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July 23, 2018

PROFESSOR BENJAMIN GRINSTEIN, Chair
Department of Physics

PROFESSOR THOMAS W. MURPHY, Vice Chair of Education
Department of Physics

SUBJECT: Undergraduate Program Review for the Department of Physics

Dear Professors Grinstein and Murphy,

The Undergraduate Council discussed the Department of Physics' 2018 Undergraduate Program Review. The Council supports the findings and recommendations of the review committee and appreciates the response from the Department. The Council's comments and recommendations centered on the following:

Website. The Council reiterates the review committee's recommendation of updating the Department's website. During the review, the committee pointed out that they were unable to locate the FAQ page that the Department developed in response to their previous program review in 2011. With students increasingly turning to the internet for information about the department, the Council would like to see the website updated (including the addition of a FAQ page) so that information is readily accessible, easy to navigate, and in a format that is easy to digest.

Diversity. The review committee suggested adding activities for female high school students and involving female faculty in these activities. The Divisional Dean's response highlighted the fact that there are few women in the Department, and they are often over-committed simply due to the dearth of female faculty. The Council recommends appointing an undergraduate committee (of both male and female faculty) to examine the issue of diversity within the Department. This committee could be charged with planning and implementing diversity initiatives to attract and retain female undergraduate majors.

The Council will conduct its follow-up review of the Department in Spring 2019. At that time, our goal is to learn about the Department's progress in implementing the recommendations of the program review committee and the Undergraduate Council. The Council extends its thanks to the Department for their engagement in this process and we look forward to the continued discussion.

Sincerely,

Sam Rickless, Chair
Undergraduate Council

Attachment
(1) Undergraduate Program Review Report and Responses for Physics

cc: F. Ackerman

S. Boggs
J. Eggers
R. Horwitz
J. Moore
R. Rodriguez
M. Sidney

UNDERGRADUATE PROGRAM REVIEW OF DEPARTMENT OF PHYSICS

UC San Diego, February 12-13, 2018

Haim Weizman, Chemistry and Biochemistry, UC San Diego (Chair)

Farhat Beg, Mechanical and Aerospace Engineering, UC San Diego

Mark Morris, Physics and Astronomy, UC Los Angeles

The Undergraduate Program Review Committee for the Department of Physics reviewed the department on February 2018. The committee finds that the Department of Physics continues to provide excellent undergraduate education and make significant improvements since their previous review (May 2011). The committee concludes that the Department of Physics leadership, faculty and staff are very committed to undergraduate education and that this commitment is translated into continued improvement of the program in spite of the challenging increase in enrollment.

Review process

Prior to the visit, the committee reviewed material received from the Dean of Undergraduate Education. This material included the Department's Self-Study report dated February 15, 2017 and various supporting materials. The committee met on February 12 with the Dean of Undergraduate Education, Department Chair, Vice Chair of Undergraduate Education, Senate Faculty, Student Affairs Officers, the Business Officer, Teaching Assistants, an undergraduate student and a representative from the College Deans of Academic Advising. On Feb 13, the committee met once again with the Department Chair, Vice Chair of Undergraduate Studies, Dean of Undergraduate Education, Dean of the Division of Physical Sciences and the Assistant Dean of Undergraduate Education. The committee provided its recommendations verbally at this meeting and this report recapitulates those ideas in writing.

The committee is thankful for all those people who took the time to share their views and appreciates the open and honest dialogue. The committee is aware that the nature of a

short visit may lead to an incomplete or biased picture, and therefore the recommendations presented in this report should be viewed in this context. The committee also notes that the department is in the midst of exploring and implementing several changes (i.e. new model for discussion sessions, novel content and laboratory experiments relevant to life science majors) and concludes that it is premature to discuss those topics at this time.

Description of the current operation of the department

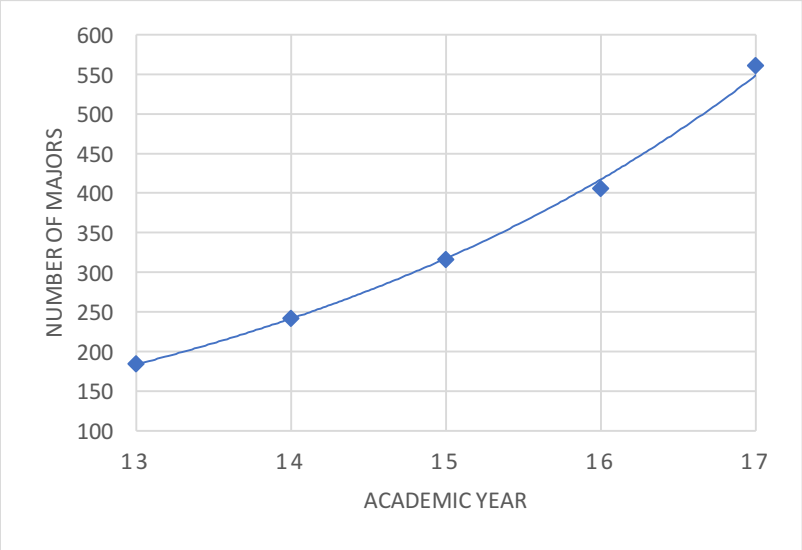
The U.C. San Diego physics department is one of the leading physics departments in the USA according to U.S. News & World Report. Its research is focused on six areas of research: 1. Astronomy, Astrophysics, and Space Sciences (17 researchers), 2. Atomic, Molecular and Optical Physics (6), 3. Biological Physics and Quantitative Biology (12), 4. Condensed Matter (20), 5. Particle Physics (15) and 6. Plasma Physics (5). The scope of disciplines provides expertise in teaching across topics and research opportunities for undergraduates.

The 2018 U.S. News & World Report ranked the physics graduate program 17th in the nation, evident of its academic strength. While this ranking is not directly correlated to the ranking of an undergraduate program, it is a strong indication of the high quality and rigor of the faculty and graduate students who serve as teaching assistants.

The department currently counts 53 Faculty FTE (Academic Senate faculty, including three Teaching Professors) under the Department Chair, Professor Benjamin Grinstein. The education mission of the department is led academically by the Vice Chair for Education (Tom Murphy) and administratively by the MSO (Tom Tomp). Student Affairs Manager Catherine McConney supervises four staff members, two of which support undergraduate education. The Undergraduate Program Coordinator & Advisor (Toni Moore) is responsible for course scheduling, advising, enrollment matters and the TA coordinator/Instructional Support Specialist (Dawn Love) serves also as the OSD Liaison. Over the last several years, the department has served approximately 16,000 undergraduate students annually, mostly in service courses, but also as departmental majors, of which there are approximately 560 across the 4-year program.

The major theme of the last program review was the impact of limited resources. The

theme of this review is an astounding growth in the number of physics majors over the last several years. Although there is a high demand for STEM among students, the increase in the numbers of physics majors is likely due to a domino effect of capping the numbers of students in Engineering and Math departments. The following graph captures the growth of majors over recent years:



While the exponential growth is very dramatic, it is important to note that the increase in numbers of physics majors brings the ratio between faculty and undergraduate students to a similar ratio experienced at UCLA physics. Therefore, it is reasonable to assume that the increase in numbers is sustainable after some adjustments. The fast growth not only imposes challenges with regard to limited resources, but also changes the profile of the student population. A recent survey conducted by the department revealed that about 50% of the physics majors did not choose physics as their first choice. This brings additional challenges related to students' motivation and professional self-identity.

During the review process the committee analyzed the following topics and has identified areas where changes can strengthen the physics undergraduate program.

Faculty:

Teaching is almost exclusively covered by academic senate members with very limited support of temporary lecturers. A normal teaching load for a faculty member is three

courses, with courses dramatically varying in enrollment numbers. The committee was impressed with the high number of faculty who are engaged in undergraduate education beyond the required teaching assignments. Several faculty members are actively experimenting with new teaching methods and strive to improve curriculum (for example, Vivek Sharma is leading a task force for reevaluating TA-led discussion sessions and Adam Burgasser is engaged in flipping courses). The dedication to students is reflected by the unusually high number of teaching awards that members of the department received in recent years.

The fast growth is of major concern to the faculty, yet none expressed any concerns with teaching load or teaching assignments. The current system in which every faculty member suggests courses and courses are assigned by committee works well. The rules that set limits of three years for teaching the same course and priority in assignments of courses given to young faculty are effective and provide a good solution to rejuvenating courses.

Students' evaluations (CAPE) reveal that the department's overall rating is in line with other science departments. The limitations of CAPE evaluations are broadly accepted but it helps to identify consistent outliers. The department developed an innovative approach to teaching evaluations that is based on qualitative analysis of students' comments rather than comparing numbers. A committee looks for repeating patterns in students' comments and then provides this information to instructors with proposed remedies. Our committee applauds this approach and anticipates positive, long-term effects on teaching quality.

Faculty are concerned with the large number of students who are underprepared for the major, particularly for upper division courses. It is important to note that faculty members feel that this issue predates the recent exponential growth, but clearly the growth intensifies this concern. There is a sense among the faculty we interviewed of degrading quality of incoming students. Instructors claim that they currently are not able to cover the same material that they used to teach, neither in depth nor in quantity. One instructor said that he can cover only about 75% of the material that he used to cover several years back. Another instructor said that he recently came back to teach a course after a few years break, and current students' performance on his older tests is far below what it used to be. While we heard only anecdotal evidence, there was a consensus among faculty that this is a

real problem. The committee has no solid evidence to support those claims, but felt that this concern goes beyond the level of expected complaints.

Some faculty feel pressure to 'water down' courses rather that maintaining rigor due to perceived expectations from the administration. The faculty feel that the failing rate is artificially kept below where it should be and that promotions are highly influenced by student evaluations, which has the potential for promoting grade inflation. While these concerns are widespread across various departments, the sentiment among physics faculty was alarming to the review committee members.

Another concern is the lack of interest and motivation among students because physics was not their first choice. The combination of underprepared students with lack of interest negatively affects the morale of faculty.

Recommendation for improving preparation

1. Currently, physics majors can enroll in either the Two or Four physics series. We recommend that all majors be required to take the Four series.
2. Consider a shared exam used by multiple instructors to ensure consistency of level and rigor.
3. Consider instituting a pre-major or a qualifying exam for transferring into the major (rather than basing it on GPA).

Recommendation for fostering interest among majors*:*

The recent growth seen by the committee is an opportunity to strengthen the department. Rethinking specializations and creating new majors may increase interest among students.

a. ***Creating an Engineering Physics specialization***: Engineering Physics specialization will cater to students interested in engineering. Such a program would provide a foundation in physics with an engineering approach. Ideally, local industry would be involved in designing the program and providing insight for future needs of the industry. Although this specialization would require rethinking course offerings, it is likely that many courses will only require some adjustments. For example, an Arduino-based course that is currently offered would fit well within Engineering Physics. Although new specializations require a

considerable investment of faculty time, the department would likely improve interest among students and be rewarded in the long run by attracting higher caliber students.

b. ***Rethinking majors:*** The previous undergraduate review committee recommended elimination of some Majors with low enrollments, but the department responded that those majors do not impose any administrative burden and chose to keep them. The data show that the numbers of students in the sparse majors has not significantly changed since the last review and therefore we recommend revisiting this issue (especially in regards to PY28, Earth Science specialization). Even if a major does not require additional resources, it is important to recognize that a major requires critical mass (pun not intended). Students are likely to feel isolated and it is hard for a student to develop a professional identity in isolation. An alternative to elimination is reevaluating course requirements. PY28 has the highest required units among the physics majors. Even if there is an interest in the subject, the excessive number of units is prohibitive. The department should consider changes that will facilitate time to degree. We also recommend taking a closer look at the requirements of each major. For example, it is recommended that Astrophysics lab (164) be mandatory for the Astrophysics specialization.

C. ***Programming requirements:*** Programming should be required for all physics majors since it will better prepare them and increase their marketability. Students should not have the option to choose between Chemistry 6A and programming. It was noted the students feel that the current programming requirements are outdated. We recommend that faculty explore other programming language options beside Mathematica, such as Python. This recommendation would also benefit the suggested new Engineering Physics specialization.

Instructional consistency and faculty training

The committee found that individual instructors choose textbooks as they please, and that students may therefore change books within a sequence. While we realize the academic freedom of each instructor is important, this practice is rather ineffective and is burdensome to students. Faculty have also expressed concerns that some instructors don't cover certain topics that are required for the courses that follow it.

Recommendation: Textbooks that will serve the students along sequences should be chosen by subcommittee. The committee should also be charged with composing a written

guideline of topics to cover in each course. It is suggested to create a culture of 'end of shift' reporting where instructors report to the next in line about their experience and any deviation from the agreed-upon structure.

Teaching mentorship for new faculty: While each new faculty member is assigned a mentor, there is a lack of mentorship specifically geared towards teaching.

Recommendations:

1. Creating a short departmental teaching workshop for new faculty with participation by experienced instructors (or alternatively, creating such a workshop for the Division of Physical Sciences).
2. Composing a handbook which covers basic information required for new instructors (For examples, how to use TritonEd, clickers, expected grade distribution, grading on curve, how to reserve rooms, etc.)

Teaching Professors mentorship: The department recently hired three teaching professors and is in the process of hiring a fourth. These hires are expected to enhance the undergraduate program in coming years and therefore it is important to provide new hires with guided plan and supportive environment. To the best of our understanding, there is no specific mentoring plan in place to support the professional development of Teaching Professors. This is especially important since the only teaching professor preceding these hires left the department and there is consequently a limited tradition in the department.

Recommendation: Develop a specific mentoring plan for teaching professors and encourage teaching professors to interact with other teaching professors from science departments.

Laboratory courses:

The Department of Physics offers laboratory courses to accompany lecture courses. Laboratory courses require significant resources and the committee applauds the department for increasing the number of laboratory sections and successfully training thousands of students in their laboratories. One concern rises through reviewing CAPE

evaluations. In general, laboratory courses received lower values than lecture courses on 'perceived amount learned'. This observation suggests that there is a need to augment the curriculum to make it more challenging and relevant to the students. In addition, several issues were identified that may explain this observation:

a. **Corequisites.** Several laboratory courses are corequisites with lecture courses (1A/1AL, 1B/1B). The labs were designed to enhance student learning with lectures, but frequently there is a mismatch between the material covered in lecture and the experiments in lab. Some instructors feel rushed to cover lecture material relevant to the labs, and on the other hand, students often come to the help room to prepare for labs since they didn't cover the material before the lecture. There is also a conundrum concerning enforcement of corequisites. Some students drop the lecture course but continue with the laboratory course, therefore effectively bypassing the requirement. This practice sends a message that the corequisite is only a recommendation.

Recommendation: Revisit lab curriculum and create a calendar that fits the pace of the lectures. Alternatively, the department should consider decoupling the labs from lectures, and add a 1-hour lecture for labs. While there are pedagogical benefits for corequisite experiments, decoupling will have other advantages. It will allow spreading students evenly between quarters, open possibilities to design broader scope experiments and allow students to revisit concepts a second time.

b. **Instructional structure:** Another concern is the practice of assigning very large enrollments to a single lab instructor. Based on TA comments, it is clear that the involvement of the instructors of record is rather limited. Weekly TA meetings are led by a senior TA (LTAC) and the instructors are hardly seen in the lab. This is not surprising, considering the large enrollments of these courses and the administrative burden they carry. Yet, the presence of an instructor, even for a short visit, serves as a quality assurance. It appears that in some cases the LTAC are replacing the instructors or an academic coordinator. In one extreme case, the LTAC was in charge of a lab for four years, while

instructors have changed. This graduate student effectively became the instructor, rewriting the lab manual.

Recommendation: Dividing very large laboratory courses into two courses and require instructors to visit lab sections and be involved in weekly TA meetings. Consider hiring an academic coordinator to allow consistency and effective TA training.

Advising

The committee was impressed with the dedication, knowledge and enthusiasm of the undergrad advisor (Toni). Nevertheless, it is clear that the advisor is stretched to the limit and the number of students that are served by the department exceeds what can be expected from a single advisor. More resources are needed urgently, perhaps in the form of another partial FTE for student services.

Website: The undergraduate website could use a major makeover. Some links are broken and other links result in downloading pdf files instead of direct web page access. Students who seek departmental information are linked to campus web pages instead of specific departmental pages. For example, OSD students who look for further information are linked to the webpage of the Office for Students with Disabilities. Students who look for research opportunities are sent to the campus REAL portal. We recommend creating department-specific information pages.

The last program review recommended the creation of FAQ pages and the department responded that pages were added. It was not possible to locate these pages, which suggests that they disappeared over the years.

In addition, the SPS club should be featured under student organization. Google indicates that sps.physics.ucsd.edu exists but has not been updated since 2014.

Petitions: Petitions are handled via paper forms. The form needs to be downloaded (broken link), printed and physically submitted or sent via postal mail. We recommend adopting an electronic system for submitting and handling petitions similar to the one developed in Chemistry and Biochemistry. This would not only improve logistics but would also create a database where similar past petitions can be reviewed for consistency.

TA training: In response to the previous review the department implemented mandatory TA training in the form of a graduate course (Phy 500). The committee found that the course has been viewed favorably by graduate students who took it, especially for its useful 'tricks of the trade'. Students felt a need for augmenting the course with fundamental topics such as learning theories, misconceptions, etc.

Instructional Center: The department created a help room to support student learning. The center is operated by TAs and each shift include two TAs. In general, TAs felt that although some students use the center, in general it is underutilized. Since the center is open to all students, occasionally students from upper division courses come to seek help from TAs who are not fluent in the material. This cause stress to both students and TAs.
Recommendations: Advertise the center on the website. Collect usage data to determine whether this is an effective use of TAs. Consider organizing the TA assignments so that each time slot will have at least one advanced graduate student who will be able to help upper division students.

Diversity: Increasing the diversity of students is a continuous challenge for physics departments. The department has increased the percentage of URM students since the last review, except for women. Over the same period of time the department hired additional female faculty and hopefully these hires will have an impact on diversity in coming years. It is noted that the department is engaged in outreach activities to promote physics among female-middle-school students.
Recommendations: It is suggested to add activities for female high school students and involve female faculty and the Women in Physics society in those activities.

Time to degree: Since last review the department augmented its course offerings with a second offering of major courses required for graduation. This will likely improve time to degree.

Comment about physics for life science. It is noted that this review coincides with current attempts to improve the curriculum for life science majors. Therefore, it would be beneficial to follow up on these changes in coming years. However, it is noted that large numbers of biology majors wait until their junior or senior year to take basic physics courses. This is likely because physics is not a prerequisite for any biology course. This situation is far from ideal because students don't see a reason for taking physics earlier and faculty end up teaching unmotivated students.

Recommendation: Consider a discussion with the Division of Biological Sciences about changing prerequisites or imposing a rule that Biology Majors complete physics by a certain point in their curriculum. Even though physics is not a prerequisite for a particular single course, it is important for students to know fundamental physics in order to gain understanding of crucial biological process. For example, some background in electromagnetic fields is required for understanding membrane potential or electrophoresis and basic mechanics is needed for understanding aspects of human physiology.

Concluding remarks

In conclusion, the committee found that the Department of Physics not only maintains high standards for undergraduate education but is also actively engaged in consistent efforts to improve the program. We hope that this review will support these efforts and further strengthen the physics undergraduate program.

General recommendations for Improving the Review Process

The committee wishes to provide several suggestions that may enhance the process of undergraduate program reviews:

1. The committee met with only one undergraduate student and feels that this limited its ability to asses students' experiences. We are aware that soliciting participation in review is challenging, and therefore there is a need to explore alternative approaches to what is currently done. For example, random students could be targeted via individual invitations from their department chair or provost.
2. The undergraduate program of the Department of Physics (as many other departments) provides service courses to thousands of students every year. The review

process has very limited ability to assess the experience of non-majors in service courses. It is suggested augmenting the review process to include this important aspect, including interviews with non-majors.

3. The Council of Deans of Advising (CDA) Undergraduate Survey provides important insights for the review process. The report would be enhanced if the responses would be categorized by the responder's academic year (self-identified).