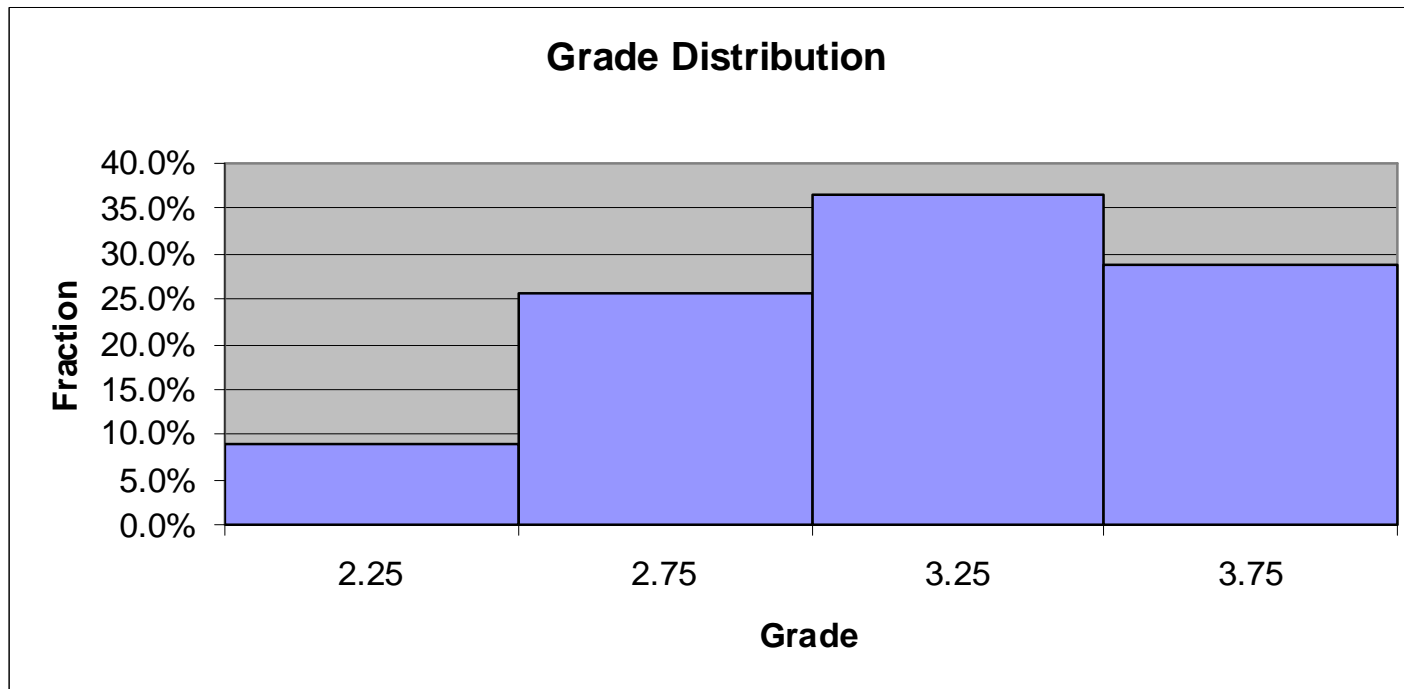


“Natural” Physics Students

Unsuccessful candidates in other programs (?)



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



⇒ If require 2.5 in these courses, lose ~ 10% of students  
If require 2.5 in Phys 228, lose ~ 20% of students

# Proposed core curriculum

	<b>Autumn</b>	<b>Winter</b>	<b>Spring</b>
<b>Yr 2</b>	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
<b>Yr 3</b>	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  $\approx 3$  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 <sup>st</sup> year and new 2 <sup>nd</sup> year Stat Phys
225 (Modern Physics)	Basic concepts in 1 <sup>st</sup> year. Replaced by Quantum I and Particles & Symmetries in 2 <sup>nd</sup> 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 <sup>nd</sup> 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 <sup>st</sup> year, further application in Particles & Symmetries and E&M. Replace with 400 level Rel & Grav
315 (Appl of Mod Phys)	Replace with 2 <sup>nd</sup> 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 <sup>nd</sup> year Stat Phys and 3 <sup>rd</sup> year Kinetics and CM courses
331 (Optics Lab)	<i>No change</i>
334 (Circuits Lab I)	<i>Update</i> and move to 2 <sup>nd</sup> year Electronics Lab
335 (Circuits Lab II)	Partially moved into 4 <sup>th</sup> 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 <sup>rd</sup> 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>

# Other open questions and issues

- Need buy-in from Engineering for substantive curricular changes in 12X
- Are multiple offerings of 2<sup>nd</sup> and 3rd year classes needed?
- Which fourth year classes to offer?

But first, we need to hear *if this faculty is accepts the underlying ideas of the envisioned curriculum*