

APS-AAPT Joint Task Force on Graduate Education in Physics

Renee D. Diehl
Physics Department, Penn State University

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Origin of the Task Force: AAPT Committee on Graduate Education

❖ Concerns about “fractionalization/factionalization” of physics, raised in Sid Nagel's Physics Today opinion piece, September 2002.



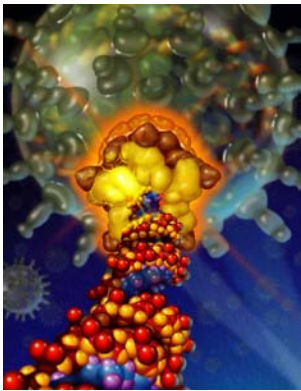
❖ Observation that in physics, unlike chemistry and biology, we apparently are still teaching the same material that we taught 50 years ago, in many cases using the same textbooks.

❖ Observation that there have been no previous studies to use as a benchmark for assessing the status of graduate education in physics.

❖ Concerns on whether scientific ethics are being conveyed effectively in graduate physics programs.

Questions Raised

- ❖ Are some (or many?) universities abandoning or weakening the "core" of courses used for graduate education in physics, e.g. quantum mechanics, E&M, math methods.
- ❖ Have some (or many?) departments dropped or changed (weakened?) the qualifying/candidacy/ comprehensive exam?



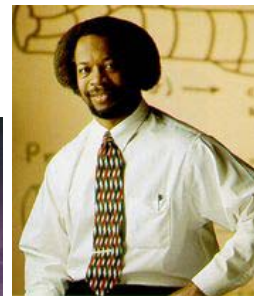
- ❖ Has "interdisciplinarity" changed the physics curriculum? (Should it?)

- ❖ How are non-physics issues (e.g. climate, diversity, ethics) addressed in physics programs?

- ❖ Are we meeting the needs of employers of physics PhD's?

Task Force Membership

- Tom Appelquist (Yale)
- David Campbell, Chair (BU)
- Renee Diehl (Penn State)
- Joel Fajans (UCB)
- J. D. Garcia (Arizona)
- Jim Gates (Maryland)
- Allen Goldman (Minnesota)
- Peter Jung (Ohio)
- Michael Paesler (NC State)



Issues considered

The Current Status of Graduate Curriculum

- ❖ key elements of Ph.D. programs
- ❖ course content
- ❖ specialization vs. common core
- ❖ interdisciplinary fields

Graduate Student Experience

- ❖ length of time to Ph.D.
- ❖ coursework vs. research
- ❖ exams
- ❖ communication skills, information literacy
- ❖ ethics, training, rights

Departmental Issues

- ❖ recruiting
- ❖ financial support and benefits
- ❖ career guidance
- ❖ diversity, balance of foreign/domestic students
- ❖ climate

Data Collection

Draw Information from Existing Resources:

- ❖ APS Fora/Committees on Education, Graduate Student Affairs, Industry
- ❖ AAPT Graduate Education Committee
- ❖ Existing AIP data and reports
- ❖ National Academy of Sciences reports
- ❖ Department Chairs meetings reports
- ❖ American Association of Colleges and Universities reports on graduate education
- ❖ Many and various books and publications on education, physics careers, etc.

New Survey of Departments Conducted by AIP:

- ❖ **Core and Depth in the Doctoral Physics Program**

New Surveys:

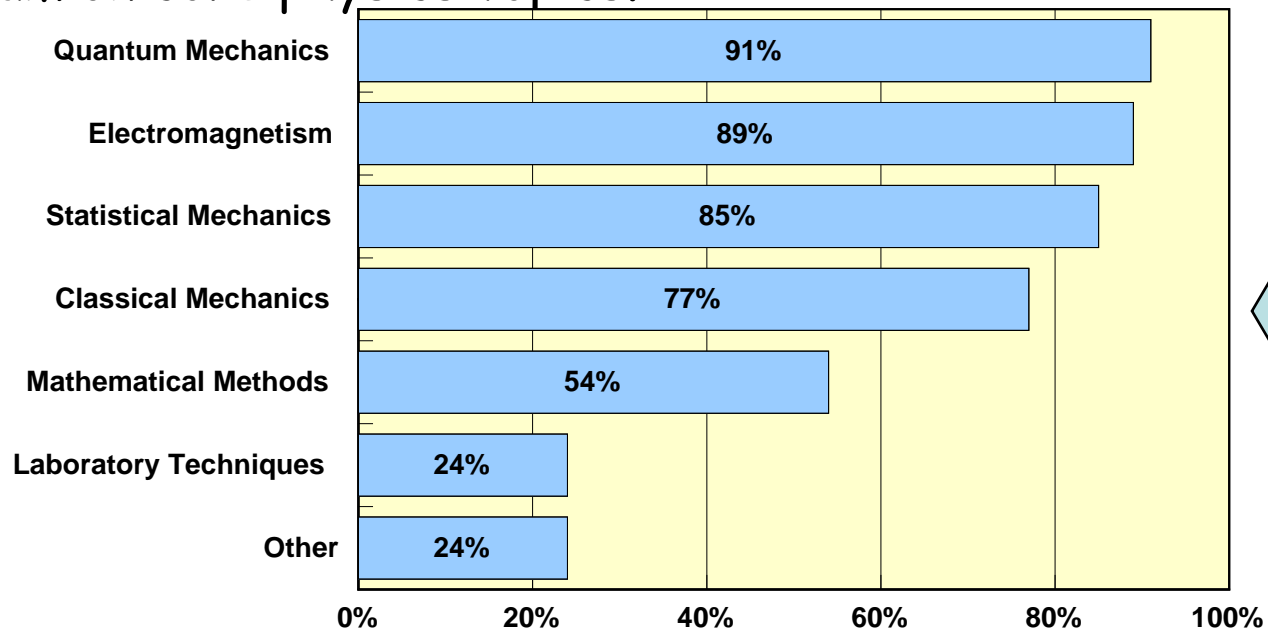
- ❖ **Forum on Graduate Student Affairs**
- ❖ **Forum on Industrial and Applied Physics.**

The AIP Core and Depth study:

- Designed by The Task Force on Graduate Education with AIP Statistical Research Center. (Final report by Starr Nicholson, Rachel Ivie, Roman Czujko, Kimberley Ray at AIP SRC website.)
- Its purpose was to assess many aspects of doctoral education in physics, especially the extent to which physics departments require PhD students to master a core physics curriculum.
- Respondents completed survey on-line, after receiving an e-mail request sent to all PhD-granting physics departments in the U.S.
- Of the total 186 PhD-granting physics departments, data were collected from 137 departments (74%). These departments enrolled 76% of all physics doctoral students.

Core Courses

- Of 137 physics departments, 129 require traditional core courses.
- Core defined as Quantum Mechanics, Statistical Mechanics, Classical Mechanics, and Electromagnetism.
- 8 departments do not *require* any core courses.
(AZ, CalTech, UCSD, FSU, UIUC, MIT, Rochester, WashingtonU)
- 5 departments *require* only lab techniques or math methods.
- These 13 departments require students to pass a comprehensive exam on core physics topics.



← %Depts that require

Most Popular Core Curriculum Texts

Electromagnetism - 76 out of 80 responding departments use Jackson

Classical Mechanics - 48 out of 80 use Goldstein

Quantum Mechanics - 26 out of 74 use Sakurai, 18 use Shankar, 14 use Cohen-Tannoudji, 11 use Merzbacher

Statistical Mechanics - 26 out of 65 use Pathria, 13 use Huang

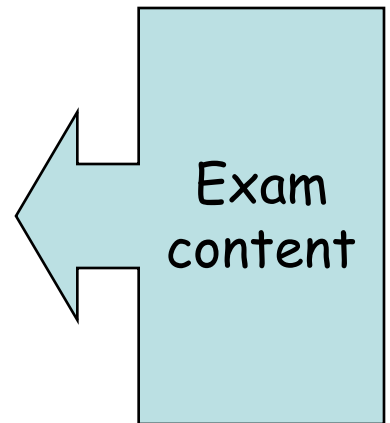
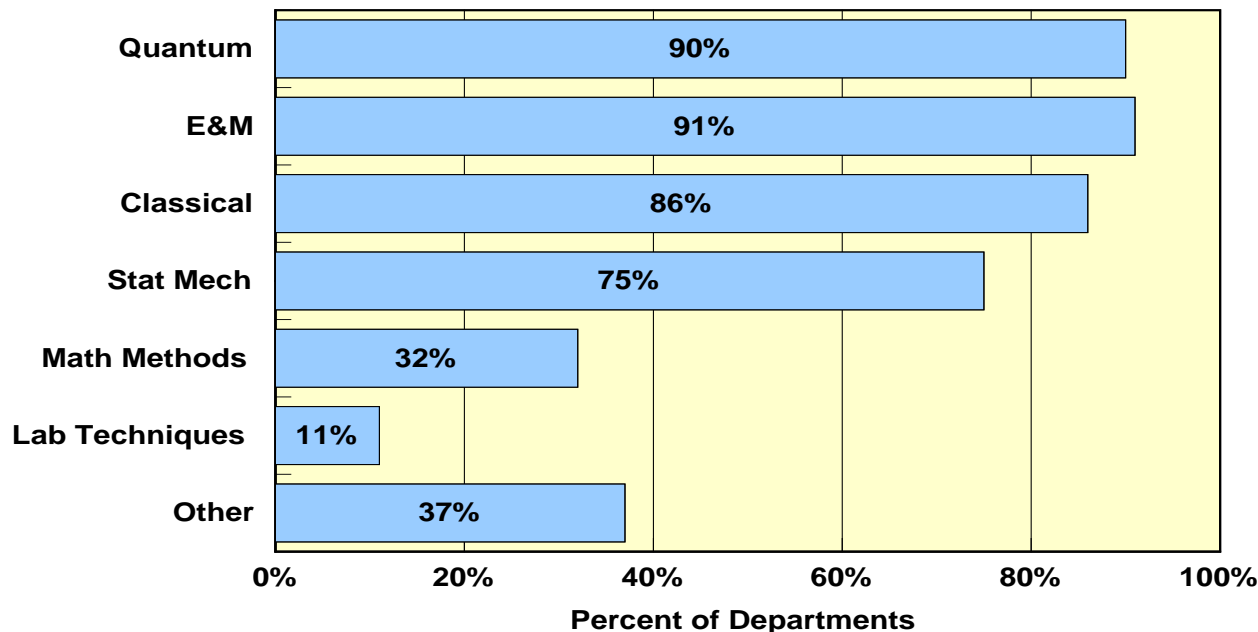
"The two texts that appear to be most widely used, Jackson for E&M and Goldstein for Classical Mechanics, are also among the oldest books, having been first published in 1962 and 1950, respectively, although the latest editions were published in 1998 and 2002, respectively."

Interdisciplinary Programs

Ninety percent of departments with interdisciplinary programs require all students, including interdisciplinary students, to take the core courses, while 6% reduce the core requirements for interdisciplinary students and 4% simply have no core course requirements.

Comprehensive Exam

- ❖ **86%** of Physics departments require a comprehensive exam on core physics concepts.
- ❖ **16%** of departments said their exam was only on undergraduate material.
- ❖ **17%** said their exam was only on graduate material.
- ❖ The majority said their exam was some combination of undergraduate and graduate material.



"Top 30" Departments

- ❖ All (29) of the "Top 30" Departments surveyed require either core courses (7), a comprehensive exam (8), or both (14).
- ❖ A smaller proportion of these departments require both, compared to "the rest".

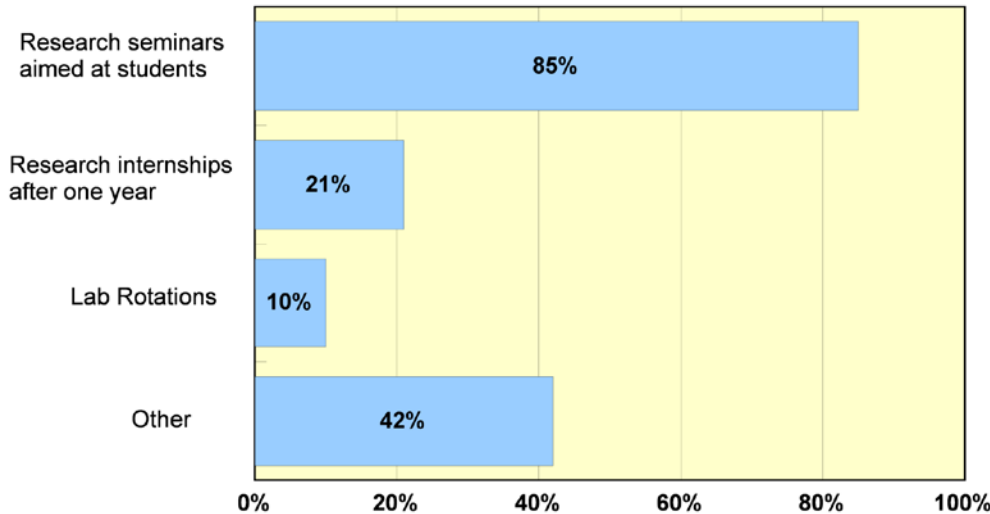
Breadth Requirements

❖ 48% of departments require no courses outside their specialization

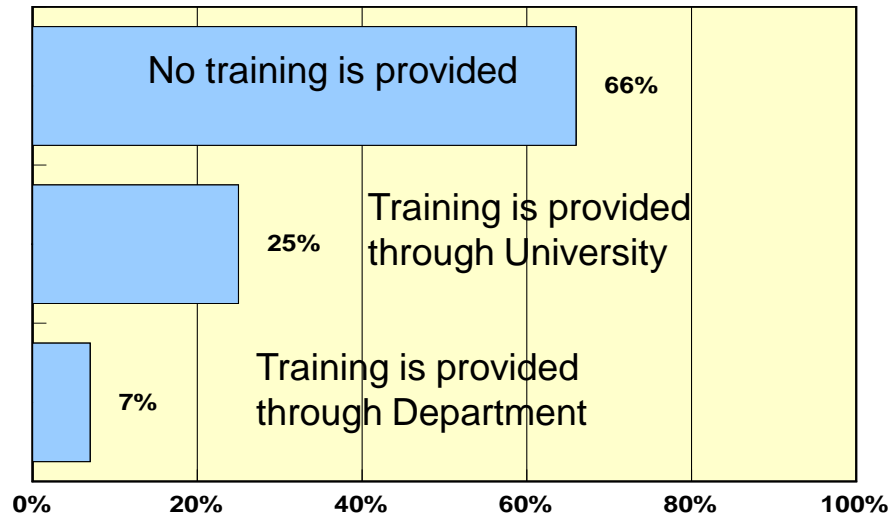
❖ 52% require at least one breadth course

Beyond the Curriculum

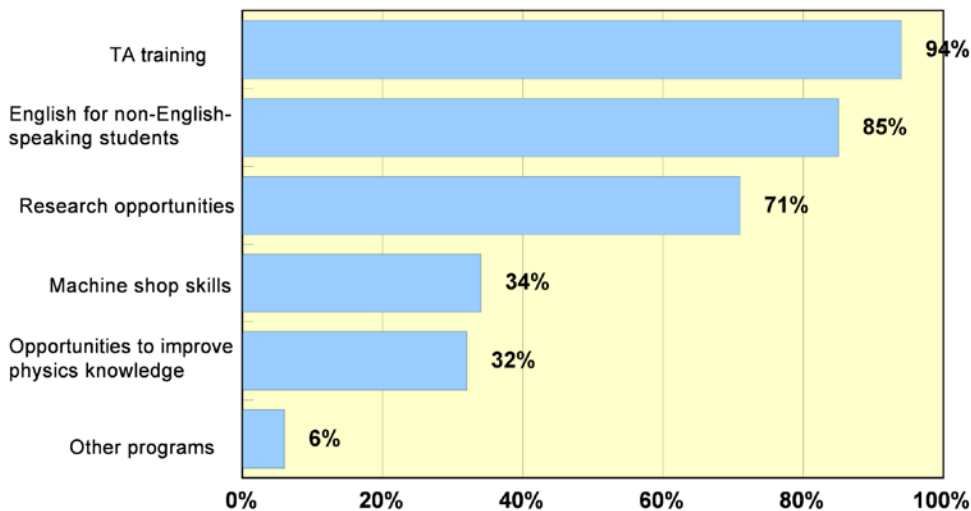
Choosing a research topic



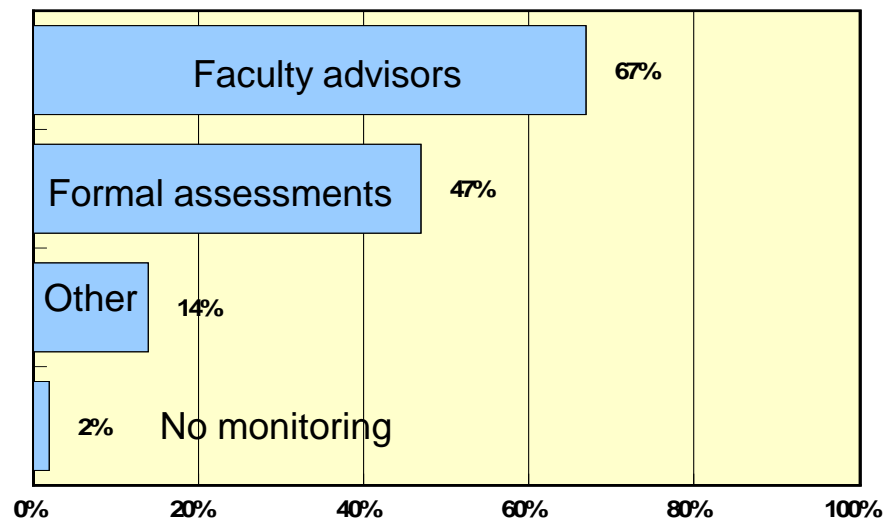
Ethics training



Programs for 1st-year students



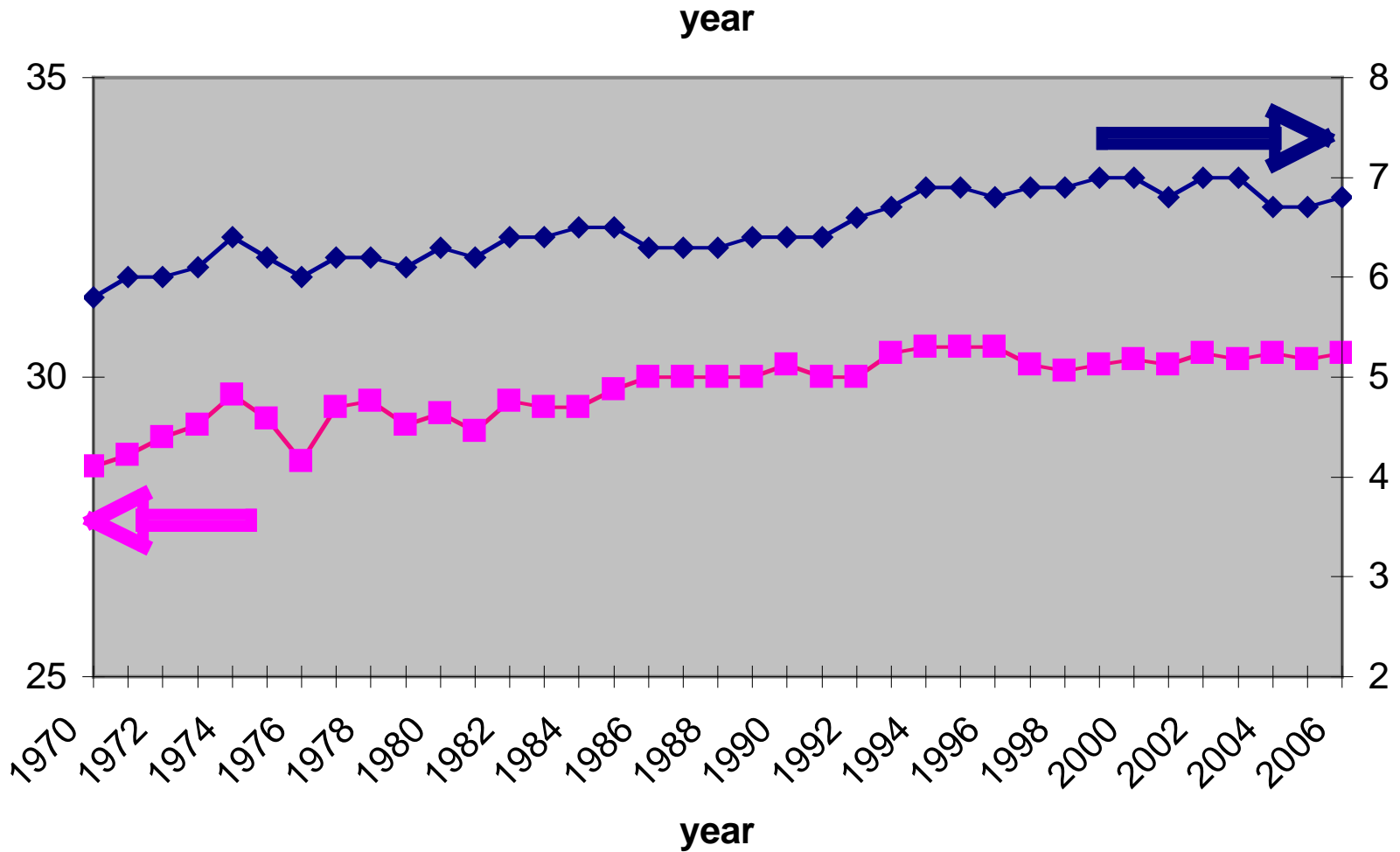
Progress assessment



Summary of Core and Breadth Survey

- ❖ There is still a “core” curriculum in physics. There is much overlap in textbooks used between departments. Some of these are classics (Goldstein, Jackson). Therefore there is a “common ground” in physics at least through the first year of graduate study. (But is it a good thing?)
- ❖ The comprehensive/qualifying exam is still almost universally used and reflects the subject matter of the core curriculum.
- ❖ Interdisciplinary research does not seem to have had a big impact on the core curriculum.
- ❖ There is little formal attention to ethics instruction, but the amount seems to be increasing.
- ❖ The “best practices” cited most often by departments have mostly to do with *increasing breadth or unifying the physics experience*, diversity, mentoring and *reducing the time to PhD* (by engaging students in research earlier, for instance).

Median Age and Time to Degree



Selected Results from **Survey of Graduate Students**

Typical time to PhD- Students felt 5-6 years is reasonable.

Mentoring - Wanted regular mentoring meetings (not just with advisor) to monitor progress.

Distribution Requirements - considered good provided the courses were taught at proper level (i.e. not specialized).

Basic rights of students - Concerns about low salaries and "meager but expensive" healthcare. Intellectual property was a concern to some.

Training for teaching - TA-ing considered valuable.

Career advice - Emphasis still felt to be on academic careers. Students want more coherent advice and assistance (e.g. writing grants and resumes, "alternative" career databases and fora).

Special issues for foreign students - Non-foreign students cited English speaking concerns, foreign students wanted clearly spelled out rules and guidelines. SEVIS and visa difficulties mentioned.

Response from Forum on Industrial and Applied Physics

- ❖ There is often a dilemma because Ph.D. physicists are trained to understand a topic deeply, but many instances in industry require that depth not be pursued.
- ❖ More options that allow students to pursue breadth over depth would be desirable in many cases. However, a Ph.D. with all breadth and no depth offers no advantage over a typical M.S. degree in a typical industrial hiring situation.
- ❖ Emphasis on teamwork, communication, use of concepts in applications and real-world problem solving would be beneficial.
- ❖ Suggested Activities are (1) Cross-disciplinary seminar series run by students (2) Instruction in skill building - communication, interpersonal, networking, e-mail, time management, etc.
- ❖ *Most faculty members could benefit from the type of supervisory training that is common in industry: e.g., learning how to listen effectively and to give honest and constructive feedback, valuing diversity.*



“He may have a Ph.D. in elementary particle physics, but he’s having an awful lot of trouble with the application form.”

Outstanding Questions



- ❖ Are we stuck in a rut with our graduate physics curriculum? Should we be moving on?
- ❖ Since we seem to have a standard curriculum for the physics Ph.D., should we go a step farther and *define* a standard graduate curriculum?
- ❖ Factionalization/fractionalization of physics - is it happening, is it inevitable, is it good or bad for the discipline and how would/should it affect the curriculum?
- ❖ Time to degree - is a median of 7 years acceptable for a degree that does not necessarily convey earning power to its holder? If not, what are effective ways to decrease it?
- ❖ How should we better address preparation for non-academic careers? What is the right balance between physics content and lifetime skills? *How much physics is enough for a Ph.D.?*