Department of Physics and Astronomy
Learning Outcomes Assessment Report
2007-2008

This assessment report is prepared June 20, 2008 by Chris Taylor, on behalf of the Assessment Committee of the Department of Physics and Astronomy. The Committee membership is: Gary Shoemaker, Vassili Sergan, Chris Taylor.

Background

A few facts 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 was 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 fall short 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 three upper division courses that were taught in Spring 2008: Phys 106, Phys 110, and Phys 135. Phys 106 is the introductory upper division course, and 110 and 135 are two of our four “core physics” courses. The instructors removed student names from the exams, and submitted three exams from each course, representing excellent achievement, satisfactory achievement, and poor (failing) achievement.
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.

2) The Committee collected and reviewed all six available senior project reports that have been completed since the start of the senior project requirement. Each report was analyzed to determine at what level the student author had demonstrated knowledge of physics — excellent, satisfactory, or poor. In the future this analysis will be extended to include publications by students of research carried out with faculty members.

*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 their 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 two sets of data: 1) an assessment report prepared during Spring 2008 by a student committee composed of four Physics majors who have been in the program for at least 2 years and; 2) exit interviews conducted on 05/16/08 with all five seniors graduating in Spring 2008.

Results

Physics Knowledge

The results from both assessments of Physics Knowledge indicate that this learning goal is being met by Physics majors.

1) Student final exam scores and course grades for Phys 106, 110, and 135 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. As expected, grades were higher for Phys 106, which serves as an entry to the higher level physics. Here two-thirds of the students earned grades of B or higher. In Phys 110, which is often the first highly theoretical course our majors encounter, four of ten students earned B or higher, and all but two earned at least a C. Physics 135, one of the most difficult theory classes, had four of eleven students earning a B or higher, and all but one student earned at least a C.

2) The results from examination of senior project reports were mixed. Some senior projects are more applied physics, rather than theoretical or experimental physics. The reports for two of the applied projects tended to focus more on the application of technology and did not adequately place the project in the greater context of the field of
physics. Most senior project reports (4/6) did demonstrate a good knowledge of physics in pursuit of the project aims.

**Analytical Reasoning**

The results from both assessments of Analytical Reasoning indicate that this learning goal is being met by Physics majors.

1) Student exam scores and course grades for Phys 106, 110, and 135 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.

**Technical Skills**

The results from assessment of senior project reports indicate that the Technical Skills learning goal is being met by Physics majors. 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 senior project reports indicate very different levels of achievement for mathematical communication and written communication in reports.

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

2) Analysis of senior project reports shows a very wide range of 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, while other work shows only a rudimentary grasp of essential writing concepts like grammar and organization.

**Programmatic Assessment**

The results of Programmatic Assessment through 1) the report of the Student Assessment Committee (SAC) and; 2) senior exit interviews indicate that overall the Physics major is well structured and does facilitate student achievement in Physics.
1) The SAC examined each of the courses in the Physics major and compared each course against the learning goals. They found that the courses did cover the learning goals, though they made some minor suggestions for revising which goals are covered in which courses. For example, they argued that our laboratory courses should be considered as teaching written communication as there is a large writing component in producing lab reports.

The SAC report makes several recommendations for revisions to the Physics major:

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

The SAC report focuses primarily on recommendations for change, but did specifically praise several upper division courses as being extremely useful and well done: Phys 116, 124, 130, and 175. The report also noted that the faculty were extremely accessible to the students, and that the faculty and staff of the Department provide “substantial amounts of strong academic and financial support.”

2) The senior exit interviews resulted in wide ranging discussions with the students, 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:

- Students were uniformly pleased with the very high level of accessibility and interaction with faculty members. They found the small class size of the upper division courses was extremely helpful in this regard.
- Students were also uniformly in favor of more advising. They found the advising they received helpful, but thought that more frequent, mandatory sessions would have made navigating the program requirements easier.
- Students found the requirement to attend seminar very helpful in exposing them to a broad range of subjects within Physics, but did not have much exposure to reading professional scientific literature.
- Students found the level of hands on experience provided in laboratory courses very useful, both in terms of teaching practical skills desired by employers in the job market, and in terms of putting topics learned in theory courses into context.
- Students found that computer literacy was well addressed in the major, despite the fact that there is no formal requirement, and that the computational physics course is only an elective. Students told us that the use of computers was well integrated into the program in several different courses.

**Discussion**

In response to the analysis of the assessment data, the Assessment Committee is making the following recommendations to the Department:
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.

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. Comparing this year’s assessment results to those from next year will be the start of a longer term study of the effectiveness of the Department.

Important assessment activities for the upcoming year include:

- Analyzing final examinations and course grade distributions for three different upper division Physics courses.
- Selecting an upper division laboratory course as one of the three courses to be analyzed. This will let us start studying the writing requirements in the program.
- Continuing to collect and analyze senior project reports and the feedback forms from the oral presentations.
• Beginning to collect examples of laboratory reports to assess all Physics learning outcomes.
• Collecting publications by students of research projects carried out with faculty members.
• Revising the questions for the senior exit interview based on the results of this report.
• Obtaining statistical data on Physics majors performance on the Physics GRE from Educational Testing Service. These data have already been requested for the past five years, but did not arrive in time for inclusion in the assessment report this year.

Assessment Materials on File

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

1) The report of the Student Assessment Committee.
2) Audio recordings of senior exit interviews.
3) List of questions used during senior exit interviews.
7) Senior project written reports for all senior projects completed by Spring 2008.
8) Summaries of senior project oral presentation feedback forms for all senior projects completed by Spring 2008.