Proposed assessment loop for Physics & Astronomy
Draft, January 2013

Summary: During 2012–2014, the Department of Physics & Astronomy plans to assess the problem-solving ability of Physics and Astrophysics majors, specifically focusing on their ability to judge the physical reasonableness of problem solutions. We will use the data gathered to evaluate (and possibly change) the way we teach problem-solving in our intermediate and advanced courses for majors.

Departmental learning goals:

The proposed work is related to two of the “top-level goals” in our departmental statement of learning goals and objectives,¹ drafted May 2012:

I. Students will show mastery of the physics and astronomy content goals enumerated in the individual course syllabi for the required courses for the major. Students will be able to solve homework and especially exam problems related to particular physical laws or principles, e.g. Gauss’s law or conservation laws.

and

IV. Students will develop and exhibit the learning, problem-solving, communication, and laboratory skills enumerated below.

Departmental learning objectives:

We will assess objective A.4 from the “Problem-solving skills” section:

A.4: A student should be able to articulate expectations for, and justify reasonableness of, problem solutions, including both dimensional analysis and numerical values.

Learning strategies:

All of our courses for majors involve problem-solving, though the degree to which general problem-solving skills (as opposed to techniques or concepts that are specific to the particular subject area) are taught explicitly varies from course to course. Teachers model problem-solving through narration of worked examples in class, and by providing written solutions to homework and exam problems. Students solve problems in class, for homework assignments (typically assigned

¹ These goals are available at http://www.swarthmore.edu/assessment/academic-areas/goals-for-student-learning.xml - Phys.
weekly), and for exams. Students receive written feedback on both the correctness of their problem solutions and, often, on their problem-solving strategy (especially if the strategy was not the most appropriate choice for the problem at hand).

However, students are rarely asked to articulate their full problem-solving strategy, and in particular they are usually not asked to exercise a very useful problem-solving skill, which is to reflect on the final answer to a problem and to judge whether or not the answer is reasonable, where “reasonable” may involve correct units, physically-meaningful results in easily-checked special cases. Students may be doing this and it is just not apparent (since they aren’t asked to comment on it), but anecdotally, based both on solutions they turn in and on the feedback from external examiners in the Honors Program, it appears that this may be an area in which the problem-solving of many of our students could be improved.

**Learning assessments:**

We propose to assess this objective in three of our classes for Physics majors in Spring semester 2013, and then possibly to expand it to other classes during academic year 2013–2014. The courses for Spring 2013 will be Physics 13, Thermodynamics/Statistical Mechanics; Physics 15, Optics; and Physics 114, Statistical Physics. The former two courses are taken by first- and second-year students who are potential Physics or Astrophysics majors, while the latter course is a seminar taken by majors in the junior or senior year.

For each weekly problem set (roughly 12 over the course of the semester), there will be at least one problem for which the students will be instructed not only to solve the problem but also to comment on the reasonableness of their answer. Similarly, there will be at least one problem on the midterm and final exams with the same explicit instructions.

Student responses to this part of the question will be scored using a rubric that is still being developed. A possible model for the rubric is provided by the work of the Physics & Astronomy Education Research group at Rutgers University, who focus on what they term “Scientific Abilities,” with one of the five abilities they enumerate being “the ability to evaluate the design and the results of an experiment or a solution to a problem.”² They provide a rubric for assessing this ability, but our initial impression is that it is too detailed to be well-suited for our purposes. We will use it as a starting point and develop our own rubric that is tailored to our particular objective and the level of our courses.

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Using the results:

We anticipate that Spring 2013 will be a pilot semester for our study, providing initial results that will allow us to modify our approach as needed (e.g. to change our rubric, the directions we provide to students, and/or the frequency and type of problems assigned). We will then be able to deploy this approach more broadly during academic year 2013–2014, likely including the sophomore level courses Physics 7, Classical Mechanics; and Physics 8, Electricity & Magnetism. We may also use it in the junior/senior seminars Physics 111–113.

Ultimately, we plan to use the results to determine whether our current approach to teaching this problem-solving skill is adequate, allowing students to fully develop this skill during their time at Swarthmore, or whether it needs to be changed, perhaps with more explicit instruction in problem-solving techniques per se and/or more opportunities to practice and receive feedback on this skill.