Physics Assessment

American Physics Society Standardized Tests
Neil Aaronson is already experimenting with several American Physics Society standardized tests for general physics concepts. We are assessing skills and knowledge in a number of areas at the beginning and end of certain courses or sequences of courses (namely PLS I, PLS II, PHYS I and PHYS II). However, the work is experimental in nature and aimed at determining whether these instruments are appropriate for basic assessment of learning outcomes in general physics.

Assessment of WebCT and Black Board in Physics Teaching
Several of the program members continue to use WebCT and Black Board in the teaching of Physics for Life Sciences I and II. The electronic class rooms assisted in the use of computer simulations to demonstrate principles of physics. WebCT homework and quiz assignments allow the students to receive instant feedback on their work. Some preliminary assessment has tentatively concluded that students using computer instruction which gives instant feedback were making progress with respect to the learning goals of the course. However, whether the steady assignment of online homework is actually having an impact on learning will require an analysis of whether the student cohorts being compared are indeed similar. High school class rankings, math SAT scores and determining how many of the students were actually first semester freshmen, might shed additional light on the significance of these preliminary results.

Faculty Direct Assessment Activities:
On a daily basis Physics faculty are constantly engaged in many types of direct assessment activities such as faculty developed In-class content specific assessment, carefully designed homework sets as the weekly assessment tool, end-of-class assessment, pre-lab assessment, lab final project assessment, student senior project assessment, etc.

1. In-class content specific assessment as a daily assessment tool
Fang Liu and Neil Aaronson have developed their own topic-specific post-learning assessment to evaluate the students’ learning outcomes on the specific topics covered in the course. This type of assessment was employed at least once a week. This type of assessment takes about five minutes each time. Usually each assessment contains three simple questions related to the specific topics covered in that class and/or in that chapter and/or in that week. The student assessments are collected and analyzed very carefully. The instructors summarize how well the students learn in each given question and where most students seem to have difficulty. At the very beginning of the next class the instructor spends about five minutes to review those topics which most students have difficulty with. The students’ feedback has shown that this technique had an overall positive impact on their learning, helped reinforce material from lecture and helped them remain engaged with material. This has encouraged us to proceed with introduction of the topic-specific assessment into the teaching of the intermediate and advanced courses where similar assessments are now conducted by other physics faculty members.
2. **Carefully designed homework sets as a weekly assessment tool**

Students in every single physics lecture course and GNM course offered by a physics faculty member have weekly homework assignments. The homework problems are carefully designed to assess the students’ understanding of the concepts and to foster critical thinking and problem-solving ability. Each homework set is collected weekly and graded with detailed feedback and solutions. The preliminary assessment has shown that the strict requirement on the homework has had an overall positive impact on their learning, helped reinforce material from lecture and helped them remain engaged with material. This encourages us to keep on using the frequent homework as both the teaching tool and the assessment tool.

3. **Pre-lab assessment in PLS I & PLS II lab, in PHYS I & PHYS II Lab**

   Based on our assessment workgroup discussions, Fang Liu has designed her own pre-lab assessment test in her PHYS I lab to test the following:

   - Equipment skills (in using air tracks, camcorders, oscilloscopes, multi-meter, etc.)
   - Data analysis concepts and skills (uncertainty, significant figures, error propagation, proficiency in using Excel, video making, etc.)
   - Plotting and interpreting graphed information (quantitative goal)
   - Basic mathematical skills (Qualitative goal)

   These questions are also a regular feature in Benjamin Agyare’s end-of-class student learning assessment. This instructor is able to accurately gauge where the students have not grasped the concept and also judge the level of challenge a student can take on, based on these layered questions leading from lower level (something that involves slightly more than direct reproduction of presented information) to higher level (synthesis questions).

4. **Lab Final Project Assessment**

   As an assessment, students in both the algebra based Physics for Life Sciences lab and Calculus based PHYS lab are required to design their own projects. In the project, each student will be assessed in the following aspects:

   1) Knowledge of basic Physics concepts (at the Introductory and Intermediate levels)
   2) Data taking and data analyzing
   3) Understanding equipment
   4) Knowledge of research methods and of effective techniques for the written and oral presentation of research findings

   The preliminary assessment has showed that the students in these introductory courses have good knowledge of basic physics concepts. However, many of them still need more training in the aspect of data taking and data analyzing. This has resulted in more instructional time on data analysis during the laboratory time.
5. **Student senior project to assess the upper level physics majors**

We have required our junior students to attend bi-weekly research method and colloquium and senior physics students to carry out a senior project. The project is both proposed and defended at the physics colloquium. The project results are required to be presented at the NAMS annual poster session and is followed by a written report in the format of a Master’s thesis. We also encourage our students to actively seek the summer research opportunity for undergraduate student (REU program).

The assessment result has indicated that the application of physics is the key to help the students understand the fundamental principles and laws. We have been working very hard to better equip our physics laboratory courses. As a result, laboratory course teaching is more effective. In addition we will continue to ask our students to design their own original experiment and to write up their results in a publishable format, which could significantly enhance their understanding of the fundamental physics concepts and strengthen their ability to apply these concepts in the solution of problems.

These direct assessments give us instant feedbacks which can be immediately utilized to fine tune the class activities, learning goals and learning opportunities, which can effectively help improve the learning outcomes.

**Assessment at the Program Level**

Meanwhile as a collective effort of the program, we have continued to develop and test several different assessment tools at the program level.

1. **Major Field Test**

We created an assessment test which contains GRE (Graduate Record Examination) physics subject test type of questions. It was given to all physics majors at the end of spring 2008. The students who took this test ranged from the freshman level to the senior level. The test consisted of approximately 16 five-choice questions, some of which were grouped in sets and based on such materials as diagrams, graphs, experimental data, and descriptions of physical situations. The aim of the test was to determine the extent of the examinees' grasp of fundamental principles and their ability to apply these principles in the solution of problems.

Most test questions can be answered on the basis of a mastery of the first year of undergraduate physics which cover the following topics: classical mechanics, electromagnetism, optics and wave phenomena, and thermodynamics.

The freshmen did surprisingly well on the materials they just learned in the 1st year of their physics course. They scored at least 60% of all the problems. In contrast, some of the junior or senior level students did not score as high as we had expected. This could be caused by the fact that this test was administered with virtually no warning. Overall we feel that these results show that our students are retaining a fair amount of the core material. Meanwhile, we believe that the test result would be more meaningful if we had notified the students in advance so they could take the test more seriously.
2. **Modular Exams I & II**

Instead of the single exit exam that is given at many institutions to graduating seniors, we feel that two topically modular exams will better assist us in assessing the learning outcomes of our students at different levels. It will help the faculty to revise their courses so as to be most effective. Students will take these exams seriously and will be able to benefit from the evaluation of their individual performance outcomes. This type of assessment can serve as a diagnostic tool to assist the students to prepare for the advanced physics courses.

Exam 1 will assess the student’s progress after having taken the introductory physics and intermediate physics courses. The classes which will be covered will include Physics I, Physics II, and Physics III. There courses constitute gateway courses for upper division physics courses and therefore a clear understanding of these subjects is essential for every physics major.

To make sure our data will be meaningful we have come up with an incentive to encourage the students to take the assessment test more seriously. We will give this test to the students right after they have completed their physics III test to help them earn an extra percentage toward their physics III final grade. We believe that this will serve as a nice incentive to encourage the positive efforts in the test and thereby ensuring a more meaningful assessment data.

Following the guidelines of our program learning goals, currently we are designing the questions to be included in this modular exam. The Modular Exam I will be administered in fall 2010 for the students who have taken the Physics I, II and III series.

Modular Exam II will assess the upper division courses such as optics, thermodynamics and statistical mechanics, quantum mechanics, laboratory methods, and specialized topics. A bank of questions will be compiled and evaluated by the physics faculty.

3. **Curriculum Re-evaluation**

Physics Program is currently re-evaluating the curriculum to provide the physics students with a curriculum with both the depth and the breadth. Physics program used to offer an application oriented physics course, the application of physics. It is proposed that this course should be offered again to enable physics students to see more applications of physics.