UNIVERSITY OF SAN FRANCISCO | College of Arts and Sciences

ASSESSMENT REPORT
FOR ACADEMIC YEAR 2018-2019

PHYSICS MAJOR, PHYSICS MINOR & ASTROPHYSICS MINOR

Department of Physics & Astronomy

University of San Francisco

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1 LOGISTICS, MISSION STATEMENT & PROGRAM LEARNING OUTCOMES

1.1 PHYSICS & ASTRONOMY CONTACT PERSON (FACULTY ASSESSMENT COORDINATOR).

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1.2 PHYSICS & ASTRONOMY DEPARTMENT MISSION STATEMENT

No changes were made to the program mission statement since the last assessment cycle in October 2018.

> The mission of the Physics & Astronomy Department is to provide our students with the fundamental knowledge and the practical tools of a rigorous physics education that will help them be players and leaders in shaping a more humane world. The Physics program is implemented via a comprehensive coverage of experimental, theoretical, and computational physics, and by combining coursework together with on- and off-campus research and exposure to cutting-edge equipment and laboratory techniques. This rigorous training prepares students for careers and/or graduate studies in any discipline within fundamental or applied science (physics, astronomy, mathematics, chemistry, biology, etc); in any of the standard engineering fields; in education; in medicine and related disciplines; and many other fields, such as law, financial analysis, or positions in the high-technology sector of the global economy.

1.3 PHYSICS MAJOR & PHYSICS MINOR LEARNING OUTCOMES (PLOs)

No changes were made to the program learning outcomes (PLOs) since the last assessment cycle in October 2018.

1. - **PLO 1 (a).**
   Demonstrate mastery of the core concepts and general principles of physics.
   - **PLO 1 (b).**
   Demonstrate competent knowledge of the specific concepts, principles, and problems of each of the basic subfields and some areas of application in physics.

2. • **PLO 2.**

   Conduct experiments for a comparison with physical models and theories, and *examine* the results with the statistical methods of error analysis.

3. • **PLO 3.**

   Formulate, solve, and interpret problems by the use of physical principles, via mathematical and computational techniques.

1.4 ASTROPHYSICS MINOR LEARNING OUTCOMES (PLOs)

No changes were made to the program learning outcomes (PLOs) since the last assessment cycle in October 2018.

These PLOs for the Astrophysics Minor are essentially identical to the ones for the Physics Major and Minor programs, with the inclusion of some astrophysical content. Thus, assessment is effectively equivalent for all the 3 programs.

1. • **PLO 1 (a).**

   Demonstrate mastery of the core concepts and general principles of physics.

   • **PLO 1 (b).**

   Demonstrate competent knowledge of the specific concepts, principles, and problems of the main *astrophysics* areas and applications.

2. • **PLO 2.**

   Conduct experiments for a comparison with physical and *astrophysical* models and theories, and *examine* the results with the statistical methods of error analysis.

3. • **PLO 3.**

   Formulate, solve, and interpret problems by the use of physical and *astrophysical* principles, via mathematical and computational techniques.

1.5 CURRICULAR MAP LINKING THE PHYSICS PROGRAM LEARNING OUTCOMES AND THE PHYSICS MAJOR COURSES

In the curricular map below, PLO stands for "Program Learning Outcome" with the corresponding enumeration [i.e., 1 (a), 1 (b), etc] The check-mark symbol ✓ is used to indicate the applicable Program Learning Outcomes for each required course. Due to the universality

of the laws of physics, there is a tight vertical correspondence leading from general principles to specifics, following the same basic patterns for all courses.

PLOs $\Longrightarrow$ **PHYS courses** $\Downarrow$	**PLO 1 (a)** **Demonstrate** concepts & principles	**PLO 1 (b)** **Demonstrate** specific knowledge	**PLO 2** **Conduct and examine** experiments + error analysis	**PLO 3** **Solve problems:** mathematical & computational
PHYS 110	✓	✓	✓	✓
PHYS 210	✓	✓	✓	✓
PHYS 240	✓	✓		✓
PHYS 310	✓	✓		✓
PHYS 312	✓	✓		✓
PHYS 320	✓	✓		✓
PHYS 330	✓	✓		✓
PHYS 340	✓	✓		✓
PHYS 341/342			✓	
PHYS 350	✓	✓		
PHYS 371	✓	✓		✓
PHYS 343	✓	✓		✓
PHYS 422	✓	✓		✓

1.6 PROGRAM LEARNING OUTCOME(S) ASSESSED FOR THE ACADEMIC YEAR 2018-2019

The Program Learning Outcomes assessed for this one-year period involve one of three major learning goals relevant to physics and astronomy: proficiency in the basic subfields and areas of application of physics (in terms of concepts, principles, and knowledge).

- **PLO 1 (a).**
  Demonstrate mastery of the core concepts and general principles of physics.
- **PLO 1 (b).**
  Demonstrate competent knowledge of the specific concepts, principles, and problems of each of the basic subfields and some areas of application in physics.

2 METHODOLOGY

Assessment activities in the Physics Major/Minor and Astrophysics Minor programs were undertaken as planned during the AY 2018-2019, following multiyear departmental guidelines.

2.1 Generic Assessment Procedures.

The program learning outcomes were assessed in the following courses: PHYS 110 (General Physics I), PHYS 240 (Modern Physics), PHYS 310 (Analytical Mechanics), PHYS 320 (Electromagnetism), PHYS 343 (Astrophysics), and PHYS 422 (General Relativity). The process was organized at the departmental level with cooperation of all the instructors involved and our Program Assistant, and according to our multiyear departmental guidelines. The data were stored electronically. The faculty members teaching these courses were responsible for the required data collection: Brandon Brown (PHYS 240), Horacio Camblong (PHYS 310, 320, and 422), Milka Nikolic (PHYS 110), and Aparna Venkatesan (PHYS 343). And the team work was coordinated by Horacio Camblong.

All of the selected courses are relevant for both the Physics major and Physics minor: PHYS 110, 240, 310, and 320 are required for the major, while PHYS 343 and 422 are electives; in turn, PHYS 110 and 240 are required for the minor, with all the other ones being electives. For the Astrophysics minor, PHYS 110, 240, 343, and 422 are all required courses.

2.2 Assessment Procedures and Data Analysis.

The relevant learning outcomes were assessed by means of direct measures consisting of embedded questions (problems) and/or multiple-choice exams. All of the above consist of questions or problems with significant conceptual content that provide the essential ingredients for an effective PLO 1 (a) and 1 (b) assessment.

- Exam-embedded questions/problems (on the final exams) were used for Learning Outcomes 1 (a) and 1 (b) in PHYS 110, PHYS 240, and PHYS 343.

  These were selected as representative, standard questions or problems with significant conceptual content, where the mathematical solution is only incidental to the underlying concepts.

  In each case, the chosen material is central to the content of the given courses,

- In addition, the whole set of multiple-choice questions on the final exams for PHYS 310, PHYS 320, and PHYS 422 were assessed. These questions typically involve significant mathematical content and problem-solving skills, similar to the ETS Physics Major Field Test and/or GRE Physics Test.

The learning outcomes were gauged with a ternary metric system: above average, average (benchmark standard), and below average. It should be noticed that these are meant to be categories defined by comparison with the benchmark standard, regardless of the statistical course average for any given class section. This classification refers to the level of mastery of the skill and knowledge set involved in the learning outcome. "Average" is meant to represent a benchmark standard set up to correspond to an overall mastery of the outcome (involving most parts of the assessed problem or question), but allowing for errors or omissions whose correction would otherwise lead to considerable performance improvement. The "above average" mark reflects almost complete command of the relevant skill and knowledge set. The "below average" mark does not necessarily imply failure to perform on the given outcome, but reflects incomplete mastery of the relevant skill and knowledge set, leading to significant gaps in understanding and/or problem-solving outcomes.

For all assessed courses in this cycle, student performance was evaluated on the basis of a representative sample of embedded questions or GRE-style multiple choice questions (as described above). The data were collected and graded by the faculty teaching the courses, and subsequently discussed at two Physics & Astronomy Department meetings.

3 RESULTS & MAJOR FINDINGS

The results for the courses selected for assessment are summarized below:

- PHYS 110 (General Physics I), Fall 2018: A representative embedded problem was selected and graded, for a total of 51 students. The selected problem is a typical multi-step classical-mechanics problem for General Physics I, involving a set of fundamental concepts (Newton's laws, energy, oscillatory motion) of introductory Newtonian mechanics.

  Number of Students: 51;
  Above Average: 40 students (78%); Average: 10 students (20%); Below Average: 1 student (2%).

- PHYS 240 (Modern Physics), Fall 2018: A representative, multi-step embedded problem was selected and graded, for a total of 12 students. The selected topics are central to the content of Modern Physics, including relativity and quantum physics. The problem mostly covered core concepts of quantum physics.

  Number of Students: 12;
  Above Average: 10 students (83%); Average: 2 students (17%); Below Average: 0 students (0%).

- PHYS 310 (Analytical Mechanics), Fall 2018: A multiple-choice final exam was administered for 20 students. All the problems were at or above the level of a Physics GRE exam, and their content is typical of Quantum Mechanics, covering the whole range of topics of this course.

  Number of Students: 20;
  Above Average: 15 students (75%); Average: 5 students (25%); Below Average: 0 students (0%).

- PHYS 320 (Electromagnetism), Spring 2019: A multiple-choice final exam was administered for 19 students. All the problems were at or above the level of a Physics GRE exam, and their content is typical of Quantum Mechanics, covering the whole range of topics of this course.

  Number of Students: 19;
  Above Average: 14 students (74%); Average: 5 students (26%); Below Average: 0

students (0%).

- PHYS 343 (Astrophysics), Spring 2019: A representative embedded problem was selected and graded, for a total of 13 students. The selected problems covered thermal properties of gases, partition functions, and relevant thermodynamic energy calculations (all central to the content of Statistical & Thermal Physics).

  Number of Students: 8;
  Above Average: 6 students (75%); Average: 2 students (25%); Below Average: 0 students (0%).

- PHYS 422 (General Relativity), Fall 2018: A multiple-choice final exam was administered for 11 students. All the problems were at or above the level of a Physics GRE exam, and their content is typical of Quantum Mechanics, covering the whole range of topics of this course.

  Number of Students: 11;
  Above Average: 9 students (82%); Average: 2 students (18%); Below Average: 0 students (0%).

4 CLOSING THE LOOP

4.1 Follow-Up Discussion and Decision-Making.

Two Physics & Astronomy faculty meetings addressed various aspects of assessment (February 7th and October 2nd, 2019). The discussions included a review of our official assessment plan, the learning outcomes, and the results of this assessment cycle. In addition, follow-up discussions are planned for the ongoing 2019-20 Physics Department meetings.

The following conclusions were drawn:

- All in all, the results of the assessment activities show a relatively high level of performance by most students, with an excellent command of analytical skills and problem-solving within physics, as relevant for PLOs 1 (a) and 1 (b)—both for lower- and upper-division level physics courses.

- The assessment outcomes of this cycle are also consistent (qualitatively and quantitatively) with the assessment outcomes of earlier academic years.

- In our departmental discussions of assessment activities and plans, we have often addressed targeted curricular questions that we consider central to the goals of our major and minor programs. One question relevant to this specific report has been:

  – Is the curriculum properly addressing the all-important framework of dimensional analysis (units, dimensions, and scales)?

  From the assessment of this learning outcome, we found that students, both lower- and upper-division, are learning this crucial approach properly at all levels (starting with the introductory PHYS 110).

- The External Program of the Academic Program Review conducted in Spring 2018 praised our assessment program as follows.

  > "The overall P&A assessment program is well designed and appears mature. The probes are robust and appropriate, and the reports provided by the department are easy to interpret and contain useful information about student performance. P&A does very good work in many areas and students are a dominant focus in much of that work. ... The assessment program for P&A is more than sufficient, and it is managed extremely well."

  This is consistent with our own self-evaluation.

- No significant curricular changes are planned/required for AY 2019-20.