

July 9, 2015

PROFESSOR DIMITRI BASOV, Chair
Physics

PROFESSOR THOMAS W. MURPHY, Vice Chair
Physics

SUBJECT: Undergraduate Program Review for the Department of Physics

Dear Professors Basov and Murphy,

The Undergraduate Council has discussed the Physics 2011 Undergraduate Program Review. The Council supports the findings and recommendations of the review subcommittee and appreciates the thoughtful and proactive response from the Department. The Council's comments centered on the following:

- **Faculty.** The Council applauds the Department's diversity efforts in faculty hires in the area of Astrophysics, and recommends that the department replicate this successful hiring model in the other areas of concentration in Physics to expand the diversity of faculty. In addition to the Physics Department's efforts to establish mentorship for newly hired faculty, the Department could investigate the new Teaching and Learning Commons for resources for the training and development of newly hired faculty.
- **Space issues.** The Council understands that more space is needed, specifically, in order to make optional sections for students required. With ongoing space issues across the entire campus, it is suggested that the Department could require that students enroll in a minimum number of sections (ex: requiring that students enroll in 2 sections during their undergraduate career), and continue this minimum registration model until there is enough space for the Department to require that students attend *all* sections. Making optional sections required would aid in course scheduling, since priority for scheduling is given to mandatory classes over optional sections. This mandatory enrollment in sections could also have the unintentional positive effect of increasing student participation in highly effective learning opportunities.
- **Teaching Assistant (TA) training.** Due to the feedback from the TAs who attended the review and expressed a desire for more training, the Council agrees with the committee's recommendation that TAs be required to enroll in PHYS 500 *Instruction in Physics Teaching* prior to serving as a TA.

The Council will review the Department of Physics again in the 2017-2018 academic year. The Council extends its thanks to the Department for its engagement in this process and we look forward to the continued discussion.

Sincerely,

Leslie Carver, Chair
Undergraduate Council

cc: G. Boss R. Continetti G. Cook M. Thiemens
R. Rodriguez B. Sawrey M. Sidney

**UNDERGRADUATE PROGRAM REVIEW OF DEPARTMENT OF PHYSICS
(May 11-12, 2011)**

**William Griswold, CSE (Chair)
Charles Perrin, Chemistry
Claudio Campagnari, Physics, UC Santa Barbara**

We have undertaken a review of the department of Physics, at the request of CEP. Based on the extensive information provided and wide-ranging discussions with representatives of the department and their undergraduate majors, we conclude that the department merits a highly favorable review. In the following we highlight the department's strengths and make suggestions for further strengthening the program, while acknowledging the limitations that the current budget climate places on any remediation. This report will occasionally make reference to the previous review of Physics, undertaken in 1997. However, the data provided by the campus for the review are limited to the last five years, AY 2005-06 – 2009-10.

Readers of this report will note a theme of problems created by the on-going deep budget cuts. The review committee is of course aware that these cuts are beyond the control of the Physics department, and in many respects beyond the control of the campus or even UCOP. The review committee also acknowledges that similar cuts are being made across campus, and that Physics is not uniquely imperiled. Yet, the specific plight of this excellent program must be acknowledged so that appropriate courses of action can be discussed, even if none of them can offer a genuine escape from the ill effects of the cuts.

External Reputation

The Physics department faculty and its research programs are recognized as excellent worldwide. The department is ranked #12 by the US News & World Report. In the rankings recently released by the National Research Council of the National Academy of Science, the department is ranked somewhere between 20 and 30, although there is debate about the reliability of the NRC's methods. In the previous NRC rankings, San Diego was ranked 19. The department is recognized as distinguished in areas such as plasma, condensed matter, and biophysics. Faculty are individually recognized in a number of ways, including four members of the NAS, three recent NSF Career awards, and an AFOSR young investigator award. The external reputation of Physics, like that of any department at UC San Diego, is imperiled by the current across-the-board cuts being implemented and currently considered by the campus.

Undergraduate Major Programs

The programs for majors offered by the department are distinguished in several ways.

- The department prides itself on its emphasis on hands-on lab courses in both the lower- and upper-division. The student representatives we spoke to spontaneously supported and elaborated this claim, noting the special opportunities provided in open-ended project-oriented courses in the upper-division, PHYS 133 and 173 serving as prime examples.
- The department offers several specializations, several unique to UCSD's strengths, such as biophysics, materials, and astrophysics. These help students think about their programs of study from the day they arrive at UCSD.

- Students have ready access to research opportunities in professor's laboratories. A large percentage of majors, perhaps a sizable majority, are involved in research through 199's and paid positions. The student representatives cited these opportunities as critical to their success in gaining admission to graduate school.
- With about 200 majors and over 40 students graduating per year, UCSD is one of the top producers of physics talent in the country. About three quarters of the majors profess an intent to pursue an advanced degree. The students in the Physics major are obviously of high caliber. The students we met were simply inspiring.
- Students seeking additional education beyond a bachelors degree can apply to continue in the contiguous BS/MS program, which allows for overlapped completion of BS and MS requirements, accelerating completion. However, very few students have enrolled in this program in recent years.

These strengths are being eroded by the on-going campus budget cuts. It was noted for example that the staff support provided to PHYS 173 is not sustainable. Likewise, a required course for the Materials specialization was not offered this year, and at least one student had to abandon the specialization (fortunately this student had already been accepted to graduate school at the time this occurred). Indeed, the number of students in the Materials specialization is rather small (7), so a course targeted to these students is not easy to justify, even in better times. It was also noted by instructors and students alike that many upper-division courses, notably theoretical courses, had no TA support, as most of that support was directed to lab courses. This necessarily limits the amount of feedback that majors can get on their work.

Service to the Campus

Physics offers specialized introductory physics sequences for Biology majors (PHYS 1A-C) and Engineering majors (PHYS 2A-D), serving thousands of students per year (including a good number of students beyond Biology and Engineering). Like the introductory sequence for majors, these sequences are lab-based (and PHYS 2 calculus-based), maintaining a welcome level of rigor. The department also offers a number of engaging and well-subscribed lower-division non-majors courses in topics such as the Universe, the Solar System, Everyday Physics, and Energy and the Environment. These courses (as well as the Bio/Eng sequences) often help fulfill general education requirements defined by the various Colleges.

As in the courses for majors, recent and impending cuts imperil the quality of these service courses, and are creating administrative headaches as well:

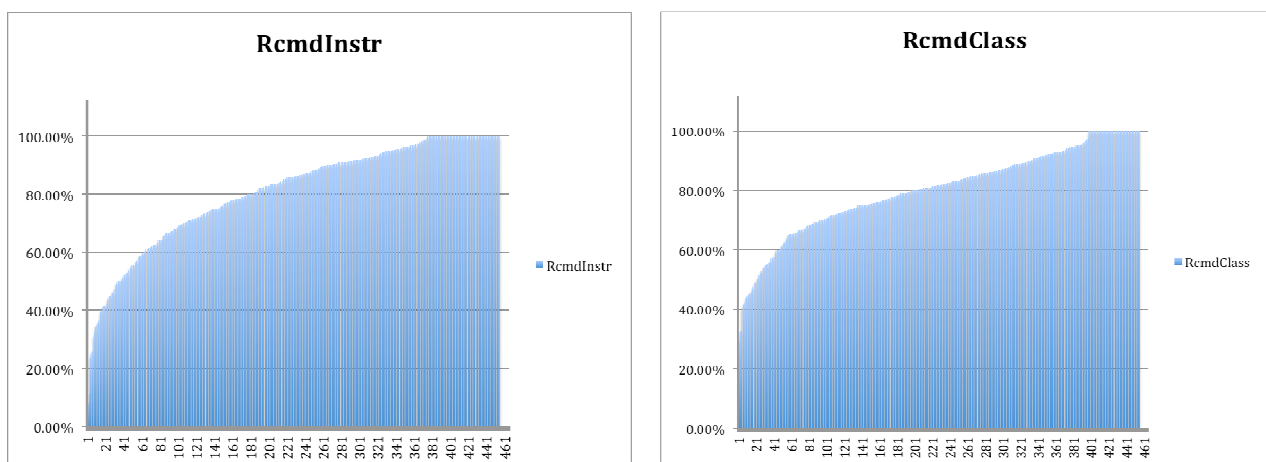
- The size of the lecture sections is beginning to swell beyond the size of classrooms generally available at UCSD (many over 200, and several over 300). This creates scheduling headaches for the staff, and will (or is) inevitably capping enrollments below what students require to make progress towards graduation. A unique challenge for these large Physics classes is the need for live demonstrations of physics phenomena to help the students gain a visceral understanding of the concepts. The set-ups required for these demonstrations are not portable, and expensive to replicate. This inevitably ties their courses to a small number of classrooms in York Hall, and just one classroom of sufficient size for their larger introductory sections. The York Hall classrooms are shared with Chemistry, which has similar needs for a large number of large classrooms.

- The Physics department’s temporary faculty FTE allocation has apparently been slashed (along with smaller cuts to the TA allocation), which had been used to support TAs that were used to staff the PHYS 1 lab courses at the level of two TAs per lab section. These labs are now supported at the level of one TA per section, straining both the TAs and the students enrolled in these sections, creating possible safety risks, according to faculty. This problem is only partially alleviated by roving coordinators.
- For similar reasons, there is just one TA allocated per 200/300-student lecture section for running recitation sections, office hours, and grading exams, quizzes, and homeworks.
- Scheduling rooms for “optional” problem-solving sections is getting harder, as the rooms and time-slots available to mandatory classes become more scarce.

Quality of Instruction

The department prides itself on its commitment to high-quality instruction. The self-report notes that ladder-rank faculty are deeply involved in teaching of the lower-division, including their most famous faculty, even in service courses. In meeting with faculty, their passion for helping students learn was refreshing. Several enthusiastically described state-of-the-art in-class active-learning methods, which help the instructors discover students’ misconceptions and then work to dispel them. The committee appreciates the difficulties of helping students learn in large-lecture environments, where it is not possible to independently query each student’s understanding and work through the issues. The use of clickers in the think-pair-share modality, pre-class quizzes, and “lecture tutorials” were cited as useful innovations for helping students overcome their misconceptions at scale.

The student representatives, when singing the praises of the faculty in offering research opportunities, noted that this very same strength was also the department’s single weakness – a feeling that research was sometimes prioritized over teaching.



Indeed, the CAPES for Physics over the last five years confirm that there is wide variance in instructional quality, as reported by the students (see charts for Recommend Instructor and Recommend Course; values are sorted). With average Recommend Instructor and Class CAPE scores of 77% and 76¼%, the Physics department lags the rest of Physical sciences by 6 percentage points on the Instructor and Course measures, and also lags slightly in amount learned. The committee surmises that some faculty, in

trying to do everything well with their limited time, are relying on the tried-and-true method of traditional lecturing – the careful transmission of content – in contrast to working to discover and dispel students' misconceptions. The most recent study comparing such methods just appeared in *Science*, offering a stark contrast (<http://www.sciencemag.org/content/332/6031/862.abstract>).

Overall, the opinion on teaching assistants was quite high. Some variability was noted on the dedication and teaching skills of the graduate TAs, which is to be expected. The TAs themselves felt they could use more training. While the graduate catalog suggests that graduate students take PHYS 500, they are not required to do so before TA'ing. Physics uses a number of paid undergraduate TAs in the lower-division lab courses (because graduate TAs cannot always be found). They appear to be highly motivated and capable. Some concerns were expressed about the potential for conflict of interest when enrolled students are friends of these TAs. Physics has not used volunteer undergraduate TAs like Biology and Chemistry does.

The Physics Tutorial Center, staffed by graduate TAs, is a unique resource that is appreciated by students, especially for lower-division courses and for the large number of days and hours that it is open.

Advising and Career Preparation

The staff and faculty in Physics are dedicated to the success of their students, and this extends to advising. There is one staff advisor for course advising of majors and non-majors, and six faculty for advanced advising to majors. Our discussions with students and the survey run by the College deans for advising suggests improvements are possible in the interface between advisors and students. Students were not uniformly aware of the faculty advisors (although the committee notes that the Physics undergraduate web site lists them). We have asked that the College survey be forwarded to the department so it can make improvements to the advising interface.

In the 1997 review poor preparation for the GRE Physics subject test was mentioned as a problem, and the problem persists today. The GREs are very important for admissions to Ph.D. programs in Physics, and many students have struggled to excel on the subject test. One student cited statistical mechanics as a weak point in preparation. There have been occasional informal efforts to help students with GRE preparation. Unlike in 1997, there are commercial programs that help with the Physics subject test. It's unclear, however, that students are fully informed on the importance of the Physics subject test in graduate admissions, how long it takes to prepare, etc.

Department Environment and Leadership

The obvious camaraderie, and dare we say, *affection*, expressed by faculty for staff, staff for faculty, students for faculty, etc., etc., was a strong and consistent positive. It is apparent that the Physics department is sustaining and even improving its programs during these dire times because they have pulled together, recognizing not only their common plight, but also their common goals. We also note that teaching assignments are made in accord with faculty preferences and without complaints. All concerned should be lauded for their positive spirit in this negative climate. The wisdom and stability offered by long-time Vice Chair Hans Paar and MSO Karen Andrews were notable. The department's organization from the Chair and MSO down through student affairs is sensible.

Transfer Students and Diversity

Transfer students in Physics seem to be as successful as in any department. The strong support for physics in the community colleges is no doubt helpful. The department has not found a need to develop

any programs for easing the acculturation of transfers. One student, a Winter transfer, cited problems in getting started because a critical course sequence began in the Fall. TAG transfers can transfer to UCSD any quarter. Given the number of students in the Physics major and the current shortage of resources, avoiding this problem could be difficult.

We support the department's efforts to increase diversity. The proportion of women students stands at about 20%, close to the national average, but lower than in previous years. The current low percentage of women on the faculty (6%) provides only a minimum number of role models to encourage women to choose the major and pursue advanced studies in physics. The department has recently established a support group, Women in Physics. Moreover, the department did receive an Opportunity FTE and made an offer to a candidate, but she chose to affiliate with a different department; the Physics department is offering her an affiliation with Physics as well. The number of ethnic minorities among the students and especially among the faculty is distressingly low, but not unusual for physics departments nationwide. We commend Adam Burgasser, who has attended national conferences to recruit minority students.

Recommendations of the Committee to the Physics Department

In light of the department's strengths, weaknesses, and the challenges it faces in the current budget climate, the review committee offers the following suggestions:

- Modify existing major specializations to add flexibility to course scheduling. Failing this, the department should consider eliminating small specializations that consume incommensurate resources. This excludes the education specialization, for example, which does not require offering additional courses.
- While the committee recognizes that instructors and students share the responsibility for student learning, it counsels the department to pursue best practices where practical to maximize the instructor's contribution to the collaboration. The department has ample expertise to tap for this endeavor, for example Mike Anderson and Adam Burgasser.
- Along the same lines, we encourage the department to participate in ongoing campus efforts to study how students learn the concepts of science and what the impediments to learning are. The one LPSOE in the department, Mike Anderson, is involved in such research, and additional instructional faculty would add to the department's efforts.
- PHYS 500 or a similar course should be required for graduate TAs. Undergraduate TAs should receive mandatory training as well. Training should include topics on ethics and academic integrity.
- In the face of on-going cuts, Physics should consider developing a volunteer undergraduate tutor/TA program, perhaps following Biology's or Chemistry's program, which uses the Instructional Apprenticeship course, numbered 195. Such a program also offers unique professional development for the undergraduates. Alternatively, paid undergraduate TAs or 195 registrants could be included in the staff of the Physics Tutorial Center that is currently staffed by paid graduate TAs. This could also reduce the number of undergraduates who are grading other undergraduates.
- Advising should be more formalized and developed. A frequently-asked-questions resource (FAQ) should be developed to handle common questions for majors and non-majors (perhaps especially the latter), lessening demand on the staff's single point of contact. A resource for career advising could be helpful as well.

- The moribund Society of Physics Students ought to be revitalized, in order to give students the opportunity to discuss and present their research (in a more specialized setting than the campus-wide UG Research Conference) and to offer a GRE preparation course.
- To aid course scheduling, optional class sections should be made required. This also could have the unintentional positive effect of increasing student participation in highly effective learning opportunities.
- To help instructors cope with large-scale grading with minimal resources, the department should consider adopting integrated teaching/grading resources such as Mastering Physics. Such resources also have the potential to aid the adoption of in-class think-pair-share strategies, with pre-developed in-class questions.
- A formal program should be created for guiding new faculty in teaching the courses to which they are assigned. This is in addition to the campus program for mentoring new faculty, which is primarily devoted to research. Coordination among instructors who share a common course is minimal, and a mechanism whereby course content on WebCT could be made accessible to colleagues.
- To increase the diversity of undergraduates, the department should consider a “flexible option” major, like that being offered by MIT Physics and considered by many other Physics departments across the country (<http://web.mit.edu/physics/current/undergrad/major.html>).
- There appears to be a catch-22 with how advanced-placement (AP) credit is treated with respect to Physics courses, whereby a student with an insufficiently high score cannot get an equivalency for PHYS 2A (or 2B), but also is not allowed to take it, though required for graduation. This should be fixed.
- There are typos and minor omissions in the general catalog copy with regard to the computing requirements in the Computational Physics specialization. “CSE 112” should read “CSE 11”. Also, completing CSE 8b is equivalent to completing CSE 11. The CSE 8a/b sequence offers a non-accelerated introduction to programming that may be attractive to many students.

Recommendations of the Committee to the Campus

While there are things that Physics can do to improve its undergraduate programs, the campus can have a big impact as well. These recommendations are not particularly unique to the Physics department’s needs, and should be construed as beneficial to most undergraduate programs.

- Simultaneously cutting faculty FTEs and TA support is a recipe for disaster. To give a smaller faculty a fighting chance to serve a larger student body well, TA support must be maintained and increased. The costs are small relative to the benefits both to the quality of instruction and in helping faculty sustain intensive, high-quality research programs.
- The larger classes that are inevitable due to a smaller faculty teaching a larger student body demand more large classrooms, and increasingly innovative and flexible ways of scheduling classrooms. The campus should strongly consider converting Mandeville Auditorium into a general-use classroom. Because the largest classes are often service courses, the use of video-connected classrooms and distance learning is less palatable: the “served” departments feel their students are getting inferior instruction. At a minimum, hard data will be required to prove them wrong.

- The nascent demand for MS degrees from the undergraduates Physics majors at UCSD is part of a wider phenomenon on campus. At present, departments are inadequately uncompensated for enrollment MS students, discouraging departments from paying attention to this important state need. Incremental increases in MS enrollments need to be compensated by proportional increases in support to the department.
- Departments should be given flexibility in budgeting. As budgets are being slashed, departments need the ability to freely reallocate resources to help meet what they decide are their most pressing needs.

Recommendations for Improving the Review Process

The committee feels that a few small things could be done to improve the review process, all relating to the data provided in the binder:

- The committee found the survey run by the Deans of College advising to be quite useful in providing insights on major advising. A similar survey provided to those who took service courses in the department would be a valuable complement. We do not recommend adding a meeting with non-majors who took service courses, because the number of hours of meetings is already quite high, and because it is unlikely that any meaningful numbers of non-majors will participate.
- The committee felt it unusual for the College Deans of advising -- an advising unit -- to be assessing another advising unit. We recommend that the office of the AVCUE take over this survey. This would also ensure that the survey is provided to the department in time to be incorporated into their self-assessment report.
- Much of the data provided by the campus about a department is hard to interpret. Many of the “tabs” could benefit from having a sheet that explains what is really being counted – basically a key or definition of terms. For example, it was hard to determine how many courses the Physics department actually taught. Secondly, some of this data could be easier to understand if plotted (graphed), rather than simply displayed in tables. The provided plot of the CAPE data is a successful example. The committee does appreciate that this could incur additional undue effort at the office of the AVCUE.
- Some of the spreadsheet data presented in the binder is hard to use in printed form. For those documents that are derived from (or are presentations of) spreadsheets, review committees should be given the actual digital Excel spreadsheet documents.