**Inventory of Program Assessment Activities, through 2011**

**PROGRAM/DEGREE: MS Physics** **COLLEGE: Science and Engineering** **DATE: January 8,2010**

**Program Mission:** This program is designed to provide a solid, in-depth background in theoretical and (optionally) experimental physics as appropriate for students who plan to pursue Ph.D. programs in Physics, Astronomy, or related fields, or who plan careers as scientists, engineers, scientific associates, scientific data analysts, or community college instructors. The program combines advanced education in core physics topics with additional advanced coursework, computer work, and (optionally) laboratory work. Students in this program are strongly encouraged to gain research experience. A culminating experience consisting of either a thesis or a comprehensive oral exam is required. Graduates should have the mathematical, scientific, and learning skills to enable them to be lifelong learners who can rapidly learn and master new scientific and technical developments and who can present these ideas to others.

| Measurable Learning Objectives | Place in curriculum where objective addressed | Academic year objective was/ will be assessed | Assessment/Procedures Methods/Strategies | Summary of Findings about Student Learning | Use of Findings for Program Improvement |
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| 1. Strong and thorough Knowledge and understanding of, and ability to use, essential concepts and methods in physics. | Phys 701,704, 706, 775 (M) | 2007-2008 | Performance on standardized examination (Physics GRE).<br><br>Performance on final oral (comprehensive oral). | Students must achieve a score of 25th percentile on better on the Physics GRE before they are allowed to complete their culminating experience. Students graduating in 2007/2008 achieved an average score of 41st percentile on the GRE, ranging from a high of 74th percentile (very good) to a low of 25th percentile (barely acceptable).<br>Performance in the final oral in many ways mimics the GRE scores. While some students gave an excellent performance, others barely squeaked by. This year we had no failures. | The problem with the GRE as an assessment tool is that the speed at which questions must be answered (1.7 minutes per question) can have a severe negative impact on some of our students. Even so, we feel we can (and must) improve the students' scores. We have already introduced a GRE prep course in the Fall semester, and we will be looking for ways to improve our courses so that the fundamentals stick better. |

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| | | 2006-2007 | Performance on standardized examination (Physics GRE). | We were unable to obtain a breakdown of scores from ETS. Overall scores had a mean of 55th percentile with a standard deviation of 19. 25% of the scores were above 75th percentile. | While we consider these scores to indicate good knowledge, there is room for improvement. Faculty are urged to stress comprehension of fundamental concepts in all graduate courses. |
| | | 2005-2006 | Performance in required courses as indicated by grades. Faculty have developed grading rubrics and have integrated grading standards into syllabi. | Graduate course grades followed a general pattern of 75% A/B (good knowledge/understanding) and 25% C/less (inadequate for grad students) | Course outlines are modified and updated to address weak areas. Advisors use results to recommend course sequencing |
| | | 2003-2004 | Survey of students in program as to their progress toward attaining this objective. | Program students rated their progress 1.9/5 (1 best). | N/A |
| 2. Strong ability to utilize mathematical relationships and methods to describe physical phenomena. | Phys 785 Phys 701, Phys 706, (D), Phys 704 (M) | 2007-2008 | Specific problems assigned on midterm and final exams in Phys 701 and 706 that will be tracked separately. | | |
| | | 2005-2006 | Performance in required courses as indicated by grades. Faculty have developed grading rubrics and have integrated grading standards into syllabi. | Grade patterns as above; informal tracking of ability w/ mathematical relationships and methods shows adequacy in 75% of MS students. | Course outlines are modified and updated to address mathematical content and development |
| | | 2004-2005 | Career success or success in Ph.D. program (alumni survey) | Alumni felt the program served them well in this regard. | Alumni felt that we did well in this area. |
| | | 2003-2004 | Survey of students in program as to their progress toward attaining this objective. | Program students rated their progress 1.9/5 (1 best). | Students feel we are doing well in this area. |

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| 3. Ability to solve problems of considerable difficulty in physics by integrating conceptual understanding, quantitative understanding, logical reasoning, and use of mathematical methods. | Phys 785 (D), Phys 701,704, 706,775, (M) and most 700-level electives (D) | 2008-2009 | Specific problems assigned on midterm and final exams in Phys 704 and 775 that will be tracked separately. | Final exam problem 1 In Physics 704, Spring 2009.<br><br>This problem was designed to integrate fundamental concepts in electromagnetism (potential, boundary conditions) with a somewhat more challenging geometry than would be found in undergraduate courses. Of the 13 students who completed the course, 7/13 scored higher than 11.5/20 on this problem. These scores are satisfactory, and the best three were very good. The remaining 6 students scored 7 or less, including one student who did not even attempt the problem and scored zero. | Students find this course the most challenging in our program, and the difficulties they exhibit are mostly a lack of understanding of fundamental concepts that should have been learned as an undergraduate. (The same issue shows up in the students' GRE scores.) We continue to wrestle with the conflicting demands of re-teaching the fundamentals and giving students a true graduate course. Part of the dilemma is that we admit a wide range of students with the idea of giving the weaker students a second chance. Then we do require that they come up to speed. Most do, but some don't. However, we feel it is important to maintain this strategy in an effort to increase the number of technically trained individuals, and in particular under-represented groups. Many of these students are required to re-take undergraduate courses here before taking Phys 704. Thus our strategy to improve performance in 704 must start with Phys 360 and 460. We must also strive to improve student reasoning and retention of fundamentals across the curriculum in all our courses. |
| | | 2005-2006 | Performance in required courses as indicated by grades, with special consideration of homework performance. Faculty have developed grading rubrics and have integrated grading standards into syllabi. | Grade patterns as for 1A. Informal tracking of problem-solving performance shows adequacy in 70% of MS students. | Course outlines are modified and updated to address problem-solving content and development. |
| | | 2004-2005 | Career success or success in Ph.D. program (alumni survey) | Alumni felt the program served them well in this regard. | Continue present course. |

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| | | 2003-2004 | Survey of students in program as to their progress toward attaining this objective | Program students rated their progress 1.9/5 (1 best). | We are doing well, but grad lab course is being reviewed for further improvement. |

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| 4. Strong ability to analyze and interpret data, with proper treatment of measurement uncertainties (lab/industry track only). | Astr 770 (D), Phys 710 (M) Thesis (M) | 2008-2009 | Evaluation of two homework assignments and evaluation of two laboratory reports in Phys 710 or Astr 770; evaluation of master's thesis. | Phys 710: The students who complete Phys 710 do well. Too many students withdraw without completing the course. Two students withdrew without completing any assignments, and one after completing only one.<br><br>Astr 770: The lab evaluated for this assessment compares predictions (based on the students' own numerical analysis of theoretical stellar spectra) with direct observations of stars (obtained either by the students themselves using the SFSU Observatory or, in the case of cloudy weather in San Francisco, by the instructor using SFSU's share of the WIYN 0.9m telescope at Kitt Peak National Observatory). Using these numerical predictions, students design various aspects of an experiment to test them. Finally, the students measure the fluxes of stars through various filters and estimate the uncertainties in their measurements.<br><br>Students showed marked improvement in this lab compared with earlier semesters. We attribute much of this improvement to the instructor's decision to add two earlier labs and lectures focused almost | Phys 710: It is unclear whether these students decided that the lab track was not for them, or withdrew for some other reason. We shall investigate this in future assessments.<br><br>Astr 770: students seem to be benefiting from the decision (based on the instructor's earlier informal assessments) to weave theory and observation more tightly together and to provide a more thorough discussion of statistics early in the course. In order to provide this extra help (which included extra homework assignments) without overworking the students, several useful labs had to be cut. In order to reinstate those labs, the instructor proposed that Astronomy 470/770 be increased from a 2-unit course to a 3-unit course. The department approved this change in Spring 2009, and the revision is currently under review by the Academic Senate. |

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| | | 2005-2006 | Performance in graduate laboratory courses as indicated by grades. Faculty have developed grading rubrics and have integrated grading standards into syllabi. | Graduate laboratory grades run higher than in theory courses; 80% A/B. Likely due to small class size and extensive feedback from instructor. | Curriculum and required activities in laboratory courses are reviewed and updated as indicated. |
| | | 2003-2004 | Survey of students in program as to their progress toward attaining this objective | Numerical survey result did not separate out those who took grad lab. Those who did commented that it helped them in this area. | Laboratory courses are being reviewed to strengthen coverage of data analysis. |
| | | 2002-2003 | Evaluation of laboratory reports and journals. | Informal reports from graduate lab instructors indicate 70-80% adequate handling of data analysis. | Laboratory courses are being reviewed to insure adequate coverage in this area. |
| 5. Strong ability to design and implement experimental investigations, with proper use of instrumentation (lab/industry track only). | Phys 710, Ast 770, (D) Phys 898 (M) | 2010-2011 | Evaluation of laboratory notebook and two laboratory reports (Phys 710, Astr 770); evaluation of master's thesis (Phys 898). | | |
| | | 2004-2005 | Career/Ph.D. program success (alumni survey) | Alumni felt that some improvement could be made. | Laboratory courses expanded their coverage of data analysis. |
| | | 2005-2006 | Performance in graduate laboratory courses as indicated by grades. Faculty have developed grading rubrics and have integrated grading standards into syllabi. | Students in the graduate lab course achieve 80% A/B. (Not all grad students take the grad lab.) Likely due to small class size and extensive feedback from instructor. | Curriculum and required activities in laboratory courses are reviewed and updated as indicated. |
| | | 2002-2003 | Evaluation of laboratory reports and journals. | Graduate lab instructor reports 80% or more develop adequate ability in experiment design by end of lab course. | |
| | | 2003-2004 | Survey of students in program as to their progress toward attaining this objective | Those taking the grad lab reported good achievement of this objective. | Curriculum and activities in the relevant lab courses will be reviewed and revised |

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| 6. Strong ability to communicate knowledge and results to others in written and oral form. | Sci 614 (I)<br>Phys 704, (D)<br>Phys 710 (D)<br>almost all 700-level electives (D);<br>Phys 712, 722 (M)<br>Thesis and thesis defense (M) | 2007-2008 | Evaluation of two laboratory reports (one of which is a full scientific paper) and oral presentations to instructor (Phys 710). Evaluation of term project (written paper and oral presentation) (Phys 704). Performance in final oral examination and/or thesis and thesis defense. | Five students completed the Spring 2008 Physics 710 course (eight were initially enrolled). Four of the students who completed the course received average report scores greater than 9, indicating excellent achievement of the learning objective. The other student who completed the course received an average report score between 8 and 9, indicating good achievement of the learning objective.<br>In Physics 704 we have chosen to assess students' ability to communicate knowledge and results to others by assigning a term project in which students work in teams of two or three. The project involves analytic and numerical computation, a written paper, and an oral presentation to the rest of the class. The facets of this assignment relevant to this assessment are:<br>**1. Written paper**. Students should write clearly and concisely, with correct grammar, spelling and punctuation. The paper should allow the reader to understand what the team did, why, and how. The results should be clearly presented, with important points emphasized. Normal physics conventions in terms of references and fonts should be respected.<br>**2. Oral presentation.** The team should organize the presentation well, and make use of tools such as Power-Point. Slides should be clearly visible in the back of the room. Important points should be emphasized, with minor details minimized. The student should speak clearly, at an appropriate speed, and avoid fillers such as "um". | The students who complete the course do well. Too many students withdraw without completing the course. Two students withdrew without completing any assignments, and one after completing only one. It is unclear whether these students decided that the lab track was not for them, or withdrew for some other reason. We shall investigate this in future assessments.<br><br>With the exception of the two students in Team alpha, the writing quality was very good, with no significant errors in grammar. The students are aware of conventions used in physics journals, and use them correctly. The oral presentation by team beta was truly excellent. Team gamma performed well. Again, the two students in team alpha performed less well. Their presentation lacked preparation, and was sloppy and amateurish.<br>Most of the students communicate well by the time that they take this advanced course. The two students who did not perform well did not appear to put in enough time and effort. We should continue to emphasize the importance of communication as a skill that physicists must possess, and emphasize more the need for preparation of oral presentations. |

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| | | | | We also evaluated student performance in two final oral examinations and 5 thesis/thesis defense.<br>Students are typically hesitant during the oral examinations, especially at the beginning. Our students prepare well-written theses using proper physics conventions. The thesis presentations were typically well done, with good power-point slides and clear oral presentations.<br>However, with one exception, the students were not able to answer questions on the thesis as fluently as we would like. | We have begun a program of helping students prepare for the examinations by having a faculty member ask them questions in practice sessions. Even though they become more proficient during these practice sessions, exam nerves can take over during the actual examination. Nevertheless, one of this year's sample students did an excellent job during the exam.<br>The department faculty are discussing methods we can use to stress the importance of the questioning part of the thesis defense. We will be stressing how to prepare for the thesis defense, and using some class time in graduate electives to this end. |
| | | 2006-2007 | Culminating experience (final oral examination or thesis and thesis defense). | 90% of students do an excellent job on the thesis defense.<br>Final orals have been more mixed, with 50% doing and excellent job and 10% having unsatisfactory performance. | Students are urged to schedule independent study courses to prepare for the final oral.<br><br>We continue to have trouble locating adequate resources to help foreign-born students with their English. Sci 614 has not proved adequate. |
| | | 2004-2005 | Career/Ph.D. program success (alumni survey) | Alumni felt that lab courses could use some strengthening. | More modern instrumentation and apparatus was obtained for graduate labs. |
| | | 2002-2003 | Evaluation of laboratory reports and research projects. | Analysis of lab and project reports and/or term papers indicates >80% adequate quality of written reports after instructor correction and revision 20% of students produce excellent written papers and oral reports. | Adequacy of writing and presentation requirements and correction/grading is reviewed. |
| | | 2003-2004 | Survey of students in program as to their progress toward attaining this objective | MS Program students rated their progress 2.3/5 (1 best). | Dept. review of writing in the graduate program |
| 7. Strong ability to utilize print and | Phys 785, Phys 710 | 2008-2009 | Evaluation of the write-up to Lab 3 (Phys 740). | Evaluation of the term project (Phys 704). | |

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| electronic resources, computers, and software to gain information and perform calculations. | (D), Phys 740, (D) Phys 704, (M), many 700-level electives (D) | | Evaluation of the term project (Phys 704). | 16 students were divided into 5 teams: 4 teams of 3 and one team of 4. The task was to use a computer to evaluate the numerical value of the potential at the center of cylinder with specified potential on the walls. The students were evaluated on the clarity and appropriateness of their numerical techniques, the accuracy of the result, and their understanding of the uncertainties in the numerical result.<br>The average score for the result was 82%, with three teams scoring 100%, one team scoring 90% and one team scoring 20%. The average score for the appropriateness of their technique was 77% ±16%, with three teams scoring above 80%, one team scoring 67% and one team scoring 53%. The average score for understanding the uncertainties was 61% ±18%, with three teams scoring above 65%, and two teams scoring 40%. This was by far the most difficult part of the assignment, and the one that was new to all the students. The top score of 85% was very good for this difficult task. In all cases the same team had the lowest score.<br><br>In the Phys 740 lab we tested the use of Matlab, gnuplot, and LaTex software, and the ability to write a program which solves ordinary differential equations with specified boundary conditions by the shooting and matching methods. Programs were written in either Matlab or C++, plots were produced using either gnuplot or Matlab software, and reports (including postscript plots and equations) were produced in LaTex. | Most of the students in Phys 704 were very comfortable with and competent in the use of numerical techniques to solve problems. One team did not do any part of the assignment well.<br>The team that did poorly on this assignment faced many challenges, not specifically related to this task. Two of them did not speak or write English well. The university provides few resources to help graduate students with their English. It would be nice if courses could be offered, perhaps through CEL, to help such students. All of them struggled through most of the material in this class, which is the most difficult in the program. While office hour help is made available, they did not take sufficient advantage of it. I am giving serious thought to changing the grading scheme for this class to make the office hour more attractive to students, as the one-on-one interactions that occur during office hour are an essential part of graduate education.<br>The remaining students in the class showed good to excellent results for this learning objective. |

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| | | | | Out of 10 points possible on this lab, the average score was 8.5, indicating that almost all of the students had a good grasp of the use of the software, necessary programming skills to solve the assigned computational problem. | Phys 740 is an elective that we recommend strongly. The students who took this class performed very well on this learning objective. We will continue to stress the importance of this elective. |
| | | 2004-2005 | Career/Ph.D. program success (alumni survey) | Alumni suggested we have more opportunities for student presentations. | We have increased the student presentations in graduate courses and labs. |
| | | 2002-2003 | Evaluation of problem assignments, lab reports, and research projects. | Informal reports from graduate course instructors indicate >80% adequate performance. | Changes in syllabus/content of some graduate courses to address this need. |
| | | 2003-2004 | Survey of students in program as to their progress toward attaining this objective | MS students rated their progress 2.1/5 (1 best). | Relevant courses and projects will be reviewed and revised to address this need. |
| | | 2004-2005 | Career/Ph.D. program success (alumni survey) | Alumni suggested we provide better computing and software resources. | Department computing has been upgraded, especially in graduate labs. A graduate computational physics course is offered. |

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| 8. Ability to work in teams to solve a problem | Phys 704, (D) Phys 710 (D) | 2010-2011 | Evaluation of team project in Phys 704. Evaluation of written and oral reports prepared by each team. | | |
| | | 2006-2007 | Evaluation of team project in Phys 704. Evaluation of written and oral reports prepared by each team. | There were eight students this semester, formed into three teams. Each team functioned well and produced a quality product. One team was less successful in coordinating their efforts into one final report. | Modify input provided to teams during the course to improve their coordination. |