PROGRAM REVIEW REPORT
WEBER STATE UNIVERSITY DEPARTMENT OF PHYSICS
APRIL 8, 2013

To: Dr. David Matty, Dean, College of Science
Dr. Colin Inglefield, Chair, Physics Department

Introduction

The site visit for the Program Review of the Weber State University Physics Department took place on March 28, 2013, by the following members of the Review Team:

- Dr. Nadine Barlow (Department of Physics and Astronomy, Northern Arizona University)
- Dr. Michael Jackson (Department of Physics, Central Washington University)
- Dr. Randall Knight (Department of Physics, California Polytechnic State University)
- Dr. Richard Sonnenfeld (Department of Physics, New Mexico Institute of Mining and Technology)

Prior to the visit, our team was provided with the self-study document from the Department of Physics. During our visit, we met with Dean David Matty; Department Chair Colin Inglefield; chairs of the geosciences (Dr. Richard Ford), chemistry (Dr. Laine Berghout), and engineering (Dr. Kirk Hagen) departments; nine faculty members of the Department of Physics; the department secretary and lab manager; two planetarium staff members; and six undergraduate students. We also were given tours of the classrooms, teaching and research labs, and the Ott Planetarium during our visit. Everyone provided candid comments in response to our questions, which allowed the Review Team to obtain a good assessment of the department's educational, research, outreach, and service activities. It was our understanding that this is the first time an entirely external review has been conducted. This bespeaks a genuine commitment to self improvement at the level of department and dean.

Physics Program Strengths

The Physics Department at Weber State University has many strengths. First and foremost is the faculty. They are a talented group of individuals with a high level of commitment to teaching, scholarly activity, and meeting the needs of students. The review team also was impressed by the

level of collegiality among all members of the Physics Department. The faculty and staff clearly work as a team to achieve the department's mission and goals, and they have a great amount of respect for each other's responsibilities and accomplishments. The ability for the department to create and sustain a productive and collaborative working environment should be promoted as a university model. The sustained level of faculty accomplishments is also noteworthy.

The department has had a solid and consistent degree production of about 11 students per year over the past five years. This is more than twice the national average for undergraduate physics degrees, and the department is to be commended for this. The students we spoke with had nothing but praise for the department, especially the small classes and getting to know faculty members well. Some of the students said that they had not begun as physics majors but had switched to physics because of exciting introductory courses – a credit to faculty teaching these classes.

Students also were outspoken about how much they liked being able to conduct research with faculty members, and many are involved in investigations conducted with the High Altitude Reconnaissance Balloon for Outreach and Research (HARBOR) project. Support for undergraduate research comes from both internal and external funding sources. The students have a resource room set aside for them within the department (an important attribute of successful departments that should be continued in the new building) and have recently revitalized the Physics Club. The students are pleased with the level of advising they receive and the accessibility of all the faculty members.

The chairs of the geosciences, chemistry, and engineering departments confirmed that students are the physics faculty's first priority and that students (both majors and those in the service and general education classes) receive a solid foundation in physics. Faculty are well-respected by other departments on campus and by all students who take their classes.

Despite their high teaching loads, faculty are engaged in a wide variety of scholarly and professional activities. These range from participating in national and international collaborations to textbook writing to serving as editors of highly respected journals.

Faculty also are very involved in university administration and governance, which is recognized by the administration through release time for several faculty members. We found evidence of a fairly strong commitment to shared governance by the university's top administration, which is critically important in difficult financial times.

The department has a very strong outreach program, both through individual faculty efforts and by the staff and students at the Ott Planetarium, which reaches out to K-12 students and the public within the local region.

The faculty expressed great optimism for the future, both in terms of possible growth of the program and for improvements in space with the new science building. We believe this optimism

is warranted and that the department's strengths provide a solid foundation from which to grow and improve.

Physics Program Weaknesses

The Physics Department has a number of readily identified weaknesses. Some of these can be dealt with by the department, but others will need a commitment from the college and the university. Our goal in making these observations is to start a conversation about how the physics department can move from being a good, collaborative, and functional physics department to a thriving physics program. Along those lines, we ask the department and members of the administration to read the SPIN-UP report prepared by the National Task Force on Undergraduate Physics if they are unfamiliar with this study:

http://www.aapt.org/Projects/ntfup.cfm

Faculty: The Review Team's greatest concern is with the demographics of the department faculty. The most recent tenure-track hire was about ten years ago, half of the faculty have been teaching for 20 years or more, and several are very near retirement. Currently there are no assistant professors in the department. Three of 13 regular faculty members are women (23%), although one of those is a visiting professor; there is little ethnic diversity. Six faculty members have reassignments ranging from 0.16 to 0.5 FTE and others are working on a reduced-time basis. As a result, the effective faculty size is closer to 10 FTE than to 13 (12 tenured and 1 visiting professor).

The faculty felt they are just barely able to cover the necessary teaching assignments with their 12 credit unit loads per semester, and were concerned that this would be a problem if anyone retired, if additional reassignments occurred, or if anyone took a sabbatical (we were surprised and concerned to learn that few faculty members ever take a sabbatical because "Who would teach my classes?"). While the basic curriculum is adequate, there are not enough faculty to offer electives that would better prepare students for graduate school or careers. Even worse, some advanced laboratories seem to hinge on just one faculty member, a situation that is not sustainable.

Most of the evening classes and labs are currently taught by adjunct faculty. However, both the faculty and the chair noted the difficulty they have in finding qualified adjuncts within the local area.

Faculty expertise is primarily concentrated in two areas: theoretical physics and astrophysics. A department this size cannot have both breadth and depth, so a concentration in a couple of areas is reasonable. However, both students and faculty commented on the need for more faculty with expertise in experimental physics. Currently only a small subset of the faculty – largely those

with experimental expertise – oversee the vast majority of student research projects. Some students commented it was difficult to find an advisor for research projects.

While the faculty's efforts to keep everything going are commendable, they are overstretched and this level of effort is unsustainable.

Research: Weber State, like most universities in its class, is pushing faculty to engage in more research and scholarly activity. We believe that undergraduate involvement in research is a valuable educational experience. At the same time, it is essential, at the college level, to clearly define what "research" means in the context of WSU's mission and what, realistically, faculty at WSU can do. Weber State cannot compete with R1 universities that have graduate students, extensive lab space and other infrastructure, and faculty with minimal teaching loads.

That said, the Physics Department is woefully short of space for carrying out even small research projects. We visited 3 small research rooms, each barely larger than 100 square feet. We are highly concerned that the new science building is being proposed at more-or-less the same square footage as the current building, which, even with careful design, will not allow an adequate expansion of research and student project space. If the faculty evolves over the next 5–10 years to, say, 6 or 7 experimentalists, a ***minimum*** of 3000 square feet of research and project space will be needed if the university is serious about having faculty do more research.

New faculty currently receive little or no start-up funding to get any research underway. At R1 schools, start-up packages for experimentalists are often several hundred thousand dollars. Weber State cannot compete with this, as noted, but it does need to offer experimentalists on the order of $50,000 (or high-end computers for theorists who do lots of computation) just to compete with other universities in its class. The physics department will be at a serious disadvantage for hiring new faculty unless it can offer space and some kind of start-up package.

In addition, faculty receive little time or credit for carrying out research or supervising student projects. The amount of load credit they receive for this important task is minimal – typically 0.25 TCH or less per SCH. The combination of high teaching, service assignments to both the university and their profession, outreach activities, and mentoring of undergraduate students limits the amount of time that faculty members can devote to original research.

We also heard concerns about the university's Purchasing Department and Office of Sponsored Projects. These had been points of concern in the department's previous review. It appears that these offices were not designed for and are unfamiliar with the requirements of scientific research. We heard some evidence that OSP has new personnel and is improving, but this is part of the university infrastructure that the university as a whole needs to focus on if it is serious about having more research activity on campus.

Teaching: The physics faculty is committed to quality teaching, but nearly all teach using very traditional lecture-based classes. We saw little evidence of innovative pedagogy. The majority of

faculty felt they were unable to institute innovative teaching methods due to the current classroom size, setup, and enrollment. Few seemed aware of research or of practices elsewhere that demonstrate the extent to which educational outcomes can be improved even in a large lecture hall setting. Some faculty expressed optimism that the new science building would alleviate some of these difficulties so they could utilize techniques such as studio physics instruction. However, the review team did not find that many of the faculty members were particularly interested in moving away from a lecture-only format. This may be due, in part, to the high loads that leave little time for reflection on course redesign.

Students: A major issue raised by several faculty members was the inadequate preparation of students entering Weber State University for the sciences. Many students have to take several semesters of remedial mathematics before they can take calculus and thus enter the physics program. While on paper there are currently 142 physics majors, the majority seem to be lost before ever reaching their first physics class

Some of those less-well prepared students could possibly be retained if the department found a way to engage the students during this period of additional preparation. Some strategies the department may consider include

- Offering a physics- or physics/engineering-oriented class for students who need additional math preparation. One example is Nathan Klingbeil's model at Wright State University: "Introductory Mathematics for Engineering Applications."
- Offering more pre-calculus physics courses. Astronomy is already offered, but conceivably course on meteorology (possibly jointly taught with geosciences) or energy could be added, as could a course such as "Physics for Future Presidents," which has been wildly popular at U.C. Berkeley (and there's a book with this title by Berkeley's Dr. Richard Muller, who developed the course).

As best we could tell, the College does not actively recruit high school students into the STEM disciplines and does not work directly with Admissions in this area. The department web page, which could serve as a useful recruitment tool, is lacking much of the necessary information to attract qualified incoming students to the program.

The number of women physics majors is low but not out of line with national norms. However, ethnic diversity is very low. The large and rapidly increasing Hispanic population of Utah is not being well served. Both active recruiting and a better web page could help with this.

Students interested in conducting research in areas not covered by the faculty's areas of expertise do not seem to be aware of summer research programs such as the NSF's Research Experiences for Undergraduates or NASA's Undergraduate Student Research Internships where they could obtain this type of experience. However we are uncertain if this is due to a lack of promoting this opportunity or to a student reluctance to leave the immediate area.

Assessment: Based on the information in the self-study, the department does not seem to have a well-defined assessment plan or to be making much effort at assessment. In part this may stem from confusion between course-level assessment and program-level assessment. It is the missing program-level assessment that could help the department better plan how to make improvements in the face of limited resources.

Budget and Support: Two other areas of concern are the budget and the inadequate technical support. The budget seems only marginally adequate for current activities. There is little money for travel (and the faculty do not travel to meetings or workshops nearly as much as they should to stay current) and no money to expand or improve what the department currently does. The technician and one faculty member provide all of the technical support for both classrooms and the machine and wood shops. There is no technical support for upper-division labs, which puts an even larger burden on the faculty who teach those labs. If department staff are ill, offices can close and services become unavailable, which can further exacerbate the problem. Student assistants to help in the office and with the set up/take down of instructional laboratories would seem a low-cost solution to improving support. However, we should note that both the technician and the secretary were adamant that they did not want a student assistant.

Physics Program Opportunities

The Department of Physics has a number of opportunities on which it could capitalize. Most important is the potential near-term retirements within the tenured faculty, which will provide an opportunity to significantly alter the expertise and demographics of the department. To take advantage of this, the department needs to think roughly ten years ahead in terms of program goals and most particularly new faculty hires. These discussions should include consideration of hiring experimental physicists in disciplines to be determined by the faculty, which could expand the breadth of the department's expertise and enhance undergraduate research opportunities for the students while maintaining the level of teaching excellence the department has come to expect. The department should also discuss the possibility of shared positions with other departments. In our discussion with the chairs from other departments, geosciences expressed interest in perhaps a joint appointment for a geophysicist.

We believe that there is good cause to expand the full-time faculty to 14 or 15 over the next 5–10 years, and to authorize a search for next year in anticipation of retirements. This could help to kick-start a departmental rejuvenation, but the current faculty need to make the case for this. The department also should consider increasing the number of full-time instructors (lecturers or visiting professors) on one- or two-year contracts for use in place of part-time adjunct faculty.

A second department opportunity is to provide input on the design of the new science building in order to obtain larger research laboratory space, better support facilities (i.e., shops), better teaching laboratories, and teaching spaces that allow use of a variety of demonstrated pedagogical techniques, such as "studio physics". There was a suggestion of creating an "imaging suite" that would include AFM, SEM, and phase contrast microscopes. Any such proposals need to get into the queue early and be argued for forcefully.

The department also should consider conducting strategic planning in the area of recruiting calculus-ready students to their program. A good place to start would be with an upgrade to the department web site, which can be used to "sell the story" of the benefits of pursuing a physics degree at Weber State (i.e., smaller class sizes than at the R1 universities, personalized faculty attention, undergraduate research opportunities, etc.). The website should include better descriptions of the tracks with sample degree plans; better descriptions of careers in physics, with case studies of department alumni (career information is the number-one thing high school seniors want to know about); and the current "links to nowhere" need to be fixed. This may be a challenge because the department currently does not have direct editorial control of its website, so we urge the dean to instruct the consultant to work with the department on this issue. While the college is able to use the College of Applied Science and Technology's STEM recruiter, more can be done. The department could become more proactive in building a partnership with Admissions and using their recruiters (especially the STEM recruiter) to sell their program to high school students. Another possibility is for the department to consider using fee waivers to help attract calculus-ready students.

During our discussions we heard of several industries in the area with which closer ties could be established (i.e., Hill AFB, L-3 Communications, Northrop Grumman, and Autoliv). While the department should be commended on its current connection with industry, these relationships can be significantly strengthened. One way of achieving this is forming an advisory board with representatives from these companies. The advisory board could help the department better prepare their students for careers with local industry along with providing fundraising assistance for scholarships and research internships.

Physics Program Threats

The biggest threat currently facing the Department of Physics is the need for new tenure-track faculty lines. The loss of even one faculty member would immediately and substantially reduce the number of courses the department could offer, including in general education areas. The growth of the new Engineering Department also will put pressure on the department's offering of service courses and require additional staffing. The difficulty of recruiting experimental physicists to the program due to lack of space and start-up funding jeopardizes the types of courses that can be offered by the department and the options for undergraduate research.

Another threat is that the new science building, as currently proposed, does not provide a substantial gain of floor space over what the department currently has available. Therefore teaching, research, and office space will continue to limit the opportunities for the department and will not allow the department to grow if the university grows. This seems to us extremely short-sighted and contrary to the long-term interests of the university.

Faculty in the Department of Physics take on an excessive amount of service to the college and university. The hiring of adjuncts to cover the teaching obligations of reassigned faculty is not optimal and enhances the threat to the department if any faculty member leaves. The faculty are overcommitted with heavy teaching and service loads, outreach, and mentoring of undergraduate students on research projects. This type of scenario often leads to burnout of the most productive faculty members and is a very real threat facing this department. While department members were generally stoic, we heard some faculty members saying, "You have to help us … this is not sustainable".

Recommendations

The Review Team offers the following recommendations:

1. Insist that the plans for the new science building be revised to ensure that the department will have adequate space to meet its current and anticipated future needs. Being locked in to inadequate space will be the death knell of any hoped-for improvements. Consider whether some of the old science building can be saved.

2. Develop a 5–10 year strategic hiring plan to expand the depth, breadth, diversity, and expertise of the faculty in the Department of Physics and to ensure that supervision of student research is spread equitably among the faculty. This in turn will benefit the students by expanding the diversity of courses offered and the types of research opportunities available.

3. Initiate a search next year, then replace retiring faculty immediately.

4. Develop an agreed-upon definition of the term "research" that the department and college can use for planning purposes and in tenure and promotion decisions. Focus on existing department strengths, which are mentoring students in undergraduate research and research in the area of science teaching and learning. Although PUIs are generally not competitive with R1 institutions regarding the generation of external research funding, the University's support offices, such as Purchasing and the Office of Sponsored Research, need to become more proficient at supporting the research needs of the science faculty.

5. Develop and implement a long-term assessment plan for program-level assessment to ascertain how well the department is meeting its overarching goals and objectives. Document how the results of assessment are used to improve the program.

6. Increase the number of faculty attending meetings and workshops to remain current in their field and to learn about new pedagogy.

7. Expand the department's recruiting effort to improve diversity and the number of calculus-ready students who come to the program.

8. Increase recognition of faculty who supervise undergraduates within a research setting. Possible solutions to consider include reducing teaching loads for faculty active in research or increasing the amount of credit hours faculty receive for supervised student research.

9. Encourage students to apply for summer research programs such as NSF's Research Experiences for Undergraduates or NASA's Undergraduate Student Research Internships.

10. Form an advisory committee composed of representatives from local industries who have interests in a physics-educated workforce. Use this advisory committee to help design coursework useful to students who plan to pursue industry careers, provide career advice, identify off-campus internship opportunities, etc.

Summary

The Department of Physics at Weber State University is good but has the potential to be better. It is a collegial and student-focused department composed of dedicated faculty and staff. However, chronically excessive academic loads caused by a shortage of staffing threaten the core competency and mission of the department in the near term. The department needs additional tenure-track faculty lines in order to accommodate the increasing demands on its service classes and undergraduate research opportunities for its majors. The department excels in the quality of its courses, its service to the College and University, and its commitment to outreach to the community. However, the department needs substantial additional space in order to provide classrooms that support more effective pedagogical methods and research opportunities for both faculty and students. The proposed size of the new science building is of such serious concern that we recommend finding a way to enlarge it or protect some fraction of the existing science building. Recruitment of calculus-ready students to the program could be enhanced by improving the department website and working more closely with a university STEM recruiter. Closer ties to local industries would benefit both the faculty and students.

ADDENDUM: ANSWERS TO DEAN MATTY'S QUESTIONS

PHYSICS DEPARTMENT REVIEW COMMITTEE 3/28/2013

Nadine Barlow, Michael Jackson, Randall Knight, Richard Sonnenfeld

Is the curriculum appropriate compared to national trends or models?
This is a standard physics program that teaches appropriate material in preparation for a variety of careers. As with past department practices, continued reflection on the curriculum is encouraged, particularly if new faculty with varying expertise are hired.

Is a common core present for major/minor tracks? Is a common core preferred?
The common core for the major/minor tracks is appropriate.

Is the curriculum flexible to allow students different options?
There is some flexibility due to multiple degree tracks but there is a lack of faculty breadth (particularly in applied areas) that limits some important electives (e.g., atomic and molecular physics, optics, laser physics).

Is the curriculum agile and able to change rapidly as workforce needs change?
Because it is a strong physics core, it provides a wide range of basic preparation for most imaginable workforce needs. It is not agile in the sense of courses or course content changing rapidly because that is not an issue in the undergraduate physics curriculum – unlike, say, in computer science where languages evolve quickly.

Are pedagogical methods being used appropriate for today's learners?
Physics-education-research-based pedagogical techniques are used sporadically and inconsistently. Conversations with the department indicate most introductory courses are taught using a very traditional lecture-based pedagogy with separate, somewhat independent, lab activities. There appear to be limited inquiry or exploratory activities being used. Even if large lecture sections are required, some techniques such as peer instruction and interactive lecture demonstrations could be used. The use of the planetarium to enhance understanding in the introductory astronomy classes is commendable, but it does not substitute for in-class inquiry-based activities. Due to the limited duration of our review, some of these techniques may be used more in the department than the self-study and our interviews led us to believe. The department

appeared open minded about such techniques and some faculty are currently using project-based learning activities.

With that said, the department should have a serious conversation about revising its instructional activities starting with the introductory courses. Timing is particularly acute given this will be a large influence affecting the design of the new science facility, decisions that will affect the next 50 years. For example, while moving their instruction to an integrated lecture/lab course would result in a slightly higher TCH for the same number of students, it would employ pedagogical techniques demonstrated through physics education research to show improved student understanding of the material.

Is the department student-focused throughout?
Yes!!! A very significant strength … and the students absolutely agree.

Is the assessment plan for all programs adequate?
Assessment activities appear scattered. We recommend less, but more targeted, assessment. It may not be clear to the faculty what the goal of assessment is. We wonder if the institution as a whole has agreed on the purpose of assessment. Is it individual courses or entire programs? We recommend assessment activities focused on the entire program. The senior seminar course could be expanded to address the programmatic outcomes of the department. The use of rubrics would also be beneficial when assessing across the department.

Should the department be investigating associate's degrees and certificates which could be integrated into the major?
Introducing an associate degree into the curriculum would add only marginal value. Certificates for targeted training for local employers could be a revenue generator for the department – IF the department is allowed to retain the income. However, there appear to be only a couple of faculty with the expertise to offer such a program, assuming the certificate would largely be in applied physics. An added challenge is that the applied/experimental physics faculty is a group having the least breadth within the department and who appear to us to be the most overloaded, largely due to the number of undergraduates they need to mentor.

What opportunities exist for partnering/working with other departments to develop new program or strengthen existing programs?

The geoscience department expressed interest in a shared faculty hire in the area of geophysics. This could be a way of adding breadth to the department and increasing collaboration within the College. Future opportunities may exist with the expansion of engineering. We did not have time to learn about the physics-teaching track, so we do not know what kind of partnerships may already exist with the College of Education. Do they exist, and if so could a shared faculty hire be possible in this area? Department of Education grants can be significant but typically require collaborations with education faculty and local school districts. The physics department is already well-connected to local K-12 through its outreach activities and involvement in the Center for Science and Math Education, so it could naturally partner for grants. A shared hire might strengthen this area and open the door to large, interdisciplinary grants with area schools. This in turn could possibly help with recruitment and retention, particularly of traditionally underrepresented groups within STEM.

Is there appropriate breadth and depth among the various faculty specialties?

Due to the limited number of faculty, there is no way to satisfy both breadth and depth, but proper planning could give a better mixture of disciplinary areas. At the moment, there is depth mostly in astronomy and breadth is limited. The department and students are very excited by experimental physics, but the current situation of almost no lab space and no start-up funds, even for an undergraduate-based program, is unacceptable in terms of hiring qualified experimentalists.

Are all faculty engaged fully in teaching, scholarly work and service?

All faculty are fully engaged in teaching, scholarly work, and service, an outstanding accomplishment that cannot be taken lightly. However, the department as a whole is over-committed, and the support of undergraduate research is disproportionately carried by a minority of the department.

Is the workload appropriate?

The instructional workload is too high if faculty are expected to engage in other activities. It amazed us that the faculty appeared so happy, but we think the department is likely on a path to burnout. Thriving physics departments, which this department has the potential of becoming, need the time to reflect on new research and pedagogy directions which will allow pursuit of grants, along with teaching their courses and conducting service activities.

Are facilities adequate for the present and future?

The present facilities are not only inadequate but dangerous due to overcrowding. Future facilities in the new building could be much better planned, but the likely space is still inadequate. Without including growth into new areas or more faculty, we recommend a ***minimum*** of 3000 square feet of faculty/student research space. In addition, studio-style teaching requires about 1500 sf per classroom.

What could be improved to better prepare tomorrow's physicists?
Overall, the K-12 preparation of incoming students is unacceptable, particularly in mathematics. The university should request funding from the state K-12 budget because it is essentially providing a high-school science and math education that the Utah K-12 system apparently is failing to provide.

For recruiting students?
We understand that the Department of Engineering allows the College of Science to capitalize on the use of their recruitment officer. Nonetheless, the College of Science should consider having a dedicated recruitment officer. At the very least, it should have an improved collaboration with the Office of Admissions (where they should have at least one person actively recruiting STEM students with everyone in their office knowledgeable about the College of Science). This can be further strengthened with the promotion of tuition waivers and scholarships to recruit calculus-ready students, as administered from within the College. Improved web pages also can help, as these are the number-one place where high school students get information about colleges and careers.

For engaging students in undergraduate research?
As previously stated, the research mentoring load in physics is not evenly shared. Not all of the existing students can find advisors easily. Equivalent TCH for taking on research students should be dramatically increased, or overall teaching loads should be decreased. A greater diversity of faculty expertise, particularly in experimental areas, would help alleviate this issue. At the very least, expanding collaboration within the department on the mentoring of students may be a beneficial, short-term solution.

For enhancing faculty research?
There are multiple ways to define faculty research. If you are talking about R1 research, Weber State lacks the infrastructure and the commitment to compete at those levels. We assume you do not really mean to enhance research that contributes to breakthrough science, but instead

research that trains students, which is a great strength of the physics department. If we accept the second definition, then lab facilities need to be dramatically expanded and faculty need more credit for conducting student-focused research.

For attracting new faculty?

The current situation would not be at all attractive to much-needed experimentalists. Experimental physicists need a minimum of $50K startup-funding, even for establishing an undergraduate-teaching-focused research program, plus space in which to work.