Introduction

On March 10\textsuperscript{th} and 11\textsuperscript{th} 2014 the committee conducted a site visit to review the undergraduate program of the Department of Physics at Oregon State University. The committee met with the Department Chair and Head Adviser, the Dean of the College of Science, faculty in the Paradigms, graduate and undergraduate Teaching Assistants, prospective physics teachers, faculty in lower division courses, the (former) interim dean of the College of Science, and undergraduate students. On March 11\textsuperscript{th}, the review committee met with the Dean of the College of Science and the Senior Vice Provost to share initial impressions and findings.

In preparation of this report, the review committee benefited greatly from the in-depth Departmental self-study, which was prepared for this purpose, as well as materials pertaining to the review of the graduate program of the Department, which had been independently conducted within the past two years. The Office of Academic Programs, Assessment, and Accreditation provided the committee with invaluable assistance, including institutional data and policies to facilitate our understanding of the context in which the Department of Physics operates.

I. Institutional Context

The Physics Department has benefited from faithful leadership from its current and former chair over three decades. This, on one hand, has helped the Department weather significant funding cuts, several retirements and reduced tenure lines, while, on the other, it has fostered an environment that made a close collaboration among faculty at the upper division level into a national exemplar.

Faculty

The Department currently has 15 tenured or tenure-line faculty with a range of experience levels, with major research areas of solid state physics, optics, physics education research and biophysics. In addition, there are six fixed-term instructors with varying levels of experience. A net of four faculty were hired in 2000-2005 and five faculty were hired in the past 3 years resulting in a relatively young Department. Three of the faculty are tenured women, a proportion greater than the national average of 14% overall as reported in 2010.

The faculty is to be commended on the well-integrated, focused, collaborative culture that has been fostered. This culture is reflected in research activities both outside and within the Department, particularly in the development of Paradigms. This curriculum should
be regarded as a major strength of the Department and a standard that other physics programs nationwide aspire to. The faculty are justifiably proud of their achievements in the area of physics education research and curriculum development.

Faculty hires have been targeted to build critical mass in key areas while entering into new and growing areas, such as biophysics. The recent departure of a tenure-line faculty in the area of physics education research was a loss for the Department. The development of a Department strategic plan would facilitate the development of both the undergraduate and graduate programs and due consideration should be given to someone in the area of physics education research.

**Students**

The number of majors per faculty member is large relative to other PhD-granting physics departments. It is approaching the size the faculty can reasonably service given their commitment to undergraduate research mentoring and the structure of their upper-division courses. In particular, the current Paradigms resources could absorb a handful of additional majors. Any significant increase would have to be accompanied by additional faculty and facilities.

The characteristics of the students are not dissimilar to that of the general campus population. The first to second-year retention rate is 86.3% (Physics) vs 84.2% (OSU total). The six-year graduation rate is 62.6% (Physics) vs. 61.5% (OSU total). The prevalence of women majors seems to be slightly lower in physics than the national average. The ethnic breakdown of majors reflects more-or-less the local demographics and is lower than the national average.

The diversity of the faculty provides a welcoming environment for women and minorities. Women students report that the Department provides a supportive environment and the presence of good role models is a key factor in retention and ultimate success.

These reports make the low percentage of women in the major a bit puzzling, especially in the presence of four excellent female role models among the faculty. The strongly cooperative ethos of the Paradigms experience suggests that the Department may be losing some women and minorities before the junior year. We recommend a careful analysis of the pipeline from the START advising to the end of the lower division courses. Understanding why women and minorities in the entering class choose to leave physics will provide invaluable information to the Department.

**Administration**

The Department has been very capably led for the past sixteen years. This is considerably longer than the tenure of most physics Department heads or chairs, but the sustained leadership has been very beneficial in the case of OSU. The Department Head seems to be well-respected by his colleagues in the Department and has done an admirable job leading the Department through both lean and good times.
The internal culture of the Department is excellent. Relationships between faculty, instructors, administrators and staff are excellent. There seems to be an environment where faculty members can and do engage in lively discussions but still come to a consensus on important issues. Students respect the faculty and have good informal relations with enough of them to get effective advisement. Both faculty and student input on curricular structure is taken seriously in efforts to be excellent in undergraduate instruction and mentoring.

We were particularly intrigued by the Physics 199 course, which was both developed and taught by undergraduate students (under faculty supervision) to meet a real need in advising. Faculty took this student suggestion seriously and helped students develop a significant improvement in an important area.

Department support of the local chapter of the Society of Physics Students also seems strong. This is a great way to connect students within the Department and give students opportunities to contribute to Departmental success. We were encouraged by the officer’s vision and efforts to enhance the undergraduate experience through peer mentoring, social connections, collaborations on homework, and other activities.

The communication and cooperation between faculty members in the Department was very evident. The idea of faculty learning communities was developed and refined in the Department well before it became in vogue nationally. Paradigms played a national leadership role in this regard. Since this program started seventeen years ago, the more recent hires were not around when this excellent collaborative reorganization of the upper division curriculum was undertaken. Through regular meetings to discuss the curriculum and excellent mentoring, the new faculty seem to have been well-integrated and sold on this curricular approach. The senior faculty have welcomed suggestions and innovations by their junior colleagues who have joined them in this effort.

The support staff has, until recently, been shared between chemistry and physics as an economizing measure. We think the decision to move office staff back to exclusive assignments within a single Department is wise given the different cultures of physics and chemistry. The IT support within the Department seems to be adequate to support both administrative, instructional, and research needs. The lack of adequate machine shop support within the Department has repercussions for both safety and research reasons. It seems the Department has been able to get by through use of machine shops in other Departments on campus, although this arrangement isn’t optimal.

One administrative challenge that faces the Department is its broken funding model. Financial necessities to close budget shortfalls result in pressures on the Department to make curricular decisions based on budget contingencies. For instance, there is pressure to offer more Ecampus and summer courses for purely budgetary reasons. Similarly, overhead from research grants which is returned to the Department is partially used to fund shortfalls in curricular funding. This money would be more appropriately spent to enhance the research infrastructure to leverage future grant proposals. We are concerned that such a use may be in violation of expectations of the funding agencies. We do not
disagree with exploring online and summer instruction for pedagogical or access reasons, but think the Department should be cautious about making sure the move does not degrade their excellence in undergraduate teaching.

Given the long tenure of the two most recent Department chairs, the current search which his underway for a new Department head is especially critical. We recommend that careful attention should be paid to the very healthy existing Department culture in the course of the search. If a highly qualified internal candidate can be found, they would have the advantage of seamlessly integrating into the existing Department culture. However, if an internal candidate is chosen as head, we recommend that the university provide an additional faculty position to compensate for the loss of a teaching position in an already understaffed Department.

We see potential opportunities for improving Departmental support through better cultivation of their alumni base. Current physics students highly value their educational experience at OSU and recognize the unique advantages they’ve had in the Department. Recent efforts to stay in touch with former students through LinkedIn are laudable and ought to be continued. In addition, faculty advisors should be encouraged to have continued contact with their students as they progress in their professional careers. Since the vast majority of the students come from and remain in Oregon, campus activities to involve alumni in physics events should prove geographically feasible. The quality of undergraduate research and education should provide a strong base in which to encourage alumni to share in furthering Department goals through financial contributions, student networking opportunities, and recruitment.

**Facilities**

The review committee toured the Physics Department facilities. Here are our findings:

The Weniger building is old. It is not as sparkly and new as anyone would like it to be. Physics is making the best of it, and doing it well.

Lab space is adequate for the student enrollment the Department has now. If there is an expectation that student enrollment will increase, the space needs to be enlarged.

In many of the labs, air conditioning is an issue. “Air flow” is not the same thing as “air conditioning.”

The Paradigms room is well designed. It is comfortable and welcoming. The whiteboards and the color-coded boxes with specific lab supplies are a nice touch.

The Department is making considerable use of computers. Most of them were obtained with TRF funds. They are replaced when they break (which gives them an approximate life span of about 8 years). We feel that the computers are so important to the pedagogy of the physics labs that they should be obtained and maintained more deliberately and strategically. There should be budget to create a more regular cycling of the computers, perhaps every 5 years, even if they haven’t broken down yet. In this scheme, the labs in
which computers are most important could get the first set of replacements, followed by the next set of labs, etc. Or, computer equipment could trickle down from one set of labs to another.

The idea of having a deliberate and strategic computer budget is also consistent with the likelihood that the TRF funding model is going to be changing, and will not be as reliable as it has been in the past.

The review committee encourages the Department to consider making a case for differential tuition to support the labs. Engineering does this already. We do not find the complexity of the Physics labs to be significantly different from Engineering’s labs.

The review committee encourages the Department to consider requiring all physics students to have a laptop. This is working well in Engineering. The price of laptops has been plummeting. This might take some of the pressure off the computer equipment in the labs. It also lets the students build up a physics software environment in preparation for when they leave OSU. If this is to be tried, there must be a standard set of software and settings that all students should get on their laptops. (Engineering has a “computer day” just before the start of the school year in which students bring their laptops in and IT specialists load them with all of the software the College has obtained a license for. This also seems to be working well.)

There obviously is very much a collaborative intra- and inter-cohort mentality among the students. Within a cohort, they all seem to know each other. Between cohorts, there is a culture of helping the next cohort. The Paradigms room is partially responsible. We feel that the SPS room and the other study rooms are also responsible. It is an excellent idea to have these rooms in the thick of faculty offices and the main office instead of in “wasted space” like we’ve seen in other units.

The Department feels that they need better access to a machine shop, with a machinist. Right now students and faculty do their own machining. This is possibly a safety issue.
II. Undergraduate Instruction

National Stature: Excellence in upper division physics learning

The Physics Department is nationally recognized for the upper division Paradigms in Physics curricular reform effort. The distinctiveness and strength of Paradigms lie in the distillation of the big ideas of physics into coherent units and the use of student-centered strategies to promote the development of deep and coherent conceptual structures. Non-physics audiences might not fully appreciate the uniqueness of this endeavor. At most institutions, upper division physics courses are almost indistinguishable, and have not changed appreciably for several decades. OSU’s paradigm (pun intended) is truly unique, and nationally recognized for being so.

In an iterative process that spans 17 years, Paradigms leaders honed the disciplinary experience for physics majors, invested significant effort empowering new faculty to teach in this model, and tirelessly disseminated the model at the invitation of the national and international physics education community. Paradigms, for instance, is the only upper division effort that is consistently invited to present at the annual National New Faculty Workshop that is sponsored by the American Physical Society, the American Association of Physics Teachers, the American Astronomical Society, and the National Science Foundation.

Equally significant in the world of physics education has been the collaborative process through which Paradigms has been developed, refined, and sustained. The Department-wide consensus arrived at serves as a model for emulation not just by physics departments elsewhere but STEM departments more generally. Long before the term Professional Learning Community came to be used, the Paradigms leaders embodied its meaning. And they still do, meeting as a group faithfully every three weeks to discuss and continue refining the student learning experience. Long before the term interactive engagement was ever relevant to upper division physics courses nationwide, the Paradigms leaders incorporated student-centered activities in all their junior and senior offerings.

The physics majors with whom the review committee met expressed the unanimous sentiment that the Paradigms experience was an OSU distinctive, extolled the camaraderie and professional identity that emerged from the experience, and articulated quite eloquently the goals of the program. The review committee interpreted this metacognitive sophistication of students as indicating that the students have internalized the goal for the reforms. Interestingly, some graduate TA’s expressed the opinion that the OSU undergraduate instructional program was superior to the physics program at their own undergraduate institution. These student impressions are consistent with the qualitative data collected in the exit interviews and the SET ratings in the 300- and 400-level courses. (Note on SET ratings: The committee shares the Departmental sense that student learning measures are more important than straightforward quotes of student evaluations of teaching. After all, there is some evidence that SET’s are negatively

These comments are also consistent with the review committee’s assessment of the situation. Paradigms is a university asset, which should be continued to be supported by the University. This is especially so because the mini-courses seem to be credit-neutral and faculty-time neutral compared to standard upper division physics offerings, whereas the resulting engagement of students in significant physics learning is much greater. Any departmental initiatives at the graduate or lower division levels should not be allowed to degrade the current upper division experience of the physics majors. In particular, if the Department seeks to increase the number of physics majors, new faculty and facilities resources will be needed to replicate the current experience, so as not to dilute it.

The Department has a unique student learning laboratory in the Paradigms. Most (if not all) physics Departments identify as a major goal of their undergraduate program “To teach students how to think like physicists.” It is the strong sense of the Department—and our committee—that this is achieved for many OSU physics majors. The committee encourages the Department to extend the PER scholarship that has already been brought to bear and describe what this means operationally, document effects on students, hypothesize mechanisms for changes, test such hypotheses, and disseminate the fine-grained results to the national community. OSU is in a privileged position to make this contribution to the field.

Local impact: Excellence in collaborative intra-institutional initiatives

The Physics Department has a lot of resident expertise in improving student learning in its own area of the STEM disciplines. The Department can contribute significantly to the University-wide Discipline-Based Education Research efforts. There is a national context for increased funding opportunities for such efforts. The Department can serve as a faithful partner in College-level initiatives, as well as in initiatives across several Colleges.

Learning in lower division courses

Courses for scientists and engineers The size of the faculty in the Department is small compared to its aspirational peer institutions. One of the unfortunate consequences of this is that only a small percentage of lower division physics courses at OSU are taught by tenure-track faculty. Several physics majors expressed the wish that Paradigms instructors were involved more closely with the PH21x and PH20x introductory physics sequences for engineers and scientists. Nevertheless, student learning in these two course sequences is comparable to that at other institutions that employ interactive engagement strategies in their introductory physics courses for scientists and engineers. Normalized learning gains on standard assessment instruments, which are widely used in the physics community, suggest that OSU students in the introductory physics course outperform (by almost 2:1) their peers who are taught in traditional lecture-based physics courses, accompanied by standard verification-type labs.
What is a bit surprising is that student learning data did not correlate strongly with the type of teaching (modified studio-style vs large-enrollment). We attribute this to the fact that the lectures in large enrollment classes do use some interactive engagement strategies, e.g., Harvard’s Peer Instruction. We support the Departmental decision to scale the studio course offerings to two per quarter and eventually to three per quarter.

One area of growth is the preparation of the undergraduate and graduate Teaching Assistants, especially those that serve at the lower division level. First-time TA’s are required to take a TA seminar, which is offered in Fall Quarter. (Optional teaching seminars are offered in Winter and Spring.) The research on TA preparation strongly suggests that TA’s require ongoing, systematic, job-embedded preparation. The TA’s with whom we met indicated that their preparation was strongly dependent on the individual faculty instructor. We recommend that the Department offer continuing support to TA’s (preferably as a credit-bearing, load-bearing course). The adoption of this recommendation is especially important if the Department pursues implementation of the Colorado undergraduate Learning Assistant Program, a plan that is strongly supported by the committee.

Courses for non-science majors The courses for non-science majors fall into two qualitatively distinct categories: PH111 (Inquiring Into Physical Phenomena) and large-enrollment courses. PH111 is taught by Dr. Emily van Zee and is required by all future elementary teachers. Dr. van Zee brings to this role extensive scholarly expertise in the preparation of elementary teachers. This excellent course is part of a coherent three-course sequence in physical science, earth science, and biology, taught in a way that is consistent with the goals for exemplary teacher preparation articulated by national science standards documents, including the Next Generation Science Standards.

To be sure, the large-enrollment courses for non-science majors are taught by earnest and enthusiastic instructors, who indeed feel appreciated in their role as an integral part of the Department. It seems, however, that some of the lower division courses are taught using traditional teaching styles as opposed to the active-learning engagement that occurs in upper division offerings. The committee did not receive detailed data on student learning in these courses. The Department would be served well by investing significant intellectual capital in assessing student learning in these courses for the goal of better leveraging the competence and professionalism of the instructors. Alternatively, the Department could consider offering these courses in an Ecampus format.

Note on Ecampus physics offerings: The committee shares the Department’s cautious approach to offering Ecampus courses. The documented pedagogical advantages of face-to-face interactions among upper division students or even students in the courses for scientists and engineers should not be sacrificed to alleviate budgetary stresses. If Ecampus offerings are to be considered, large-enrollment lower division courses for non-science majors is a good place to start, given that these courses do not contribute significantly to the national stature of the Department.

The committee encourages the Department to consider providing targeted opportunities to selected long-term instructors to participate in teaching the Paradigms. The short-term
cost in mentoring such instructors is likely to be outweighed by the long-term positive effects on coherence of the whole undergraduate experience. Furthermore, this move will enable upper division faculty to teach in lower division courses bringing a different sophistication to them.

III. Undergraduate Mentoring and Advising

Formal undergraduate advising has recently been handled by the Department Head. Based on conversations with Henri and with a group of undergraduates consisting mostly of juniors and seniors, the advising seems to be very effective, particularly during the students’ junior and senior years. The students said they felt the Head Advisor was well informed, approachable, and had good rapport with them as students. Many also mentioned how much they appreciate informal advising by other faculty mentors.

The university has a wise policy in which annual advising is mandatory for each physics major, enforced by a registration block. Students didn’t see this advising as perfunctory, but rather as a valued opportunity to get advice from a knowledgeable faculty member. As a committee, we were surprised that Dr. Jansen was able to handle the heavy responsibility of doing all of this advising himself. However, he indicated that he particularly enjoyed this role and, according to students, was doing a very good job at it. We see no need to change it.

Two specialized areas where advising could use some attention are providing students with career advice specific to non-academic careers and advising students in the physics teaching track. The Department seems to be aware of the specific issues associated with physics graduates getting industrial jobs, but some of the students were unaware of how they could get this information. Some improvements in connecting students with alumni in industrial positions and an acquiring and marketing their skills critical in non-academic jobs would help these students feel better about transitions from their undergraduate training directly to the jobs market.

One of the physics education majors commented that the dual-college nature of his studies made it difficult for him to get advising sometimes. He didn’t always know if he should be directing his questions to the College of Education or the Department of Physics. An advisor for physics teaching with strong connections to both areas, such as Dr. Emily van Zee, might help eliminate confusion for this relatively small cohort of students.

The Department’s research mentoring program involves a requirement that all physics majors complete a senior thesis. This is a significant investment in faculty resources with a very high pay-off in undergraduate preparation. One undergraduate in the Department summarized the importance of this experience for him when he said, ‘The courses taught me how to do physics, but the undergraduate research experience taught me how to be a physicist.’
This research experience for undergraduates is critical to both their preparation for graduate school and for employment in the private sector. Top graduate programs in physics often consider undergraduate research experience as a prerequisite for successful matriculation. Such experience is also invaluable for securing industrial positions in physics. Private sector employers are generally much more interested in a prospective employee’s practical experience than how they did in a classroom environment.

Having an assigned research advisor also provides an important informal mentoring opportunity for undergraduate students. Although the students indicated that their formal advisor provide the most valuable curricular and graduate school advice, the looked to their research advisor as a role model for professional and ethical conduct and a standard for scientific excellence.

Mentoring undergraduates in research involves a significant investment in faculty time and the Department is feeling the negative impact of this commitment. The investment in undergraduate research typically does not provide a net return in faculty research productivity. As the Department looks for ways to increase their research productivity, they may need to look for ways to streamline how undergraduates are mentored.

One idea that is already employed by the Department in this regard is to enroll students working on their senior thesis in a thesis-writing course that satisfies the university WIC requirements. This consolidates the time-intensive tasks of teaching students how to write professionally in an efficient group environment rather than requiring mentoring in individual writing.

Another idea that the Department is pursuing involves finding research opportunities for students to have summer research experiences and internships outside the Department. Although the faculty recognizes the benefits of doing so, the number of students who take advantage of these opportunities is relatively small. With about half of the students anticipating industrial employment after graduation, increasing the number getting industrial internships could be valuable. Facilitating this will probably require increased cultivation of alumni and Departmental friends presently in the industrial sector.

Another avenue that may help meet the need for students to have mentored research experience would be the formation of design teams for applied physics majors. These groups of students could be given design rather than research projects culminating in a project report rather than a senior thesis. The College of Engineering has apparently been quite successful using this model for student capstone experiences. Such projects could be designed to give students real-world project experience, add ties between physics and neighboring industries, and provide students experiences that better prepare them for industrial job opportunities.

One of the places where undergraduate advising might be strengthened is in working with lower-division students. These students start their physics experience in undergraduate courses primarily composed of non-physics majors. Several of the students said they felt disconnected being in large classes with students outside their major. Although declared physics majors get formal advisement from the Department Head, some expressed a
feeling of not being completely connected to the Department until their junior year.

Making the connection with actual and prospective physics majors is challenging and steps are already underway in the Department to make better connections. The new PH199 course is a good step in this direction. First Year seminars targeted to declared and potential physics majors might also help here. The addition of planned majors-only lab sections for the introductory calculus-based course will help as well.

Finally, as the faculty expands its research activities, it should include graduate students and post docs in the mentoring process. This will spread the mentoring load around somewhat, but also has the benefit of exposing undergraduates to a variety of people at different stages in their research careers.

IV. Commendations and Recommendations

The review committee recognizes that in a short visit, it is impossible to fully reveal and do justice to all the areas of excellence of a complex organization. With that in mind, we make the following commendations and recommendations, which are meant to distill the several recommendations that are embedded in previous sections of the report.

1. The Department is commended for the able leadership it has enjoyed, both administrative and programmatic. In particular, the leading-from-the-middle collaborative outlook of the Department is worth emulating in all academic Departments.

   We recommend that the choice of and charge to the new Department Head be done in a way that recognizes the significant intellectual capital that is resident in the Department. Special care needs to be taken to ensure that the Department ethos of collaboration is not compromised.

2. The Department is commended for its Paradigms in Physics national curricular effort. Faculty leaders have worked tirelessly over seventeen years to refine and disseminate this effort.

   Neither the University nor the Department should do harm to Paradigms. Any institutional or Departmental undergraduate initiative should build on Paradigms, not dilute it. In particular, any significant increase in the number of majors should be accompanied by a commensurate allocation of new human and facilities resources to the Department.

3. The Department is commended for being one of the few physics Departments in the nation that requires a significant undergraduate project for graduation. This requirement provides significant benefits to the students.
We recommend that the Department explore new ways to satisfy this requirement, including shifting the advising onus to REU programs elsewhere, and provide more opportunities for students to satisfy this requirement through internships with industry.

4. We recommend that tenured and tenure-line faculty teach more lower division and service courses and appropriately mentored instructors teach in the upper division curriculum. We think this could cross fertilize the lower division instruction with lessons learned from the Paradigm approach. This improved instruction would potentially attract more majors, especially among women and underrepresented minority students.

5. We commend the Department for its current support of teacher education.

We recommend that the Department and the College of Education develop stronger collaboration in the area of teacher preparation and professional development.

6. We recommend that the Department develop stronger connections to its alumni by tracking them better.

7. We recommend that the Department strengthen the preparation for Teaching Assistants by making it ongoing and instituting Departmental guidelines and expectations that will make it less instructor dependent. We applaud the Department for considering implementing the Colorado Learning Assistant model.

8. We recommend that the Department engage in a strategic planning process that will allow it to proactively map out the next five to seven years, i.e., develop a prioritization of efforts and hiring that goes beyond reacting to annual budgetary exigencies.
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