DEPARTMENT OF PHYSICS – ASSESSMENT PLAN

INTRODUCTION

This assessment plan for the Physics Department outlines assessment procedures for the graduate and undergraduate components of the instructional program. The plans for each component include the following major items:

1) Articulation of the overall goals of the program,
2) Statement of objectives matched to these goals,
3) Development of instruments that measure the extent to which the objectives are being achieved,
4) Implementation of these instruments to gather assessment data, followed by analysis and interpretation of these data.

Each of these components is addressed in the sections below for the graduate program and for the undergraduate instructional program, the latter including both the program for the majors and the "service courses" for non-physics majors. The ultimate purpose of this assessment plan is to improve our programs so that our students will learn and retain more, will understand better what they learn, will have more motivation to learn, and will be able to apply what they learn in new and different situations.

THE GRADUATE PROGRAM IN PHYSICS

Assessment Report - Department of Physics

ABSTRACT

The Graduate Program in Physics is evaluated in the form of a self-study every ten years. Evaluations of the admissions criteria, the curriculum, advising, the Qualifying and Preliminary examinations, the research program, the time required to obtain a PhD degree after entering graduate school, and professional placement are obtained through surveys of current graduate students and recent alumni. Given that the last evaluation was conducted in the 1997-98 academic year, a new self-study is planned for 2007-08.

The goal of the Ph.D. program is to graduate students who:

1. are well trained in the core areas of physics, that is, the basic, widely applicable subjects that every physicist is expected to have mastered;

2. have mastered the research techniques of a subfield of physics, and have demonstrated the ability to pursue independent research and apply known results in that field;

3. have acquired and demonstrated through courses and examinations a breadth of knowledge about physics which enables them to formulate physical problems clearly, recognize the experimental or theoretical techniques relevant to their solution, and apply those techniques to the solution of physical or technical problems.

The total number of graduate students has increased from 134 in 1996-97 to 156 in 2005-06. The present graduate student class is sufficient to cover the TA requirements of the introductory undergraduate courses, to supply the needed enrollments in the graduate courses, and to meet the demands of the research groups for RA's. A vigorous recruiting which has been in place for the past several years, including group visit weekends for prospective graduate students, has succeeded in increasing the size of the entering graduate student classes and has over time restored the population to around 150. A terminal masters program described below in more detail has been implemented to meet the needs of students who plan to enter the work force at that stage. The time required to complete a PhD has been shortened. The UW has waived tuition for both TA's and RA's, which has improved our competitive position in recruiting. The overseas component of the graduate classes is stable at about 30% (27.5% currently). Total of women/minorities and economically disadvantaged are about 20% (22.1% currently).

The graduate student and alumni surveys have yielded generally positive results regarding experiences at UW. Some of the concerns, like the tuition, have already been addressed. Others are part of the ongoing effort to tune the graduate program to meet the requirements of its customers.

ASSESSMENT TOOLS USED:

Direct indicators
Graduate program

National Exams: GRE's
Local Exams: qualifier/prelim
Review theses: yes
Pre/post testing: not formally

Indirect indicators

Student surveys: yes
Alumni surveys: yes

NARRATIVE

The review of the graduate program was conducted by the Physics Graduate Program Committee, which compiled and analyzed data for the past ten years on applications and enrollments, the quality of incoming students as measured by GRE scores and subsequent performance on the Qualifying Examination in Physics, the makeup of the applicant pool, the composition of the graduate student body, and the time necessary to complete the Ph.D. It conducted surveys of the present graduate students and of Ph.D. graduates since 1990 to get student and graduate assessments of their graduate experience in all areas, including courses and research, experience as TAs and RAs, and, for the graduates, the relevance of their preparation to their professional activities. The committee invited suggestions for possible improvements in the program, and followed up on the suggestions with discussions with current graduate students. Some changes in the program have already been made as a result of the discussions. Other possible changes are being considered.

The Ph.D. program:

The Ph.D. program in Physics is quite selective, and heavily oriented toward research. The only course requirements are in core areas. Students are admitted only if there is a high likelihood of their finishing the Ph.D. Successful candidates are well trained in the core areas of physics, have mastered the research techniques of a subfield of physics, and have demonstrated the ability to pursue independent research.

The graduates from this program have been notably successful in obtaining employment and continuing to pursue basic or applied research in universities and in industrial and government research laboratories.

The M.S. and M.A. programs:

New two-year terminal Master's programs were started in 1996-97 in response to demand from prospective graduate students, and the recognition that many of the employment opportunities in applied physics require advanced training, but do not require the full Ph.D. research degree. Graduate students may now be admitted directly to one of two Master's programs:

Master of Science Program:

This is a two-year professional program which gives the student a significant introduction to research. It requires the completion of a Master's thesis based on a short directed research project, and has flexible course requirements to allow the program to be tailored to the professional needs of the student.

Master of Arts Program:

This is an academic program based on enhanced course requirements without a research component. It is suitable as background for students who wish to move into non-traditional areas with a strong physics background, or for students in physics education. Both degrees require that the student pass the comprehensive Qualifying Examination.

The new Master's programs have begun to attract entering graduate students; to date, ten have chosen this path and been awarded degrees. There are only a few programs of this type in major physics departments in the U.S., and those have been very successful in preparing students for work in technical areas.

DATA AND COMMENTARY ON THE GRADUATE PROGRAM:

Size of the graduate program:

The total graduate enrollment in Physics has increased in the last decade from 134 students to 156. This increase in entering graduate students is a nationwide phenomenon, caused partly by an increase in the pool of qualified applicants.

UW's competitive position for attracting qualified students has been improved by the TA and RA tuition remissions. However, the non-competitive TA stipends over the last several years have resulted in the Department's decision to implement an aggressive recruiting drive, supplement stipends with Foundation funds, make the graduate program more flexible to meet the needs of today's market, and streamline the path to the PhD degree. The quality of those admitted, as measured by the Graduate Record Exam scores, has increased to a caliber not seen before.

The lower enrollments of previous years led to difficulty in running graduate courses. With the increased enrollment of the last decade, course offerings are no longer restricted by the size of the graduate student population, but instead have been impacted by numerous faculty retirements and the resulting smaller faculty. The department and the college are making considerable efforts to maintain the necessary faculty size.

Quality of the students:

The Graduate Admissions Committee routinely monitors the quality of the students admitted to the graduate program through GPAs, recommendations, and GRE test scores. In 2004, the physics subject GRE was changed from very strongly recommended to required as part of the application materials. The admissions process is checked by the performance of the students on the comprehensive Qualifying Examination which covers undergraduate physics at a sophisticated level. The success of the students on the exam is a measure both of the quality of their undergraduate education, and of their ability to carry what they have learned to a higher level and recognize new applications. There has been a measurable increase in the quality of the students admitted in recent years.

The department has not been notably successful in attracting the very top fellowship students in competition with more prestigious programs elsewhere, but competes very effectively for good students with other large state universities.

Makeup of the graduate student body:

The makeup of the graduate student body has been remarkably stable, with approximately 3/4 domestic students and 1/4 international. The enrollment of females has been stable at about 20%, while the enrollments of targeted minorities have varied from 10% to 5% of the domestic enrollment, with an average of about 8%.

An average of 21% of the applicants have been female, while about 6% of domestic applicants have been in minority categories. These percentages define the pool from which the Physics Department recruits. Females have averaged 21% of students offered admission over the last few years, while minorities constituted roughly 4% of domestic admissions. The percentage of women actually enrolling at Wisconsin is systematically 1/2 to 2/3 smaller than the percentage admitted. The percentage of men enrolling is the same, indicating success in recruiting women who have already applied. However, given the historically low percentage of women in physics careers, there is a clear need to improve recruitment of women. The problem in attracting minorities is much more severe.

Student support:

Most incoming graduate students are admitted and enroll as TAs, teach for 1-2 years, and then go onto RA support with research groups. A smaller number are admitted as fellows of various kinds. There continues to be adequate support for RAs. The staffing of TA positions has been sufficient with the increased overall enrollment and good RA support.

Because there are vacancies in RA positions, and because there is a need for turnover in TA positions to make them available for incoming students, the department has recently taken steps to help students make the transition into research groups and RA positions where available. These steps are also designed to help reduce the time required for obtaining the Ph.D. by reducing the time taken to begin dissertation research. Students seeking TA support in the third semester

and beyond are now required to discuss their research with their major professor and write a short description of their research efforts. Both the student and the major professor sign this document and submit it to the department.

CONCLUSIONS ON THE GRADUATE PROGRAM

Strong points in the program:

We conclude from the data we have acquired in our review of the graduate program in Physics that it is generally successful in attaining its objectives. We note in particular the following:

The quality of the students admitted to the program is good as measured by GPAs, GRE scores, recommendations, and internal standards, and has been improving by the increase in the applicant pool. The success of Ph.D. and Master's graduates in obtaining positions that offer suitable career opportunities confirms the quality of the program.

The research experience provided in the program is highly valued by graduates as well as current students. The depth and breadth of knowledge provided by the core graduate courses is regarded as useful and is appreciated by the graduates and current students.

The program is successful in preparing students for their subsequent careers in traditional and non-traditional positions, but more breadth in the graduate training in physics would be useful. The new Master's programs are likely to provide an attractive alternative for students who want advanced training, but do not need the full Ph.D. research degree for their intended careers.

Areas for future change:

1. Although the length of time necessary to complete the Ph.D. is decreasing as a result of changes in the Qualifier and Prelim and tightened requirements for obtaining a major professor and starting research, a further decrease would be desirable. Future data and progress on this will be monitored by the Graduate Program Committee.

2. The advising of incoming students should be improved, especially with respect to department and university requirements, the necessity to plan a coherent major and minor program early in the graduate career, and the desirability for later employment of using the Minor to build breadth into the program.

3. The advising of students on job opportunities in industry and other non-academic situations should be improved, and more help should be provided in placement. Physics students are now invited to participate in applicable interviews and job opportunity seminars at the Engineering Placement Office.

4. The coordination of the graduate courses could be improved. There may be possibilities for changing existing courses or adding new courses to better prepare students for the new breadth of employment opportunities. The Graduate Program Committee will continue to work on these questions. It will also continue to monitor enrollments and will further adjust the course schedule to ensure that the advanced specialty courses can be taught regularly. To maintain the graduate curriculum it is also important that the faculty size be maintained at historic levels existing prior to the recent spate of retirements.

5. The department's effectiveness in the recruiting of outstanding students, women, and minorities can be improved. The enrollment of women is consistently about 1/2 to 2/3 below their availability in either the applicant pool or in the set of students offered admission. Greater emphasis should be placed by the Admissions Committee and the Department as a whole on actively recruiting women and providing a supportive atmosphere for them.

6. The number of minority graduate students has remained very small despite continuing recruitment efforts by the Graduate School at traditionally black institutions and a high acceptance rate as a fraction of all domestic admissions. We have typically had 1 out of 3 targeted minority or economically disadvantaged students accept our offer of admission in the past several years. The present recruitment efforts should be continued, but more extensive options should also be considered, including active recruitment of Hispanic students.

THE UNDERGRADUATE PROGRAM IN PHYSICS
Assessment Report - Department of Physics

The assessment plan that we have developed over the past years focused mainly on our majors program. However, majors account for fewer than 10% of the students enrolled in our courses. This year we are developing an assessment plan that will allow us to monitor our progress toward learning goals for the bulk of the students we teach.

A. Learning Goals (These goals differ according to the student populations involved.)

1. Learning Goals for students in introductory service courses (for non-majors. These goals are primarily for our "General Physics" courses: Physics 103/104, Physics 201/202, Physics 207/208, and Physics 205, 241, and 244):

    a. to know basic physical principles (forces, conservation of energy, etc.)
    b. to solve problems using both quantitative and qualitative applications of these physical principles
    c. to overcome misconceptions about the behavior of the physical world
    d. to understand the range of applicability of physical principles, particularly to the each student's particular field of study
    e. to apply physics to topics not explicitly covered by the courses
    f. to appreciate the excitement of physics
    g. to make quantitative measurements of physical phenomena and understand the statistical significance of observations made in the presence of statistical and systematic uncertainties.

2. Learning Goals for students majoring in Physics, AMEP, Astronomy-Physics:

    a. same goals as "1"
    b. to understand basic physical phenomena in depth
    c. to be acquainted with a wide range of research areas in physics
    d. to prepare students for graduate study or careers in physics and related fields.

3. Learning Goals for non-science majors. These goals are primarily for Physics 107 ("The Ideas of Modern Physics"), Physics 109 (“Physics in the Arts”), Physics 115 (“Energy”), and Physics 371 ("Acoustics for Musicians").

    a. to know basic physical principles (forces, conservation of energy, etc.)
    b. to overcome misconceptions about the behavior of the physical world
    c. to appreciate the excitement of physics

B. Assessment Plan for Physics Undergraduate Program

1. Introductory service courses (many parts are new)
    a. Instructional Program Manager (IPM) monitors enrollment trends (annually) in student population of the introductory courses through surveys and on-line databases. By studying demographic information IPM assesses whether our courses are accessible to the full spectrum of the undergraduate population. This process needs to be automated. Assesses Learning Goal 1.
    b. Course evaluations of lecture, lab, discussions (in place). Assesses all of Learning Goal 1.
    c. Periodically administer Force Concept Inventory to students at beginning and end of each course. The FCI is a short, standardized test of students’ understanding of physics. It is easy to administer and score. Our physics education visitors reported using it at the beginning and the end of a semester to assess their courses. Compare to scores at other institutions for similar courses and to historical trends in our own courses. Assesses Learning Goals 1a, 1b, and 1c.
    d. Periodically survey (with class questionnaires and interviews and interviews with students enrolled in the Peer Mentor Tutor program) students in introductory courses. Questions include: (i) relevance of course content to their course of study, (ii) reaction to course organization. Assesses Learning Goals 1d,1e, and 1f.
    e. Periodically invite faculty from departments that require physics for their majors to visit introductory courses and fill out questionnaires about relevance to their programs. Assesses all of Learning Goal 1.
    f. Lab Director assesses discussion sections and laboratories through periodic visits.

2. Majors (in place)
    a. ILM conducts annual exit survey of graduating seniors by email and regular mail and maintains a data base of where they go after graduation. Assesses Learning Goal 2d. Topics include:
        (i) the department environment,
        (ii) enrichment experiences,
        (iii) professional and employment preparation, and
        (iv) review of academic program.
        (v) effectiveness of new intro sequence: Physics 247/248/249
    b. IPM periodically surveys alumni to assess long-term relevance of program to real world. Assesses all of Learning Goal 2.
    c. Course evaluations. Assesses Learning Goal 2a.

3. Non-science Majors

    a. Instructional Program Manager (IPM) monitors enrollment trends (annually) in student population of non-science majors courses through surveys and on-line

databases. By studying demographic information IPM assesses whether our courses are accessible to the full spectrum of the undergraduate population. This process needs to be automated. Assesses Learning Goal 3.

b. Course evaluations of lecture, lab, discussions (in place). Assesses all of Learning Goal 3.

C. "Physics for Biologists" course: a test-bed for new assessment procedures.

1. Overview

For several years the Department of Physics has worked with members of the biological sciences on campus to improve the way we teach introductory physics to students majoring in biology, biochemistry, genetics, etc. These efforts began with the encouragement of Dean Wang in the form of a program called "SyMBiosis." SyMBiosis was a response to the realization that a large number of students that take introductory physics major in some field related to biology and that the level of physical understanding required in biological fields will continue to increase. We are now developing a course that we call "Physics for Biologists," and the collaboration between physics and biologists has evolved to what we call "SyMBiosis II." Our overarching goals are to:

a. present physical principles in a manner that is especially useful to biology students (Learning Goal 1d)
b. develop pedagogy that improves students' understanding of physics (Learning Goal 1a,b,c,d,e)
c. and its applicability to biology. (Learning Goal 1d)
d. encourage students to take physics as freshmen and sophomores (Learning Goal 1d) so that biology departments can
e. integrate physical principles into biology courses (Learning Goal 1d).

The curriculum changes will immediately affect Physics 207, "General Physics". This course is offered each semester and has an enrollment of about 150 students each term. We do not have adequate resources both to offer the new course and continue to offer the original course, so we are planning to gradually modify the current course.

Prof. Don Cox has volunteered to spearhead the effort in Physics. As he teaches Physics 207 in Spring 2006 he has introduced new materials incorporating biological examples to the lectures, discussion tutorials and homework assignments. With the assistance of Larry Watson (Physics), Lillian Tong (CBE), Dave Nelson (Biochemistry and CBE) and others, he organized a meeting on Nov. 4 2005 between about 20 physicists and 20 biologists (http://www.physics.wisc.edu/news/bio-phys/). We outlined more than 50 ideas that we are starting to develop into curricular materials at a Learn@UW course website/discussion forum. Larry Watson is organizing these ideas now and has helped Cox introduce them to Physics 207.

This semester we were fortunate enough to receive funds from the Assessment Council to hire a Project Assistant to assess the changes underway in Physics 207. It has been particularly important for us to do so, for two reasons: (1) The assessment will tell us which of our pedagogies is most effective. (2) The assessments we develop will lay the groundwork for the new assessment plan for all of our introductory courses. The assessment strategies are of enormous importance to our entire undergraduate program; we need to measure our progress toward achieving Learning Goal 1.

Our Project Assistant is Mr. Peter Hyland, a fourth-year graduate student who has been an active member of the DELTA program for the past two years; funds from the University Assessment Council are allowing him to serve as a DELTA Intern in spring ’06. (DELTA does not fund interns.) The Internship is required for earning a DELTA Research, Teaching and Learning Certificate. Hyland joined DELTA’s Expeditionary Learning program in spring '05 and this semester is part of the Creating a Collaborative Learning Environment (CCLE) program. He is also taking a DELTA course this semester (Teaching Science and Engineering: The College Classroom [3 credits]) and serves on the DELTA Steering Committee. A large part of his training is in assessment of teaching and learning. He is responsible for implementing the assessment plan outlined below.

2) *Specific plans for assessing the course:*

a. We invited faculty from biological science departments to sit in on Physics 207 lectures and discussions during the semester and provide feedback on topics covered and how to integrate them better with biology. Through SyMBiosis-II we had established these contacts and have commitments from over 20 faculty members outside our department. At our forum on November 4, biology faculty and staff worked side-by-side with physics faculty to write outlines of examples that we might use in Physics 207/208. (Assessment Plan 1e)

b. Surveyed the P207 students with questionnaires. The questionnaires asked about students’ perceptions of the course content and structure and have been given at the middle and end of the course. (Assessment Plan 1d)

c. Surveyed the P207 students with the Force Concept Inventory at the beginning and end of the semester. (Assessment Plan 1c)

d. Interviewed students in P207 to determine their views on the effectiveness of the changes. Interviews complement the questionnaires of part “b” by giving the opportunity to dig deeper on student responses and ask questions in a flexible way. These interviews occurred throughout the semester to allow timely adjustments. (Assessment Plan 1d)

We expect the results of the assessment will be of interest to colleagues across campus and throughout the physics education community. Indeed, Larry Watson will present them at the Teaching and Learning Symposium in Spring ’06. Furthermore, we expect to write an article for either “The Physics Teacher,” the monthly journal of the American Association of Physics Teachers, or the American Journal of Physics, which focuses on pedagogical issues in physics. We have obtained an exemption for conducting Human Subjects research.

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