Physics and Applied Physics
Program Self-Review (Draft)

January 4, 2024

1 Overview of the major

Questions: What are the Program Learning Outcomes identified for this major? What is the role of this major in undergraduate education on the campus, i.e., how does the major contribute to the undergraduate educational mission of the campus? Is the major clearly distinguished from other similar majors on campus?

The physics major plays a vital role in the undergraduate education mission of the campus. Ours is an ancient discipline, and much of the undergraduate program is spent learning theoretical physics from a hundred years ago or more. Yet these ideas and concepts remain highly potent in the modern world and are equally challenging and rewarding to master. While studying fundamental physics concepts, our students are exposed to the latest cutting-edge research and concepts concerning the physics of the small (nuclear processes, atomic struture, particle searches, and cellular processes) and the large (dark matter, dark energy, cosmology). Our majors are trained in the techniques of experimental physics, and we have recently dramatically expanded our training in computational physics.

We are in the process of updating our undergraduate curriculum, as described below. The catalog description of the major provides an accurate overview of the program, and the proposed undergraudate curriculum update includes updates to the catalog to maintain its accuracy under the new program.

Our department is distinguished from other departments in the cluster by the requiremenst of the most vigorous introductory physics courses, a diverse upper-level curriculum that develops physics concepts which appear nowhere else on campus, and a vigorous and sustained emphasis on fundamental concepts and anlytic thinking. The program learning objectives specific to our major are described in detail below.

Undergradudate Curriculum Update (UCU): The physics department, led by the undergraduate curriculum committee, has been developing over the past five years on an update to the undergraduate physics curriculum. The proposal was subjected to an extensive vetting process that involved assigned department readers who were not involved in formulating the initial plan. The proposal was unamimously supported by the department in a December 2021 vote. All new amd modified courses have been approved in the UC Davis Integrated Curriculum Management System (ICMS). We are working toward final approval, by campus, of proposal during AY 2023-2024.

The proposed changes to our program reflect three main observations about our current program:

- Workload over four years of study was imbalanced, with too few physics courses in the sophomore year, and too many in the junior year.
- Integration between transfer students and four-year students, who have somewhat different backgrounds, needed to be improved. Our recent departmental Climate Survey confirmed this by showing a huge satisfaction gap between the groups.
- The curriculum did not reflect the explosive growth in computational methods and their applications.

There are many other aims of the update, but these are the primary motivations.

The proposed undergraduate curriculum update will be widely referenced throughout this document by the acronym UCU. The proposal itself is far too ponderous of a document to include as an appendix to this document. It will be provided as a stand-alone file. The latest version of the proposal is also available for download online[1].

Program Learning Objectives: Although we did not use the specific term program learning objectives (PLOs) in that document, these objectives were carefully considered as part of the development of the UCU (see Sections 4-6 in particular).

There are a number of objectives that are both widely applicable and central to the discipline of physics, most of which are reinforced in nearly every physics course that a physics major takes:

- Using logic and analytic reasoning to make predictions.
- Applying general principles (e.g. conservation of energy, symmetry) in specific situations.
- Testing results using dimensional analysis and limiting cases.
- Dividing complex problems into manageable steps.
- Establishing feedback to determine if something is working or not.

The next set of objectives are related to mathematical preparation:

- Understand the theory and practical application of differential, integral, and vector calculus, linear algebra, ordinary and partial differential equations. (MAT 21ABCD, 22AB, and PHY 104A.)

While these concepts are first introduced in those courses, they are continuously reinforced throughout the major. The second set of objectives are related to theoretical physics, students are expected to acquire a working knowledge of the theory and practical application of the following core topics:

- Classical Mechanics (9A/9HA,105AB): the fundamental principles of physical laws (e.g. least action and symmetries) are taught in a familiar and intuitive context.
- Electromagnetism (9C/9HD,110AB): a remarkable special case of classical phenomena that anticipate non-Newtonian physics (e.g. special relativity, gauge theories). No other force in nature can be understood so completely in such a straightforward fashion.

[1]See https://github.com/mulhearn/classwork/blob/main/curriculum/curriculum.pdf and use the download option to view the entire document from the pull down menu to view the entire document.

- Quantum Mechanics (9HC/9D,115AB): the rules governing the microscopic world are different from those governing our familiar macroscopic world. The rules are not intuitive but they can be codified and used to make quantitative predictions which can be experimentally verified.
- Statistical Mechanics (9HB/9B,9D,112): the crucial statistical explanation for how microscopic laws ultimately produce the macroscopic world which we inhabit.

A major focus of the curriculum update has been to devote more coursework to computational physics.

- Develop programming skills sufficient for tackling problems from computational physics (PHY 40,45)
- Apply the techniques of computational physics to problems from theoretical physics (PHY 110L, PHY 112L, 115L).

The next set of objectives are related to experimental physics:

- Learn how to conduct and report scientific experiments (PHY 80,117,118,122A/B)
- Gain practical hands-on knowledge of lab equipment, electronics, and technical troubleshooting (PHY 80,117,118,122A/B

The objectives is for student to apply what they have learned previously to advanced specialized topics such as nuclear physics, particle physics, condensed matter, and astronomy. We refer to these courses as capstone courses:

- Demonstrate mastery of physics by applying it to advanced topics (PHY 129AB, 130AB, 140AB, 151-155)

2 Outcome of Previous Program Review

Please list the recommendations made at the conclusion of the previous review (these may have been made by the review committee, Executive Committee and/or Dean) and comment briefly on the current status of the matters noted in the recommendations. Discuss any other significant changes in the major since the last review.

The committee report of the Undergraduate Instruction Program Review (UIPR) and the Review Team Report from the previous review are included in the appendix. These reports were a source of motivation for the UCU described above, particularly in the specific cases noted below. The reports identified strengths in our program, which we appreciate, but in this overview, we will address only the identified weaknesses:

- **Space, Lab Conditions and Maintenance:** the review team was concerned that the undergraduate lab space was "shabby and in need of renovation". Within the UC, the cost of building renovations is shockingly expensive[2], and the university funding available for renovations is limited. Fortunately, we have received vigorous support from campus with several sizable grants for both equipment and renovations, for which we are deeply appreciative. This issue is discussed in more detail below (Section 4)

[2]Even by the standards of cost-of-living-numbed California residents

- **Transfer Student Readiness:** the review team was concerned that a large fraction of incoming transfer students were not prepared for a physics major, and were dropping out or changing major at a high rate. Following the recommendations of the review team and committee, we began selective major review in time for academic year (AY) 2021-2022. The department has since seen a substantial drop in transfer enrollment at a level that we find potentially troubling, if it persists. This is dicussed in more detail below (Section 5: Students in the major). **Improving the experience for incoming transfer students was a major focus of the UCU.**

- **Computational Instruction:** The review team noted that programming coursework students were taking outside of the department was not adequately training our students in computational physics. **Expanding the role of computational physics in our major was a central focus of the UCU** and we have added to our curriculum several new required courses focused on computation physics. This is described in more detail below (Section **??**: Major strengths and weaknesses).

- **Academic Advising:** The review team noted low satisfaction with campus and department advising. In this report, we note that student satisfaction with advising has improved, most noticably with respect to faculty advising. The likely contributions to this improvement, as well as some lingering concerns, are described below (Section 6: Student perceptions of the major).

- **PHY 122: Advanced Physics Laboratory** the review team was concerned that students were generally poorly prepared for this upper division lab course. Following the recommendations of the committee, we have introduced a new course (PHY 80: Experimental Techniques) as a prerequisite for PHY 122. **As part of the UCU, PHY 80 is now a required course for all physics majors (not just those taking PHY 122).** This is ciscussed in more detail below (Section **??**: Major strengths and weaknesses)

- **PHY 157:** The review team noted that demand for PHY 157 is greater than it's capacity. Regrettably, and despite deligent effort by Prof. Tucker Jones in particular, we have struggled to maintain the same level of throughput in this course, due to the retirement of the previous instructor. The pratical challenges here and future plans are discussed below (Section **??**: Major strengths and weaknesses)

- **Communication Skills:** The review team reported anecdotal evidence of student dissatisfaction with the level of development of skills in writing and oral presentation. Although this concern has not been treated with same level of priority as the concerns above, we discuss this issue, along with related concerns about creativity and qualitative reasoning, in more detail below (Section 6: Student perceptions about the major.)

We have taken the concerns raised during the previous review quite seriously, and have made as much progress as we could manage, too the clear benefit of our department, including our students. We therefore look forward to a fruitful collaboration during this review as well.

3 Faculty in the major

Questions: Who does the bulk of teaching in the major? What are the demographics of instructors in the major? Will the program be affected by substantial changes in

the faculty (e.g. anticipated retirements) in the next review period?

This section refers to tables which are available in the Appendix. We use a compact notation, where, for example, [B3] refers to Table 3 in Appendix B. The program was provided with an explicit list of items to discuss. To increase readibilty, we discuss the salient issues in the most natural order first. At the end of this section, we include a "Discussion Checklist" which indicates where each discussion point was covered, using the original enumeration (a-e) of topics provided in the original prompt. We have omitted the original prompt to increase readability. TODO: copy to other sections as needed.

Our teaching responsibilities are evenly shared by the faculty, and the demographics of our course instructors largely reflects the demographics of our faculty. A long period of limited hiring has put the department in a very uncomfortable position: new hiring is not keeping up with retirements and the size of the faculty is shrinking. This contraction is occuring when the number of physics majors, and demand for introductory physics courses by non-majors, are both increasing.

Rank and Age of Faculty: There are clear trends revealed in [B1-2]. The Physics department faculty is significantly older than the the average for the L&S, and the size of the faculty is shrinking. These trends are correlated: retirements are outpacing new hires. While these numbers do not reflect our most recent hires (Profs. Matthew Citron and Nancy Argawal) even this recent brisk pace of hiring has not been fast enough to avoid a shrinking department. Retirements have also left us with no LSOE (lecturers with ladder-rank) faculty at present.

A significant obstacle to hiring at an even faster rate is the availability of startup funding. Under the current budget model, the physics department will struggle to maintain a pace of one hire per year, a pace which would lead to size of the physics faculty shrinking further.

Diversity, Inclusion, and Equity: The data provided in [B3-5] is incomplete, so we will address the topic of diversity of the faculty in purely qualitative terms. Most importantly, our faculty is overwhelming supportive of taking strong measures to to improve the diversity of our faculty within the limits of what we are legally allowed to do. We are not looking for quick and easy fixes. Instead, we have been studying and adopting best-practices in hiring. For example, our two most recent faculty searches were intentionally broadened in scope, as this has been shown to increase the diversity of the applicant pool. As another example, we have started providing zoom interview questions in advance, as well as more details about the interview process in general, because evidence shows that members of URGs are systematically disadvantaged when such details are assumed to be already known. As is often the case when adopting best practices, we found that these steps have also made the interview process better overall. For example, when provided with the questions in advanced, applicants gave better, more thoughtful, and more useful responses. This remains an urgent issue, and their remains much to be done here.

Discussion Checklist: (a-e) Discussed above [B1-5].

4 Instruction, advising, and resources in the major

Questions: How effective is the delivery of instruction in the major? Are faculty

engaged in the major? Is advising adequate? Is there adequate staff support? Are adequate space and facilities available? Is the program keeping pace with developments in the field? Are grading standards appropriate? What is the role of virtual and hybrid courses in this major? Please attach or include here a sample 4 year graduation plan for your program.

Our highly-engaged faculty is dedicated to delivering effective instruction to our students, and we adhere to rigourous academic standards with respect to grading. While we do face challenges from limited resources, overall we find that advising, staff support, space and facilities are all adequate for our purposes. In the sections that follow, we attempt to provide evidence to support this bold assessment, as well as call out areas where we hope to do better than "adequate". Undergraduate physics is largely focused on the cutting-edge theoretical physics of a hundred years ago or more. But yet we do stay relevant in the modern world: those old ideas remain challenging to master and highly potent. Our multiyear continuing commitment to the UCU is strong evidence that we continue to innovate within our ancient discipline. One exception: outside of emergencies, we have no plans to include virtual or hybrid courses in our program, as we have found, for our discipline, that no reasonable amount of effort can produce such a course which is as effective as learning in person (See Section **??**). Sample four-year graduation plans (as well as two year plans for transfer students) are provided for every major and specialization, in the UCU. See Table 6 in that document, for one example[3].

Grading Policy: The grade distribution in [B12] shows that physics (and chemistry) are grading significantly more strictly than L&S overall, which is a conscious decision on our part. Our adherence to rigourous academic standards adds significant value to the physics degree, and to physics coursework in general. For example, our top students are regularly accepted into top graduate programs, likely in part because the A's they receive in our courses represent a meaningful accomplishment. We are concerned about the ability of UCD to continue as a forefront research institution and engine of social mobility if the grade inflation that we see in L&S overall is allowed to continue or accelerate.

Instructors: Our department prioritizes providing physics majors with ladder faculty instructors, particularly for upper-division coursework. The student FTE per faculty FTE is increasing [B6]. This is the result of both an increase in the number of physics majors and a decrease in the number of faculty. Despite the challenges from a shrinking faculty, physics majors are being taught by ladder faculty [B9-10] for 90% of their upper division coursework, a larger fraction than any other L&S department considered this cycle. Undergraduate physics majors are being taught by ladder faculty for 58.5% of their physics coursework, also above average for L&S.

For introductory physics coursework, we also utilize the highly-effective pedagogy of Continuing Lecturers. Dr. Dina Zhabinskaya manages the PHY 7 series (introductory physics aimed at bioscience) and Dr. Weideman manages the PHY 9 series (introductory physics aimed at natural science and engineering). They are both deeply committed to innovative pedagogy, are great assets to our department, and regularly share their wisdom with the rest of the faculty. We regularly hire unit-18 pre-six instructors as well. Some of our graduate students are interested in more extensive teaching experience than typical TA assignments afford, and, when we believe they are up to the challenge, we also hire Associate Instructors to teach in PHY 7 and 9.

[3] We can update this report with one example included here if requested.

Staff Suppport: Physics is a unique discipline with its own unique culture, and we are profoundly grateful to the staff members that work alongside us to maintain it. (TODO: Discuss with Tracy how we would like to describe the adequacy of staff support overall, Mike can meanwhile describe the key players in instructional support)

Instructional Space, Equipment, and Facilities While total assignable space has increased [B11], it has not been faster than the number of student FTEs has increase. The overall amount of assignable space is above average for L&S, but this reflects our need for dedicated laboratory space, and large lecture halls adjacent to demonstration support. As discussed in Section 2, the previous review noted a deficiency in the condition of the lab space used for undergraduate instruction. Fortunately, we have received vigorous support for acquiring new instructional equipment and renovation of lab space. (TODO: get detailed list from Tracy, e.g. 122 renovations, new computing room, equipment grants, computing lab, etc.)

Collaboration with other programs: Physics (like Mathematics) is a foundational discipline for most Science, Technology, Engineering, and Math (STEM) disciplines. Nearly every STEM discipline trains its students in our introductory physics courses. Physics itself is a rather unique discipline, and we have little competition from other fields to consider. Instead, we focus on collaboration, which is much more useful. We have a wide range of applied physics majors which afford students the opportunities to study complementary specialized topics (e.g. computer science, atmospheric science) outside of the department. The UCU strengthens those majors by affording more flexibility with a more expansive list of specialized courses to choose from. Our new coursework in computational physics (particularly PHY 40: Introduction to Computational Physics, a course with no college-level prerequisites) focuses on the bare minimum of programming techniques necessary to tackle challenging physics problems (See Section **??**). It moves very quickly from "introductory programming" to "computational physics". This makes the course highly complementary to coursework in the Computer Science and Engineering department, and the markedly different emphasis may be of interest to other disciplines as well.

Discussion Checklist: (a) Discussed above [B6]. (b) Nearly 70% of students enrolled in upper division physics courses are physics majors [B7]. The other students are from a wide variety of other departments, and their willingness to tackle these challenging courses illustrate the broad appeal of physics. (c) There is an expected increase [B8] in the number of TAs that resulted from new courses, particularly PHY 80, PHY 40 and PHY 45, which require significant TA support for lab sections, as well the addition of discussion sections to some core upper division courses. (d-e) Discussed above [B9-10]. (f) Discussed above (Instructional Space, Equipment, and Facilities) (g) Discussed above [B12] (h) Discussed above (introductory remarks) (i) Discussed above (Staff Support) (j) Staff advising is discussed in Section 6 (Academic Advising). (k) Discussed above (Instructional Space, Equipment, and Facilities) (l) Discussed above (introductory remarks) (m) Discussed above (Collaboration with other programs) (n) Discussed above (introductory remarks).

5 Students in the major

Questions: This section is intended to characterize the students in this major. How have enrollments in the major varied over the period of the review, in terms of both the numbers and quality of the students? Are students succeeding in the major both

in terms of qualitative and quantitative academic standards? Are students graduating on time? Are there impacted classes (e.g., with limited offerings or long waitlists) or other bottlenecks that unnecessarily impede student success? How do students find out about the major? Is the major reaching a wide and diverse spectrum of students? Are students who enter the major retained in the major, and if not, why not?

As described in detail below, during this review period, the undergraduate program has grown in both size and diversity. We do not plan to increase the size any further, but we do hope that the diversity will continue to increase. By most measures are student academic achievement, physics students are performing just slightly below the average for L&S, which is a notable accomplishment given that we have established physics courses are graded significantly more stringently then L&S on average. The most concerning metrics are a dramatic drop in transfer student admissions to eight total in AY 202-2023, and a four-year time-to-graduation for 73% of physics majors, which is significantly lower than for L&S overall (85%). The UCU includes a number of changes to our program, including the removal of bottlenecks, that we expect to impact these and other metrics. However, it is too soon to judge the efficacy of these changes. Looking at the available metrics all together, we see that our program is successful at attracting, retaining, and graduating students.

The primary source of information about our major is the department website, the UC Davis course catalog, and the undergraduate academic advisor. We do considerable outreach with our students to keep them on track. This is all discussed in more detail in Section 6 under "Academic advising".

Size of the undergraduate program: The number of physics and applied majors has been growing, as the result of a mutual agreement between the university and department to begin admitting about 50% more students into the program starting in time for AY 2019-2020. This amount was targeted as the maximum number of additional students that physics could handle without the need for additional lecture sections in core physics courses. This increase is the main trend evident in [B13] and [B17] Taking applied physics and physics together, the number of international students in physics [B25] has increased by roughly 25%, consistent with the increase in L&S. To accommodate the increase in the number of students, we added TA-led discussion sections to some of the upper-division physics course courses, which is something physics majors had been requesting even before the class size increase. These tables also put the ratio of applied physics to physics majors historically at 1:2, but of late the share of applied physics majors appears to be growing.

Diversity of physics majors: Combining physics and applied physics majors, the fraction [B15] who are women has increase just slightly during the review period, while the fraction of women in L&S overall has decreased by about 3%. Again combining physics and applied physics majors, the fraction [B16] who are from underrepresented groups (URGs) has increased from 14% to 19%. When the number of majors is accounted for, the increase in the number of women is not statistically significant, but the increase in the number of students from URGs is statistically significant.

Double majors and minors: There has been a noticable increase in the number of physics majors who are double majors [B14] but the rate is still lower than the average for L&S. We expect that this reflects the challenging nature of the physics major. The number of applied physics majors who are double majors has remained even lower, and we suspect this reflects that applied physics majors already complete significant coursework outside of the physics department. Physics advisors do not actively encourage double majors. In our experience, double majors in physics have very little flexibility left in their schedule to pursue other interests and electives. We do heartily encourage minors, but yet very few physics complete one [B24].

Transfer students and their experience: As discussed in Section 2, the previous review was concerned that a large number of incoming transfer students were not prepared for a physics major. Following the advice of the review committee, the department started selective review of transfer students in time for AY 2021-2022. Our hope is that by selecting students that are more likely to succeed as physics majors, we will continue to graduate transfer students as physics majors at approximately the same rate, while dramatically reducing the number of students who drop out of the program. A major focus of the UCU was improving the experience of transfer students, by leveling out their coursework in the first year to avoid a "brick wall" of intense coursework that previous students faced in their first quarter. It is too early the judge the effectiveness of any of these majors.

Omitting AY 2020-2021 from consideration due to the pandemic, we see that since AY 2021-2022 there has been a siginficant drop [B18] in the number of new transfer students, which reflects the lower acceptance rate due to selective major review. However, we are concerned by the size of this reduction: there were only eight new transfer students in AY 2022-2023. This is a much larger drop than the (still sizable) 35% reduction of transfer student in L&S overall.

A significant number of transfer students in applied physics and physics require an additional year to graduate: only 22% of applied physics majors and 41% of physics majors graduate in two years as intended [B22]. This is significantly lower than 64% for L&S overall. Improving this experience for transfer students was a major focus of the UCU.

We believe it is too soon to draw any conclusions about the changes to our program that we have made which impact transfer students. However, we have made a request for reports of additional metrics pertaining to transfer students[4] We plan to scrutinize these statistics to judge the impact and efficacy of these changes to our program.

Student Academic Performance: The average GPA [B19] of physics and applied physics majors is around 3.2 but varies as lows as 2.8 and as high as 3.3 depending on the class and major. This is slightly lower than the average for L&S (3.3). This likely reflects the fact that physics majors take more physics courses, which we have already established are generally graded more stringently than courses from other departments in L&S. In [B20] we see qualitatively similar results with respect to the fraction of students in good standing, which rangest from 79% to 94% depending on the class and major, and is slightly lower than L&S overall. We see a slight increase in degrees conferred [B21], for both physics and applied physics majors. When the data for AY 2023-2024 is available, we should start to see an increase due to the larger number of physics majors.

Looking at time to graduation [B23] for students that remain physics majors the entire time, we see that 83.3% of applied physics majors and 72.7% of physics majors graduate within four years as planned. That rate for physics majors is significantly smaller than the average for L&S (84.5%). This is integrated from 2016 to 2022, which makes it somewhat difficult to interpret. We should monitor this metric over the next few years to see if there is a persistent problem here to address. We do expect that time-to-graduation for nominal four-year students should decrease as a result of the changes in the UCU, which includes changes that remove stalling out of four-year students in their sophomore year. But it is too soon to judge the efficacy of these changes.

[4] Perhaps we will have historic data in time for the site visit...

Discussion Checklist: (a-m) Discussed above [B13-25] (n-o) Discussed above (introductory remarks)

6 Student perceptions of the major

Question: What are current students' and recent graduates' opinions of the major?

Our students' opinion of the physics and applied physics majors are for the most part consistent with college averages, within the limited statistics available from survey responses. In the dicussion that follows, we note some areas of encouragement and concern, and include anecdotal data where pertinant.

Interpretation of student feedback: Soliciting feedback from students is a useful and important diagnostic tool, but the results must be carefully interpreted. We know that student evaluations reflect significant implicit biases[5] and are strongly correlated with student perceptions of their course grades. For example (referring [B12] and [C29]) we are not surprised to see that the music department is an outlyer with respect to both grading (85% of letter grades are A's) and student satisfaction with faculty instruction (88%). In the physics department, 33% of letter grades are A's and student satisfaction (amongst junior and senior physics majors) with faculty instruction is a more modest 67%. We should not conclude that the music department is performing any better (or worse, for that matter) than the physics department, only that our approaches are different, likely reflecting the different needs of our students.

Limited Statistical Uncertainty from Alumni Responses We also need to be careful not to draw sharp conclusions from samples with limited statistics. There were very few responses collected from physics alumni: three from applied physics majors and 17 from physics majors. We have carefully checked all of the alumni responses [C12-22], [C31-36], [C41-43], and [C49-54]. Amongst the questions, the only ones which yielded a statistically significant deviation from the college average were:

- Questions [C18], [C21] and [C22] none of which we found to be illuminating.
- Questions [C31] and [C32] where we do see (borderline) statistically significant dissatisfaction with the grading system and use of information technology.
- Question [C43] which references peer advisors, which we do not have in physics.

Maximizing Statistical Uncertainty from Student Responses: To maximize the sample size from current students, we have included all years in the survey result (the default results include only juniors and seniors). We have also computed a weighted average of the responses from both applied physics and physics majors. This combined sample has a size of N=61 (with a slight variation from question to question that has been neglected from our analysis) from which we estimated a naive binomial statistical uncertainty. The results are reported in Table 1.

[5] See, for example: Kreitzer, Rebecca J. & Sweet-Cushman, Jennie (2021). Evaluating Student Evaluations of Teaching: a Review of Measurement and Equity Bias in SETs and Recommendations for Ethical Reform. Journal of Academic Ethics 20 (1):73-84.

Table 1: Survey results from Appendix C, using results from freshman through seniors, combining results from physics and applied physics majors. The sample size is N=61 from which a binomial statistical uncertainty has been calculated. Results as a percent are organized by question (Q) and the results for physics and applied physics majors (Physics) are compared to the College (L&S).

Q	Physics	L&S	Q	Physics	L&S	Q	Physics	L&S	Q	Physics	L&S
C1	90 ± 4	91	C5	55 ± 6	64	C23	53 ± 6	76	C38	55 ± 6	52
C2	91 ± 4	90	C6	71 ± 6	74	C24	84 ± 5	68	C39	56 ± 6	47
C3	79 ± 5	85	C7	57 ± 6	60	C25	84 ± 5	73			
C4	89 ± 4	93	C8	78 ± 5	79	C26	82 ± 5	76	C44	46 ± 6	37
			C9	30 ± 6	46	C27	48 ± 6	61	C45	52 ± 6	56
			C10	68 ± 6	69	C28	39 ± 6	49	C46	41 ± 6	54
			C11	69 ± 6	69	C29	52 ± 6	66	C47	55 ± 6	59
						C30	75 ± 5	61			

Understanding of the major: Using the combined survey results in Table 1 we see that understanding of the major [C1], program requirements [C2], program policy [C3], and accuracy of the catalog [C4] were all comparable to the L&S average, with the last two being low by about one standard deviation. Even though there is therefore no statistically significant evidence to support the claim, we do suspect there may be some student confusion in the context of the UCU. For example, we have begun teaching newly approved courses, even though they are not yet required by the major, as the UCU has not yet reached final approval. We have done our best to communicate the situation to our students, and we are encouraging them to take the new courses even though they are not required yet. We would not be surprised if some confusion exists in this context. We plan to complete the approval process and make the necessary catalog updates as soon as possible, at which point we are confident that any confusion will begin to dissipate.

Satisfaction with major: Using the combined survey results in Table 1, we see that the responses from our majors regarding fair treatment [C6], faculty access [C7], ability to get into major [C8], library resources [C10], and overall satisfaction [C11] were all consistent with college averages within statistical uncertainty of the survey sample. As discussed above, there are no statistically significant results from the alumni survery that warant further discussion.

Our majors were less satisfied ($30\% \pm 6\%$) than the college average (46%) with respect to [C9] “Education enrichment programs”. In the current program, it is nearly impossible for our majors to study abroad, which likely contributes to the observed student disastisfaction. In the UCU, four-year students have sufficient flexibility that more students may find it feasibile to study abroad. The department does provide other sources of education enrichment, such as student research, and it would be illuminating to probe student satisfaction with specific avenues of enrichment.

Our majors were less satisfied ($55\% \pm 6\%$) than the college average (64%) with respect to [C5] the “faculty being open to discuss students’ needs, concerns, and suggestions”. Even though this is just barely more than one standard deviation from the college average, it is dissapointing to learn that so many students feel this way. This is something we should consider as a faculty.

Satisfaction with Instruction Using the combined survey results in Table 1 we see that our majors believe plagiarism is not being adequately explained [C23]. We encounter plagiarism most frequently in physics courses through the use of online websites, such as Chegg, to provide answers to homework questions. There is growing evidence that using sites such as Chegg for cheating expanded during the pandemic and hasn't receded. We wonder if the low score here is reflecting student and faculty disagreement as to what constitutes plagiarism, or, conversely, if it indicates students concerns that we are not doing enough to discourage and condemn this relatively new form of cheating. Clearly more discussion between students and faculty is needed about cheating.

The results of [C24-26] show that students believe they are well practiced in recalling, explaining, and analyzing concepts, methods, and ideas. However, when it comes to qualitative judgement [C27] and creativity [C28] physics majors reported lower than average practice, which we discuss further below.

Our majors are quite well satisfied with their TAs ($75\%pm5\%$) compared to the college average (61%). This is heartening, if not surprising. TA's are most often cast in roles which directly support students, helping them work through their homework problems in discussion sessions, for example.

Satisfaction with faculty is lower ($52\% \pm 6\%$) than the college average (66%). This is concerning and warants a closer look at the data. If we consider physics majors only, and restrict ourselves to junior and seniors. we we see 67% are satisfied with faculty instruction, just a bit higher than the colleage average. Further investigation confirms that the heightened dissatisfaction comes from two contributions: current freshman and sophomores, and all applied physics majors.

One major difference between applied physics and physics majors is the amount of coursework that is taken outside of the department. We are well aware of the frustration that applied physics majors are facing in completing their coursework outside of physics. Perhaps part of the dissatisfaction stems from this. The UCU aims to give applied physics majors more flexibility which we hope will improve this stuation. In any event, it is clear that additional outreach with applied physics majors and physics majors in lower division courses is needed to determine the root causes of this elevated dissatisfation.

Academic Advising: The satisfaction of alumni with advising was all consistent with the college average, within the statistical uncertainy of the sample. The only exception was a question regarding peer advising, which physics does not provide. Amongst our majors, using the combined sample of Table 1, we see that students are satisfied with the quality of academic advising (55% ± 6%) slightly higher than the college average (52%) and with access to academic advising (56% ± 6%) higher than the college average (47%). Only the latter is (borderline) statistically significant.

These results are encouraging. As discussed in Section 2, low satisfaction with advising was noted by the previous review. We believe we understand the source of the improvement, based on our own anecdotal data from individual student interactions. Most importantly, Prof. Boeshaar runs a physics career seminar and Prof. Know runs an alumni speaker seminar. These are not required courses, but the scope of discussion typically extends to academic advising, particularly for subjects that students are concerned about. Secondly, the staff undergraduate advisor, Amy Foelz and the vice-chair for the undergraduate program, Prof. Mulhearn, have devised a highly effective triage system, whereby typical issues are handled by Foelz, and more complicated problems are immediately kicked up to Prof. Mulhearn. We have found this arrangement to be quite effective. Foelz also arranges multiple annual outreach events (pizza nights) which provide a forum for academic advising. Prof. Mulhearn is an annual speaker in the physics career seminar. Lastly, a significant number of students participate in undergraduate research, and research advisors are a natural source of academic advice as well. Our attempts to impose a more top-down assigned faculty advisor had lackluster results, with a clear lack of student and faculty interest, which was compounded by the pandemic. Fortunately, it seems that our more organic, fully optional avenues for academic advising are proving to be effective. Prof. Boeshaar is continuing to play her pivotal role past her recent retirement, but we cannot expect this to continue indefinitely.

Course Offerings: Using the combined data sample from Table 1, we that our students rated access to small class sizes [C44] higher (46% ± 6%) than the college average (37%). Our students rated the availability of courses needed to graduate [C46] at lower (41% ± 6%) than the college average (54%), and this lower level of satisfaction is present for both physics and applied physics majors. Anecdotally, we are aware that applied physics majors stuggle to schedule their coursework outside of the department. We are addressing this problem in the UCU by increasing the number of choices available to applied physics majors for their coursework outside of the department. We are also discussing with the computer science department the possiblity to give higher priority to our applied physics (computational physics) majors in their impacted courses. We are also aware that physics majors struggle to schedule advanced physics labs, and we are attempting to improve throughput in these courses as well. We offered a fall section of advanced physics lab for the first ime in AT 2023-2024. We have also begun renovations to provide more space, and are adding additional lab modules, toward increasing the number of students in each section. Our students rated the availability of general education courses [C45] and the variety or courses [C47] at levels consistent with the colleage average within the statistical uncertainty of the sample. The alumni responses were all consistent with the college average within the statistical uncertainty of the sample.

Communication, Creativity, and Qualitative Judgement: TODO Communication was mentioned as a concern in the previous program review. Addressing this deficiency immediately runs into several major practical challenges. With a throughput of order 60 students per year, even having each student provide a 15 minute presentation would be a commitment of 15 hours: 50% of standard lecture course. As we are limited in the number of units which we can require of our majors, we have already made difficult cuts to required coursework. We don't see a way to definitely address this problem that doesn't include either (1) an increase in the number of units we are allowed to require for our students, or (2) improving the quality of GE instruction so that students receive adequate training in writing and oral commmunication as part of the 50% of the coursework they complete outside of their major requirements. However, one anticipated outcome of the updated curriculum is that four-year students will have more time for elective offerings in physics. We think therefore, that an incremental way forward here is to provide an elective course designed to provide more opportunities for practicing scientific communication.

and applied physics major reported significantly lower than average practice. This is disappointing, if not entirely surprising. A large fraction of the undergraduate physics degree is invested toward understanding well-established theories which more mostly developed a century ago or more. Problems for these theories which have exact analytic solutions are limited and so students invest a lot of time solving problems that have been being solved by students for a century or more as well. This paints perhaps too bleak a picture, as instructors do labor to breath life into their subjects every quarter, but they are facing strong headwinds, and these results most likely reflect those headwinds. One are of the undergraduate physics degree where creativity and qualitative judgement is more naturally exercises is in computational physics and experimental physics. Here students devise and debug their own code or experimental apparatus, face new problems not constrained to those with exact analytic solutions. It will be interesting to see if the improvements and increased focus on these subjects in the curriculum update will lead to students getting more practice in these topics.

Discussion Checklist: (a-e) Discussed above [C1-52]