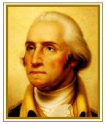
A New Curriculum for
Physics Graduate Students at GW



THE GEORGE WASHINGTON UNIVERSITY
WASHINGTON DC

H. W. Grießhammer

Physics Graduate Advisor
The George Washington University, DC, USA
hgrie@gwu.edu

CNS
Center for Nuclear Studies

1. Navigating a Minefield of Expectations
2. New GW “Two-by-Four” Graduate Curriculum
3. Assessing Students: New Qualifying Exam Format
4. Evaluation and Future: Best Intentions – Where are the Hard Facts??

How to overcome 60 years of stagnation
in teaching PhD students?

No answers; only what seems to work for GW.

Office of Science
U.S. DEPARTMENT OF ENERGY

NSF

1. Navigating a Minefield of Expectations

cf. Joint APS/AAPT Task Force 2006
"Which Way Forward?" Workshop 2008

Great ideas $\Longleftrightarrow$ **No time, money, resources**

US Physics is the best $\Longleftrightarrow$ **US Physics has missed the boat**

1. Navigating a Minefield of Expectations

cf. Joint APS/AAPT Task Force 2006
"Which Way Forward?" Workshop 2008

Great ideas	$\Longleftrightarrow$	**No time, money, resources**
US Physics is the best	$\Longleftrightarrow$	**US Physics has missed the boat**
Mold Future Professors	$\Longleftrightarrow$	**Educate Glorified Engineers**
Formal Knowledge	$\Longleftrightarrow$	**Concepts & Skill-Sets**
Gegenbauer polynomials, Fresnel's rhombus, renormalisation, What I Do Right Now, Fortran		abstraction, "real-world" problem solving, teamwork, present/communicate, management, accounting

1. Navigating a Minefield of Expectations

cf. Joint APS/AAPT Task Force 2006
"Which Way Forward?" Workshop 2008

Great ideas	$\Longleftrightarrow$	**No time, money, resources**
US Physics is the best	$\Longleftrightarrow$	**US Physics has missed the boat**
Mold Future Professors	$\Longleftrightarrow$	**Educate Glorified Engineers**
Formal Knowledge	$\Longleftrightarrow$	**Concepts & Skill-Sets**
Gegenbauer polynomials, Fresnel's rhombus, renormalisation, What I Do Right Now, Fortran		abstraction, "real-world" problem solving, teamwork, present/communicate, management, accounting
Rugged individualism	$\Longleftrightarrow$	**One-size-fits-all**
Sneer at PER	$\Longleftrightarrow$	**Adore PER**
Traditional lectures	$\Longleftrightarrow$	**Fashionable formats**
Adhere to Canon & Exams	$\Longleftrightarrow$	**Hip topics & free-for-all**
Compulsory core	$\Longleftrightarrow$	**Need-to-know learning**

1. Navigating a Minefield of Expectations

cf. Joint APS/AAPT Task Force 2006
"Which Way Forward?" Workshop 2008

Great ideas	$\Longleftrightarrow$	**No time, money, resources**
US Physics is the best	$\Longleftrightarrow$	**US Physics has missed the boat**
Mold Future Professors	$\Longleftrightarrow$	**Educate Glorified Engineers**
Formal Knowledge	$\Longleftrightarrow$	**Concepts & Skill-Sets**
Gegenbauer polynomials, Fresnel's rhombus, renormalisation, What I Do Right Now, Fortran		abstraction, "real-world" problem solving, teamwork, present/communicate, management, accounting
Rugged individualism	$\Longleftrightarrow$	**One-size-fits-all**
Sneer at PER	$\Longleftrightarrow$	**Adore PER**
Traditional lectures	$\Longleftrightarrow$	**Fashionable formats**
Adhere to Canon & Exams	$\Longleftrightarrow$	**Hip topics & free-for-all**
Compulsory core	$\Longleftrightarrow$	**Need-to-know learning**

my score

What Made Us Think:

- Frequent student complaints (overwhelmed, no structure seen,...).
- Imbalance duration $\Longleftrightarrow$ material covered; temporal $\Longleftrightarrow$ logical ordering; initiation-rites.
- **Some courses** offered not/not regularly/only in combination with UGrad/by part-time lecturers.

Goal: ***Emphasise Shift: Formal Knowledge*** $\Longrightarrow$ ***Concepts & Skill-Sets***

- **Strong conviction: Physicists are All-Rounders.** $\Longrightarrow$ Proficiency in all disciplines of Modern Physics.
- **Better & faster prepare for and immerse into research**.

2. New GW "Two-by-Four" Graduate Curriculum

June	**Informal Pre-test Math Skills; support remedial self-study.**			
Sem. 1	**Theoretical Mechanics (4)**	**Computational Physics I (1)**	**Mathematical Methods (4)**	Colloquium
Sem. 2	**Quantum Mechanics I (4)**	**Computational Physics II (1)**	**Electrodynamics & Classical Fields (4)**	Comm. Phys. & Colloquium
Sem. 3	**Quantum Mechanics II (4)**	**Computational Physics III (1)**	**Statistical Physics (4)**	Colloquium
Sem. 4	**Qualifying Exam Prep. Course (3)**		**Astro I or Bio I or Nuclear&Particle I (3)**	Comm. Phys. **(3)** & Colloquium
	May: Qualifying Exam; within 1 year: Proposal Exam; mentoring & annual progress reports			

New Format:

- ***Increase* from 150 min. to 200 min./week in core-course**: More depth, cautious additions.
- ***Decrease* number of parallel core-courses from 3 to 2**: Less "parallel-processing", better focus.
- **Re-distribute teaching resources**: Less courses $\Longrightarrow$ free resources for Advanced Astro/Bio/Nuclear

New Contents: Avoid "One-Book-Courses": loose script, lesson-by-lesson Refs. $\Longrightarrow$ time for discussion

- ***Emphasise* synergies & logical ordering**: e.g. 1st Sem.: Mechanics and Math. Meth. set foundation.
- **Core-curriculum as bridge to research**: Integrate recent developments, dept. research (EDyn, QM II, Stat.).
- **Foster "research skills"**: Abstraction & reduction to essence, independence, team-work, communication.

Implementation Examples:

- **Computational Physics** Integrated with core: 6 weeks intro; then: projects from core courses (reports).
- **Electrodynamics** Jackson as rite-of-passage $\Longrightarrow$ natural stepping-stone: rel. fields, condensed matter.
- New **Math. Methods**; (re-)launch **Astro/Bio/Nuclear**; eliminate **Graduate Lab** (immerse in groups instead).

3. Assessing Students: New Qualifying Exam Format

– **Old Format:**

Four 3-hour sections, 2 per day: “test of stamina” instead of milestone on readiness for research.

No qualitative difference to course final exams; strong correlation with Finals grades.

$\Longrightarrow$ Relatively large administrative effort, given predictable outcome.

Criterion: Basis of informed decision on potential for success in research *at graduate level*:
Committment; problem-solving skills; physical intuition; transfer; grasp of synergies.

Students to perceive test as fair.

– **New Format**: 2 written parts, 4 hours each, 2 days, usually at end of Sem. 4.

Problems from any of the 4 core-subjects, plus problems which integrate different fields.

Preparation Course: emphasises integrated problems, review.

– **PhD Proposal Exam** ≤ 1 year after Qualifying: $\lesssim 20$ pages like grant proposal plus oral presentation.

Annual informal progress reports to committee, continuous mentoring.

4. Evaluation and Future: Best Intentions – Where are the Hard Facts??

Monitoring and Assessing Success

– Very difficult: PER on Graduate Education scarce; small-number game. Scattered information.

Need comprehensive review of contents/skills & agreed standards, quantifiable tests.

End the Era of Anecdotal Evidence!

$\Longrightarrow$ **Ideas?**

Our Criteria: no bean counting

Time to PhD; reduced attrition; quicker placement in research groups, sooner productive.

Feedback from students, lecturers, PhD advisors, mentors.

Is being aware of issues already a measure of success?

Work In Progress: Continue with careful, diligent change.

– Clear, written rules and guidelines; student contract.

– Increase synergies, emphasis on concepts & meta-cognitive skills.

– Move towards more interactive settings, away from “one” book.

– Re-design advanced courses: Astro & Bio & Nuclear Physics I+II.


END OF
IMPROVEMENT
THANK YOU
FOR YOUR PATIENCE

5. Old GW “Standard” Graduate Curriculum

cf. Joint APS/AAPT Task Force 2006
"Which Way Forward?” Workshop 2008

Sem. 1	**Theoretical Mechanics (3)**	**Electromagnetic Theory I (3)**	**Theoretical Methods (3)**	Comm. Phys. & Colloquium
Sem. 2	**Quantum Mechanics I (3)**	**Electromagnetic Theory II (3)**	**Computational Physics (3)**	Comm. Phys. & Colloquium
Sem. 3	**Quantum Mechanics II (3)**	**Statistical Physics (3)**	**Graduate Lab (3)**	Comm. Phys. & Colloquium
Sem. 4	**Qualifying Exam Preparation Course (3)**	**Quantum Field Th. I or Nonlin. Systems I (3)**		Comm. Phys. & Colloquium **(3)**

6. Parameters

Physics at GW:

- GW aspiration to close up to tier-1 private urban research universities.
- Physics: small department with concentrated, competitive research.
- 12 faculty in 3 fields (Nuclear, Bio, Astro) to cover Intro, Major, Grad lectures.
- ≈ 5 new grad. students p.a.; during courses, most in GTA positions; ≈ 30 total; $\gtrsim 70\%$ non-US.
- Very diverse background, skills.
- Median to PhD: 5-6 years; attrition: $\approx 30\%$.
- Mentoring system in place. “Department Family”.

Positive Example: Good experiences with “German” curricula.