Learning Goals for Physics and Astronomy Majors at Swarthmore College

Top-level Goals for Major Program

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.

II. Students will gain an understanding of the nature and breadth of contemporary open questions in physics and/or astronomy.

III. Students will experience the scientific process, and the nature of the interplay of theory and experiment, in contemporary physics and astronomy. One way that students can gain this experience is by doing research.

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

Affective and attitudinal learning goals, for students in all of our courses:

1. Students will be excited and inspired by physics and astronomy (*Engagement and Excitement*)

2. Students will develop a belief in their ability to solve problems using physical models and tools (*Self Efficacy*)

3. Students will develop a view of themselves as belonging in the field of physics and astronomy (*Identity and Belonging*)

    - This requires viewing the field of physics and astronomy as one that benefits from and requires diverse perspectives. (*Equity and Inclusivity*)
    - This may also require exposure to the diversity of career paths (including writing, teaching, outreach, science policy, education policy) for which a degree in physics and astronomy can be excellent preparation.

Purpose of attitudinal/affective learning goals: Articulating affective and attitudinal goals for our students foregrounds our own goal of creating a department in which students with a variety of preparations and from a variety of backgrounds can find a home, an identity, and a passion for our subject. In turn, these goals (hopefully) inform the values by which we make curricular and pedagogical decisions.

Specific skills

A. Problem-solving skills:

A student should be able to . . .

1. translate a physical description into a mathematical equation, and conversely, explain the physical meaning of the mathematics.

2. represent the key elements of a physical situation with a sketch.

3. choose, apply, and justify appropriate problem-solving techniques in novel contexts. For all students these techniques include approximations and symmetries, and as students advance, their techniques will come to include series expansions, multivariable integration, differential equations, and linear algebra.

4. articulate expectations for, and justify reasonableness of, problem solutions, including both dimensional analysis and numerical values.

5. devise an algorithm for solving a problem numerically, and translate that algorithm into a working computer program

B. Learning skills:

A student should be able to . . .

1. articulate the fundamental ideas from each chapter, section, and/or lecture.

2. see the physical relationships in the course as both coherent and broadly applicable, evidenced by being able to use these physical relationships to solve a range of problems, including ones in novel contexts.

3. demonstrate awareness of what he/she doesn't understand, evidenced by asking sophisticated, specific questions, articulating where they experience difficulty, and taking actions to move beyond that difficulty.

4. work productively in a group to solve problems, including asking questions and giving constructive feedback to others.

5. build on the material learned in earlier courses on the same topics and make connections to material on nominally different topics.

C. Communication skills:

A student should be able to . . .

1. write clearly and persuasively about an experiment, calculation, or observation, following the conventions of scientific writing.

2. design and give a clear presentation, with a well-supported argument, aimed at the appropriate level for a variety of different audiences.

3. effectively and supportively critique their own and other students' arguments and presentations.

D. Laboratory skills:

A student should be able to . . .

1. explain the connection between a measurement of a natural phenomenon and the experimental apparatus and tasks of a laboratory exercise. The explanation will exhibit an understanding of the theory behind the experiment, an understanding of the experimental equipment, and an assessment of the accuracy of the technique.

2. devise a strategy for analyzing quantitative data to obtain a desired result, including characterizing the precision, accuracy, and robustness of the result (i.e. understanding how sensitive the results are to various types of errors, both measurement and fitting errors, and identifying the appropriate way to fit the data that takes error into account).

3. troubleshoot an experiment, *i.e.,* identify the sources of something producing an unexpected result or not working at all.

4. use a software environment (Mathematica, MATLAB, *etc.*) to do fairly sophisticated numerical calculations and/or data analysis, as well as graphing and fitting data.

5. analyze experimental data to determine best-fit parameters and reasonable error estimates on those parameters from the data, and be able to judge whether or not a given relation is an acceptable fit to the data given the uncertainties.

6. reflect on results of an experiment and discuss whether the experiment was successful.

(last revision: June 2020)