Department of Physics and Astronomy  
Assessment Report 2009

This assessment report is prepared on June 19, 2009 by Gary Shoemaker, on behalf of the Assessment Committee of the Department of Physics and Astronomy. The Committee membership is: Gary Shoemaker, Vassili Sergan, and Chris Taylor.

Background

First, some background information to provide context for the assessment report. The number of majors in the Physics program is small for departments on this campus, but is in fact large for similar departments at other universities across the United States. The American Institute of Physics (AIP) conducted a survey of the size of Physics departments for departments whose highest degree granted were either bachelors, masters or Ph.D. Among Physics departments whose highest degree was a bachelors, in 2005, the year of the survey, 65% granted between 0 to 4 degrees, 25% granted between 5 to 9 degrees, and 11% granted 10 or more. Our department granted 7 degrees that year, and our average from 2002 – 2007 is 5 per year. The small number of majors graduating each year makes statistical analysis of learning outcomes difficult, but this department is in a better situation that almost two-thirds of similar Physics Departments across the country. The Assessment Committee has made an effort to use rigorous statistical measures when possible, but where numbers are insufficient for that kind of analysis, a qualitative study of course curricula and examples of student work were examined to assess student learning outcomes.

Learning Outcomes and Methods of Assessment

**Physics Knowledge** – *Students should develop a broad understanding of basic principles of physics and mathematics and the foundation for acquiring new knowledge and applying it in a variety of situations.*

The Physics Knowledge outcome is directly assessed in two ways 1) analyzing exams and final course scores in upper division physics courses on a rotating basis; and 2) analyzing examples of student work such as lab reports and journals, computational physics projects, faculty/student research projects, and work on the capstone senior project.

1) The Assessment Committee obtained copies of final examinations from the instructors of five upper division courses that were taught in AY 08/09: Phys 124, Phys 150, Phys 151, Phys 145, and Phys 175. All of these courses are “core” courses in our major program and the last two listed are lab courses. Phys 175 is considered a capstone course in conjunction with the Senior Project 191 course. The instructors removed student names from the exams, and submitted three exams from each course, representing excellent achievement, satisfactory achievement, and poor (failing) achievement (when
possible). Laboratory reports were submitted as evidence for the 175 course following similar guidelines as the exams for the other courses.

The Committee reviewed each of the exams to ensure they accurately reflected the required course content, and that the exams were neither too simple nor too difficult for the level of the course. The Committee looked at the scores assigned to the students of the three examples to ensure that grading was fair and represented a real evaluation of the abilities of the students. The Committee was satisfied in both regards (level of the exam and level of the grading) and established that the exams provided useful information on the students’ levels of physics knowledge. Since final course grades are largely based on exam performance and homework scores, the course grade distributions will accurately reflect the degree to which the body of students in each of the reviewed courses. The Committee also examined laboratory reports for the Phys 175 (Advanced Lab) course and applied the same analysis as we did for the exams as described above.

2) The Committee collected and reviewed five senior project reports that have been completed during the AY 08/09 (all happened to be completed in the Spring semester). The Committee made a comparison between these reports and those project reports that had been reviewed during the last assessment cycle. Each report was analyzed to determine at what level the student author had demonstrated knowledge of physics -- excellent, satisfactory, or poor.

**Analytical Reasoning** – In addition to Physics content, students should develop problem solving, critical thinking and analytical skills and be able to learn new skills as needed.

The Analytical Reasoning outcome is assessed through 1) the analysis of final exams as previously described; and 2) analysis of student work, also described above.

1) The example student exams were studied by the Committee for evidence of mathematical reasoning and critical thinking. The exams are an excellent opportunity for this because the students are required to show their work, giving the Committee insight into their problem solving processes.

2) Examples of student work were studied for evidence of computational and experimental reasoning. For this year, the student work was restricted to all senior projects that had been completed to date. These projects are the capstone experience for our majors and require the students to demonstrate their competency in many areas. Projects include experimental and/or computational work explicitly and are perfect for this purpose. In the future the Committee will also look at examples of lab reports and computational projects completed for various courses.

**Technical Skills** – Physics students must be exposed to a broad range of technical skills and should become proficient in many.

The Technical Skills outcome is assessed primarily through analysis of student work. For the current year only senior project reports will be analyzed. The senior project pulls together all the competencies a student develops in carrying out the work, including use
of experimental equipment, data analysis, design of novel instruments, and computational work. Each senior project report was examined to determine the degree of competency with which the student used her or his technical skills. These skills are taught in our laboratory and computational courses, so in future assessment cycles student work from these courses will also be examined.

**Communication Skills** – Students should develop the ability to clearly express their thinking in both oral and written form and to efficiently acquire new information from many sources.

The Communication Skills outcome is also primarily assessed through analysis of student work, including exams and senior project reports. While solving physics problems students must learn to communicate effectively using mathematical symbolism, and equally as important, learn to communicate in a written fashion the relationship between the math and the physical concepts the math is describing. Oral communication is also part of the senior project – every student must give an oral presentation on his or her work. Students receive feedback forms in which the audience evaluates their performance. The Committee examined these feedback forms to look for evidence of effective oral communication skills.

**Programmatic Assessment**

In addition to assessing particular student outcomes, the Assessment Committee also initiated a broad look at the entire Physics program, to determine if the structure of the program facilitated student learning, and to determine if the students were achieving their own goals in Physics, be that admission to a graduate program, or entrance into a satisfying career path outside of academia. This year the Committee analyzed one set of data: exit interviews conducted at the end of the Spring 2009 semester with the two seniors graduating in Spring 2009. Last year we also considered a report by a student committee; however, this committee will be impaneled on a biannual basis and so no report was available this year.

**Results and Discussion**

**Physics Knowledge**

The results from both assessments of Physics Knowledge indicate that Physics majors are meeting this learning goal.

1) Student final exam scores and course grades for Phys 124, 145, 150 and 151 and lab scores and grades for Phys 175 show that nearly all physics majors demonstrated satisfactory levels of physics knowledge by achieving passing grades. Many students demonstrated excellent levels of physics knowledge by earning grades of B- or higher in these courses. Overall about 60% of the students earned grades of B- or higher. However, the grade distribution was significantly higher in the two lab courses 145 and 175 where about three-fourths of the grades were B- or better and no one failed. The
theory courses 124, 150, and 151 showed fairly consistent distributions, allowing for sampling error. Here greater than 50% achieved better than C grades; however, approximately 25% of the students received D grades which may be some cause for concern since it is significantly above our historical average, and so this matter will be closely watched for long-term trends. Note that these courses are somewhat sophisticated, both conceptually and mathematically and thus having some less than satisfactory grades are not terribly surprising.

2) The results from examination of senior project reports were quite positive. The written reports exhibited stronger evidence that all of the students in this current sample possessed a good command of the background physics and adequately placed the project in the greater context of the field of physics. All of senior project reports in this sample demonstrated a good knowledge of physics in pursuit of the project aims. These results were also supported by an analysis of the oral presentations, which the assessment committee agreed was of considerably higher quality than in previous years.

**Analytical Reasoning**

The results from both assessments of Analytical Reasoning indicate that Physics majors are meeting this learning goal.

1) Student exam scores and course grades for Phys 124, 145, 150 and 151 show that students have demonstrated Analytical Reasoning at the satisfactory level or higher. These grades reflect a combination of Physics Knowledge and Analytical Reasoning, which together go hand in hand in the Physics major.

2) The results from examination of senior project reports also show that students have demonstrated Analytical Reasoning in pursuit of their senior projects. Students work with a high degree of independence on these projects, and each project showed that students were capable of planning their project, identifying problems as they occurred, and working out solutions to those problems. In addition, the oral presentations and written reports showed a good understanding of the background physics in the application of mathematical reasoning to derive what were often new results, applicable to their particular project.

**Technical Skills**

The results from assessment of senior project reports indicate that Physics majors are meeting the Technical Skills learning goal. Each of the reports demonstrated effective use of various technical skills to fulfill project goals.

**Communication Skills**

The results of assessing Communications Skills through exams and particularly the senior project reports and presentations indicate a significant closing of the gap in levels of achievement for mathematical communication and written communication in reports,
relative to our analysis of a year ago.

1) Analysis of student final exams shows that Physics majors can effectively communicate physics concepts using mathematical symbolism.

2) Analysis of senior project reports showed a significant improvement in the achievement by Physics majors in meeting the Communications Skills learning goal. Some student work is nearly at a level suitable for publication in a peer-reviewed journal; however, all of the projects exhibited a good grasp of essential writing concepts like grammar and organization.

**Programmatic Assessment**

The results of Programmatic Assessment through the senior exit interviews lend support to our previous results from last year’s assessment that overall the Physics major is well structured and does facilitate student achievement in Physics.

The senior exit interviews of the two graduating students resulted in wide ranging discussions using the pre-scripted interview questions as a starting point. The Committee reviewed audio recordings of each interview to pull together a set of common themes, given here in no particular order:

- The two students were pleased with the very high level of accessibility of the faculty members. One student also praised the degree of interaction with faculty members, while the other student did not, though he readily acknowledged that this was probably due to his shyness rather than to any unwillingness on the part of the faculty. One student repeatedly emphasized the importance of the close bond between faculty and students and collaborative, not competitive, relationship between the students that fostered a “safe” and effective learning environment.

- These two students were also quite satisfied with our advising program. They found the advising they received very helpful. In particular, one of the students mentioned that she had had rather complicated articulation issues that the Chair was able to resolve in a timely manner. The other student felt that he received accurate and timely advising on course offerings to adequately plan his schedules, although some course cancellations beyond the department’s control did at times complicate his matriculation plans.

- These students echoed the comments from last year’s graduates that the requirement to attend seminar very helpful in exposing them to a broad range of subjects within Physics. Also, one of the students expressed that the department did encourage the reading of the professional scientific literature.

- Both of the students found the level of hands-on experience provided in our laboratory courses very useful, both in terms of teaching practical skills desired by employers and in terms of putting topics learned in theory courses into context. Also, both students strongly felt that the Senior Project was an important experience for our majors, since it was an excellent opportunity to integrate their physics knowledge into a bona fide application. In addition, both students acknowledged that the oral presentation, though somewhat intimidating, was also
an important experience in its own right, as it provides an opportunity to develop skills in a type of communication that is critical in many occupations. In particular, one of the students who had no plans to continue with a career in physics specifically highlighted this fact indicating that the Senior Project does more than “just to turn out another scientist” (paraphrased). Her career plans will focus on administrative jobs in possibly a technical business environment and she found the Senior Project experience to be one of the most important that she had in our program.

- One of the students noted that he regarded the Phys 150 course (Quantum Mechanics) as particularly valuable since it exposed him to a very different kind of reasoning experience than the other courses in our major. The other student particularly found the Phys 110 course helpful in developing her mathematical reasoning ability.

- The students found that computer literacy appeared to be well addressed in the major, despite the fact that there is no formal requirement (and that the computational physics course is only an elective). These students essentially confirmed what had been communicated previously, that the use of computers was well integrated into the program in several different courses.

All in all, the results of these interviews largely supported the results from last year’s interview pool.

The Committee determined after reviewing the course materials for the courses listed above, that the conclusions reached in our analysis were quite similar as regards student performance, and the content for these courses appear to be in-line with historical precedents and generally recognized expectations on the national level. However, the Committee also noted that some course syllabi needed to be upgraded to include more detail and be more consistent with the general university standards. Also, in one of the courses, a take-home final exam was given using problems straight out of the textbook, a practice that should be discouraged given the availability of homework solutions to the students.

The Committee examined five senior project folders from the Spring 2009 semester. The folders included the written reports with reviewer comments, the score sheets and statistics from the audience review of the oral presentations, and the mentor evaluation of student performance. In comparing these projects to projects from preceding years, the Committee unanimously agreed that there had been a “quantum leap” upward in overall quality in both the written reports and oral presentations. The written reports showed marked improvement in grammar and structure as well as content. The oral presentations appeared to have been better prepared given the general professionalism exhibited by their talks and the confidence that the students appeared to have during their presentations. This past year, based upon a recommendation from the Curriculum Committee, the format of the Senior Project course was changed so that students could sign up only for two sequential semesters at one-unit each instead of the previous one-semester 2-unit option. (The only exceptions were made for students who had done their research off-campus, such as a summer REU program. These students who then signup
for a single semester option to complete their reports and oral presentations.) The Committee believes that this new modality enabled the mentors to be far more involved in helping the students prepare their reports and presentations, permitting the students to submit drafts that could be reviewed and returned by the mentor with corrections and suggestions. This was in fact the motivation for the change, since the old one semester option simply did not allow sufficient time for a student to initiate and complete their projects as well as compose a quality report.

Closing the Loop

Last year the Student Assessment Committee (SAC) examined each of the courses in the Physics major and compared each course against the learning goals. The SAC report made several recommendations for revisions to the Physics major:

1. Describe more clearly the optimal sequence for taking upper division physics courses.
2. Institute mandatory advising for all Physics majors.
3. Regularize the curriculum for core courses like Phys 110 so that the same core topics are covered no matter who is teaching it.
4. Offer more formal instruction in writing lab reports.

The Department Curriculum and Assessment Committees responded to each of these points. Item 1 has been addressed through additional information included in the student handbook that we provide for each major. The Chair, under a mandate from the Department, instituted mandatory advising each semester for all declared physics majors. The advising was conducted by either direct personal contact, and where appropriate by email correspondence. Holds were placed on registration until the student had fulfilled their advising obligation. The Curriculum Committee discussed item 3 and each of the 4 courses mentioned in the SAC report were carefully reviewed. However, the Committee determined that no action on this item was needed at the present time. The last item was addressed by providing more information on the expectations for written lab reports by instructors. (See documents in the assessment folder re lab reports.)

The Department Assessment Committee also made the following recommendations in their report last year:

1) **Mandatory advising for all declared Physics majors each fall semesters. This will be enforced by the use of registration holds.** Advising sessions in the spring semester will also be required on an as-needed basis. This will prevent students from taking courses in the major that they are not yet prepared for. This will be in place starting Fall 2008.

2) **Revise and clarify the materials available to students on the Department website.** This will help students know what the requirements are for the various academic programs offered by the Department.

3) **Revise the senior project requirement so that students must take Phys 191 over two semesters instead of one.** This will prevent students from trying to cram too
much work into the semester prior to graduation, and give them more time for one-on-one interaction with their project mentors and for mentor feedback on the written and oral reports.

4) **Formalize the requirements and create a rubric for the senior project written reports.** This will establish standards for format and content that students will know at the outset of their projects. Examples include: demonstrating understanding of the background physics for the project and receiving feedback from the project mentor on the written report and oral presentation prior to their completion.

Items 3 and 4 will start for students beginning their senior projects in Fall 2008.

5) **Regularize the curriculum in the core courses Phys 110, 124, 135 and 150.** This will minimize the variations in content when these courses are taught by different faculty members from semester to semester, and ensure that students are prepared for the more advanced courses that have the core courses as prerequisites. The Department Curriculum Committee will meet during Summer 2008 to begin this process.

Items 1, 2, and 5 overlap with the recommendations of the SAC and have already been addressed. Starting in Fall 2008, based upon a recommendation from the Curriculum Committee, the new course modality for the Senior Project was instituted, as discussed above, with very positive results. The Assessment Committee will continue to monitor these results each year and make further recommendations to ensure that this new modality will continue to work as intended. Item 4 was addressed by the Senior Project Coordinator who placed additional detailed information regarding written reports in the Senior Project Information packet that is distributed to the students who sign up for the Senior Project.

**Recommendations**

All members of the Assessment Committee felt that the review and analysis of the assessment data was a very helpful process and that it has provided a valuable look at the goals and procedures of the Department. Following the recommendations outlined above will result in an immediate improvement in the quality of our Physics program. The Committee was satisfied that the Department made a more than satisfactory effort to put into place last year’s recommendations, and is delighted to see that some of these changes have already had a positive impact on our program.

Based upon this year’s results, the Assessment Committee makes the following recommendations to the Department:

1) **Develop minimal standards for upper-division syllabi.** The Department Curriculum Committee should take this up this summer.
2) **Develop guidelines for the use of take-home exams.** The Curriculum Committee should develop these guidelines and its chair present for discussion at a department meeting.

3) **Continue with mandatory advising, but spread the advising workload over more of the faculty.** The major program is just large enough, that for one person (Chair) to handle mandatory advising is a challenge. In addition, it is better for both the students and the department if advising is shared among the faculty in terms of fostering better student/faculty interaction. The Department should put the new structure in place for mandatory advising during the Fall 2009 semester.

Important assessment activities for the upcoming year include:

- Analyzing final examinations and course grade distributions for the following upper division Physics courses: Phys 110, 115, and 116.
- Analyzing final examination and the course grade distribution for the following lower division Physics course: Phys 11A (the entry course for our majors).
- Impanel the SAC in the Fall 2009 semester to make their biannual report to the Department.
- Continuing to collect and analyze senior project reports and the feedback forms from the oral presentations. This will be done in the spring semester for reports covering the entire academic year.
- Obtaining statistical data on Physics major performance on the Physics GRE from Educational Testing Service has proved to be a big disappointment. The data provided (at great cost we might add) were simply not in a form to be very useful for our intended purposes. We will explore other options for obtaining the needed data on the GRE exams.

**Assessment Materials on File**

The following assessment materials used in the preparation of the 2009 report are kept on file in the Department of Physics and Astronomy office:

1) Audio recordings of senior exit interviews.
2) List of questions used during senior exit interviews.
3) Examples of excellent, satisfactory and poor student work on final examinations for Phys 124, Phys 145, Phys 150, Phys 151, and Phys 175 for the academic year 08/09.
4) Syllabi for the same courses listed in (3) above.
5) Grade distributions for the same courses listed in (3) above.
6) Senior project written reports for all senior projects completed in Spring 2009.
7) Summaries of senior project oral presentation feedback forms for all senior projects completed in Spring 2009.
8) Additional documentation on written reports for the senior project.