Physics Department Goals

Strategies for Implementation

Measures of Progress

Introduction

The task of educating Physics and Engineering students is a complex process that depends, not just on the department or even the academic area but the college as a whole. Beyond the core of physics/engineering courses, the mathematics, chemistry, computer science as well as humanities and social science courses are critical to their academic development. But off campus programs, student life and the chapel program also are part of the essential college experience. We depend on all these areas. Any departmental planning must begin with the understanding that we are part of a whole. That said, this document focuses primarily on our role in the process. How we can improve our part of the process. We have identified three goals going forward.

Three Goals: The first goal is to improve classroom teaching. Both physics and engineering involve developing analytical abilities as well as learning a great deal of content. This is done in the classroom and on homework and exams. It is a sequential process layering knowledge on knowledge. In many areas of the college a freshman could, in principle, take a senior level course. There is no way that could be done in the physics. So weakness in any level affects all levels above.

The second goal is to improve laboratory courses. Both physics and engineering require not just head knowledge but the ability to work with scientific equipment, make measurements, do experiments and interpret and write up the results. The laboratory courses play a critical role in developing these skills. Often lab courses are connected to lecture courses to give hands-on experience to the theoretical topics being taught.

The third goal is to develop greater opportunities for student research and practica. By the time students graduate they should have “real world” experience in doing physics and engineering. For physics students this primarily means getting experience in research with a faculty member. For engineering students this more likely means an internship or practicum in conjunction with a local research and development company.

Classroom Teaching

The question of what makes for good classroom teaching may have as many answers as there are teachers but there are some common factors. Students must be engaged in the process. From “sage on the stage” to the various theories of “active learning,” no one questions the importance of students taking ownership of the learning process. Lectures need to be interesting and informative. Concepts need to be developed, explained then illustrated by demonstrations and examples. The underlying theories must be clearly laid out but also the connection to using the information to solve problems must be explicit. The methodologies of science need to be discussed and the connections to other courses,
especially previous classes, need to be made. Student teaching assistants (which themselves learn a great deal by their participation in the teaching process) play an important role. Opportunities for student work need to be well thought out and varied. Problem sets will always be the backbone of a physics/engineering program but it is important that students also participate in public speaking and paper writing as well. Exams need to test problem solving ability and the grasp of qualitative concepts. Feedback on student assignments in the form of grading, comments and corrections need to be prompt and effective.

**Strategies for Implementation:** This begins with initial placement. We are seeing an increasing number of incoming students who have taken AP physics in high school. At Westmont a 4 or 5 on an AP test allows a student to receive course credit, but in these cases we give the student the course materials for general physics (including the previous year’s final exam) and let them self select whether they would benefit from taking the course. This emphasizes the importance of foundational courses.

Textbook selection is important, so great care is taken in selecting the texts used for the courses. We examine several texts, look at reviews and ask which institutions use each text. Once selected, we examine the effectiveness of the text from our own experience and judgment as well as from student feedback on course evaluations to see if the selection is working well.

Classroom demonstrations illustrate concepts presented in lecture, and serve to make class more interesting and engaging for the students. We are always looking for new demos and improving those in our existing archive.

Teaching techniques are discussed among the faculty in an ongoing effort to improve. Faculty are encouraged to experiment with new ideas then report back success or failure. Techniques that work are implemented those that don't are dropped.

Teaching assistants are selected with care and we are looking to improve training of TA’s. Currently each professor works individually with the TA for the course but we are looking at introducing training sessions for the TA’s as well as group discussions among the TA’s.

Broadening student work has been part of curriculum revision as well as an issue within individual courses. It is important not to back off of problem set assignments to make room for increased paper writing and oral presentation but all are needed. On exams we have been including qualitative sections to supplement the problem solving problems. Upper level courses often have take-home exams which allow more in depth problems for testing.

**Measures of Progress:** The clearest measure of progress will be the performance of the students on the exams. We will keep a file of the exams given in selected courses along with the mean score on those exams. We will also make copies of representative “A” “B” and “C” papers. From time to time we can use an exam given at another college or university to draw a comparison of performance.

Sample papers from student assignments will be kept (once again example A, B and C papers will be saved).

We will also administer course evaluations on an occasional basis to measure student response to the teaching of the various courses.
We will keep a record of classroom demonstrations done for each of the classes and note as new demos are brought on line.

**Laboratory Courses**

The challenges for a small college to run an excellent laboratory program are substantial. Large universities have hundreds of students taking the lab courses so that the same piece of equipment is used 10 or 15 times in a week. The budgets are then far greater than a college can do. Nonetheless solid lab courses are essential. Most physicists will be experimentalists but even the future theorists need to have a working knowledge of equipment, experiments and data taking. For engineers it is obviously essential. In these times using computers for data acquisition and analysis is critical. In addition, students need to learn to keep laboratory notebooks as well as write up experimental results. Both of these require progressive instruction as students are able to improve their work from assignment to assignment. The supporting role to the lecture courses needs to also be kept in mind.

**Strategies for Implementation:** The biggest issue here is how to pay for the wealth of equipment needed for a first rate laboratory program. Space for that equipment is also an issue. The current physics building is limiting to the program. Grant writing must play a large role in raising money for laboratory equipment. This is something we have done with great success over the years. In the past two years we have received $3/4 million in grants for new laboratory equipment and a new telescope for our observatory (which will be made use by our students in their coursework). The new science building should provide extensive space for our laboratories and equipment. In fact we will be doing more grant writing to obtain more equipment as space opens up in the new building.

Among the new equipment had been computers for data acquisition. These have been folded into the laboratory courses and new labs have been written to take advantage of them. As new labs have been added, we are always evaluating their effectiveness to determine the best labs for each course.

We are putting together an advanced lab course for seniors.

The writing components of the labs involve specifying what we look for in a lab write-up then helping their labs improve to where they are well written. In addition there is a requirement to write a paper in some of the lab courses. There are also opportunities for oral presentations.

The new telescope (a 24 in reflector due next spring) will be used as part of the laboratory experience allowing an increased astronomy component to the labs.

**Measures of Progress:** Clearly the money raised will be a measure of the improvement of the labs but the real question will be the student learning that takes place. This will be measured first by the quality and improvement in the lab write-ups as they progress through their career here. We will track this by saving representative labs in a portfolio of student work. The real test will ultimately be those students who work in research and internships (see next section) as well as graduates who go on to graduate school and industry. Do they find themselves well prepared? We will be asking the questions and tabulating the results.
Student Research and Practica

Arguably the single most important factor in influencing an undergraduate’s future plans in science is the opportunity to conduct research with scientists. The most fundamental understanding and appreciation of science is achieved not through classroom instruction or the reading of textbooks, but through the apprenticeship-type experiences of conducting research one-on-one with trained scientists. Working with scientists and instrumentation provides an authentic scientific experience, something the classroom cannot fully provide.

Our department has had a long history of providing students opportunities to conduct research with faculty. Each of the three physics department faculty members have held National Science Foundation grants (as well as others) with which to employ students in research. Students have conducted research in superconductor physics, theoretical nuclear physics, and (at present) in experimental nuclear physics and astronomy. Once the Keck grant project for the Carroll Observatory upgrade is complete, new research opportunities will be available for students using that facility.

We have also had great success in placing students in practicum projects with scientists at local hi-tech firms (Santa Barbara Research Corporation, Raytheon, Litton Guidance Systems, among others). These experiences give the engineering-oriented students experience working in an industrial environment, which can prove invaluable to them as they explore future career possibilities.

Strategies for implementation: For the physics oriented student, there are advertised opportunities to apply for summer research, either here at Westmont or offsite as part of, for example, the National Science Foundation’s “Research Experience for Undergraduates” program at participating universities and laboratories. Students are selected on the basis of merit, and receive stipends and free housing for approximately 10 weeks of research. The varieties of experience they gain moves them far beyond what they learn in class, and equip them with tools and methodology they will carry with them into the next phase of their careers. For the engineering oriented students, we maintain a database of local companies expressing an interesting in enlisting practicum students, and put them in touch with those that have good overlap with their interests. Students receive pay and/or course credit for their work. Goals of the project, as well as final grades are determined in consultation with the company scientist serving as mentor for the student.

The ability to offer such in-house research opportunities for physics students will require that we maintain sources of external funding (for travel, equipment, stipends, etc.). However, we also hope to increase the amount of internal funds (departmental, local foundation-funded, etc.) available for use as summer stipends. Currently we are able to support around ½ to 1 summer position through departmental student employment funds. As the observatory facility comes online and begins to be used for research, we plan to apply for external funding through the NSF or NASA.

Measures of Progress: Experiences students gain in one-on-one research experiences with faculty are numerous and demonstrable. Often they will result in honors projects
during the students’ senior years. Indicators of success include student names on publications, students accepted to present research at national conferences, and graduate school entrances, which these days depend heavily on research experiences gained by the applicants. We are beginning to compile a database of student researcher activities and their projects. We will keep track of student names on professional publications, presentations at local and national conferences, graduate school entrances, etc. Additionally we will compile statistics on what other schools across the nation are doing and how Westmont Compares with similar institutions. From this information we ought to be able to demonstrate in tangible ways the effectiveness of research experiences for undergraduates. We will also retain student posters prepared for national conferences and hang them in the department to publicize some of our students’ noteworthy accomplishments to other students and staff, in hopes not only of highlighting student accomplishments, but inspiring future student researchers.

Summary
Measures for the three goals listed above are summarized in the following. Items with an asterisk indicate areas where we are now currently implementing the measures.

Classroom Teaching
- Maintain a file of exams given in selected courses, with mean scores.
- Make copies of representative “A” “B” and “C” papers.
- Occasionally use an exam from another college or university for comparison of performance.
- * Collect sample papers from student assignments (with sample A, B and C papers)
- Occasionally administer course evaluations to measure student response to the teaching of the various courses.
- Maintain a record of classroom demonstrations done for each of the classes and note as new demos are brought online.

Laboratory Courses
- * Save representative labs in a portfolio of student work to compare early and later work through the semester.
- Track possible correlations with lab performance and success in research, internships, application to graduate school, industry.
- Document feedback from the students and tabulate results as to their assessment of the lab experience in improving their experimental abilities.

Student Research and Practica
- * Keep record of student researcher activities and their project descriptions.
- * Compile database of student names on journal publications, students presentations at conferences, and graduate school entrances.
- Compare Westmont with other schools across the nation, for number of graduates per year, number entering graduate school or the workplace, number of student research students per capita, student authors on professional publications, etc.
- Retain student poster presentations from local and national research meetings, hang them in the department to publicize the students’ accomplishments
- Solicit and record feedback from practicum and internship advisors