UNIVERSITY OF SAN FRANCISCO | College of Arts and Sciences

ASSESSMENT REPORT
FOR ACADEMIC YEAR 2020-2021

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 December 2020.

> 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 December 2020.

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.

Note: The learning outcomes for the physics major and minor are identical as the relevant courses involve the same learning skills and basic knowledge set. The lower-division courses and mathematical background are identical for both, but the major involves a much larger concentration of upper-division courses (30 units versus only 8 for the minor).

1.4 ASTROPHYSICS MINOR LEARNING OUTCOMES (PLOs)

No changes were made to the program learning outcomes (PLOs) since the last assessment cycle December 2020.

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, the check-mark symbol ✓ indicates the applicable PLOs for each 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 (General Physics I)	✓	✓	✓	✓
PHYS 210 (General Physics II)	✓	✓	✓	✓
PHYS 240 (Modern Physics)	✓	✓		✓
PHYS 310 (Analytical Mechanics)	✓	✓		✓
PHYS 312 (Statistical/Thermal Phys)	✓	✓		✓
PHYS 320 (Electromagnetism)	✓	✓		✓
PHYS 330 (Quantum Mechanics)	✓	✓		✓
PHYS 340 (Optics)	✓	✓		✓
PHYS 341 (Upper-Division Lab)			✓	
PHYS 350 (Physics Colloquium)	✓	✓		
PHYS 371 (Math Methods Sci/Eng)	✓	✓		✓
PHYS 343 (Astrophysics)	✓	✓		✓
PHYS 422 (General Relativity)	✓	✓		✓

1.6 PROGRAM LEARNING OUTCOME(S) ASSESSED FOR THE ACADEMIC YEAR 2020-2021

The Program Learning Outcome assessed for this one-year period—in the Physics major, Physics minor, and Astrophysics minor—involves one of three major learning goals relevant to physics and astronomy: application of physical principles to novel situations both in the classroom and in research settings, through critical thinking, problem solving, mathematical and computer modeling, and laboratory experimentation.

- **PLO 3.** (Physics major and minor)
  Formulate, solve, and interpret problems by the use of physical principles, via mathematical and computational techniques.

- **PLO 3.** (Astrophysics minor)
  Formulate, solve, and interpret problems by the use of physical and *astrophysical* principles, via mathematical and computational techniques.

1.7 ASSESSMENT SCHEDULE

The last Academic Program Review (APR) of Physics & Astronomy was conducted in Spring 2018. For the Physics Major, Physics Minor & Astrophysics Minor discussed in this report, the following timetable of Program Learning Outcomes has been followed thorough last academic year:

- AY 2018-19: PLO 1
- AY 2019-20: PLO 2
- AY 2020-21: PLO 3

We anticipate reassessment of these PLOs until the next APR according to a flexible timetable that will depend on internal factors involving course offerings (as most courses are not offered every year) and ongoing departmental discussions on the assessment procedures. For this academic year, we are already collecting data for next year's report as follows:

- AY 2021-22: PLO 2

2 METHODOLOGY

2.1 Methodology.

Assessment activities in the Physics Major/Minor and Astrophysics Minor programs were undertaken as planned during the AY 2020-2021, following multiyear departmental guidelines.

2.2 Generic Assessment Procedures.

The program learning outcome PLO 3 above was assessed in the following courses: PHYS 240 (Modern Physics), PHYS 310 (Analytical Mechanics), and PHYS 320 (Electromagnetism). 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 and grading of the students' work products: Aparna Venkatesan (PHYS 240), Seth Foreman (PHYS 310), and Milka Nikolic (PHYS 320). In addition, the overall logistics and final re-grading was conducted by Horacio Camblong, and the results were subsequently discussed at a Physics & Astronomy Department meeting.

All of the selected courses are relevant for both the Physics major and Physics minor: PHYS 240, 310, and 320 are required for the major; in turn, PHYS 110 is required for the minor, with PHYS 310 and 320 being important electives. For the Astrophysics minor, PHYS 240 is a required course, and PHYS 310 and 320 are useful electives when other upper-division courses of the Astrophysics minor are not offered in a given academic year (due to enrollments and other departmental constraints).

2.3 Assessment Procedures and Data Analysis.

The relevant learning outcomes were assessed by means of direct measures consisting of embedded problems or questions and/or complete exams with problems and questions. The problems and questions being considered are formulated mathematically in such a way that they provide the essential ingredients for an effective PLO 3 assessment.

The learning outcomes were gauged with the *4-level scale system* listed below. It should be noted that these 4 levels are meant to be categories defined by comparison with the

minimum benchmark standard, defined as "average," regardless of the statistical course average for any given class section. This classification refers to the level of proficiency of the skill and knowledge set involved in the learning outcome.

- Outstanding = Full Mastery. This represents superior performance, with an almost complete command of the relevant skill and knowledge set.
- Proficient = Partial Mastery. This represents basic, solid performance that reflects a level of achievement where errors or omissions only affect the final results in a minimal way.
- Satisfactory = Meets Expectations. This represents performance that meets expectations as benchmark standard set up to correspond to an overall, satisfactory outcome (involving most parts of the assessed problem, question, or project), but allowing for errors or omissions whose correction would otherwise lead to considerable performance improvement (i.e., not reaching partial mastery, but showing a minimum acceptable level for most of the relevant skills).
- Inadequate = Unsatisfactory Level. This mark does not necessarily imply complete failure to perform on the given outcome, but involves serious gaps in understanding and/or problem-solving outcomes for the relevant skill and knowledge set.

3 RESULTS & MAJOR FINDINGS

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

- PHYS 240 (Modern Physics), Fall 2020:

  A final exam consisting of a variety of questions and problems was administered for 15 students, and all of the questions and problems were graded, with the cumulative results shown below. The selected topics for the exam are central to the content of Modern Physics, including relativity and quantum physics. The problems mostly covered electronic and nuclear properties with quantum-mechanical behavior (atomic levels, tunneling, and relativistic nuclear binding energies).

  Number of Participants: 15 students;
  Outstanding: 5 students (33.3%);
  Proficient: 9 students (60.0%);

Satisfactory: 1 student (6.7%);
Inadequate: 0 students (0%).

- PHYS 310 (Analytical Mechanics), Fall 2020:

  One representative challenging embedded problem was selected and graded, for a total of 11 students. The selected problem covered a representative sample of fundamental properties of classical mechanics: orbital motion for a two-body system, its description in terms of an effective potential, and the corresponding oscillatory frequency for dynamical perturbations.

  Number of Participants: 11 students;
  Outstanding: 1 student (9.1%);
  Proficient: 6 students (54.5%);
  Satisfactory: 4 students (36.4%);
  Inadequate: 0 students (0%).

- PHYS 320 (Electromagnetism), Spring 2021:

  A final exam consisting of a representative sample of problems was administered for 14 students, and all of the problems were graded, with the cumulative results shown below. The selected topics for the exam are central to the content of Electromagnetism. The problems mostly covered the calculation of properties of electric and magnetic fields for both static and dynamic configurations, and for a variety of media and boundary conditions.

  Number of Participants: 14 students;
  Outstanding: 2 students (14.3%);
  Proficient: 8 students (57.1%);
  Satisfactory: 4 students (28.6%);
  Inadequate: 0 students (0%).

4 CLOSING THE LOOP

4.1 Follow-Up Discussion and Decision-Making.

A Physics & Astronomy faculty meeting addressed various aspects of assessment. The discussions included a review of our assessment plan, the learning outcomes, and the results of this assessment cycle, as well as the feedback from our last assessment cycle. In addition, follow-up discussions are planned for the ongoing 2021-22 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 PLO 3—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:

  – Learning Outcome 3: Are physics majors proficient in problem-solving techniques for "complex problems" (involving multi-step tasks)?

  We found that students, both lower- and upper-division, are learning have a satisfactory command of the relevant problem-solving techniques needed in our physics courses, including finding the solution to a variety of complex problems.

- We are using a model that has been successful in our Physics & Astronomy programs for several years. 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 2021-22. It has also been agreed that the ongoing pandemic created additional constraints and challenges that exceed the boundaries of a regular assessment plan—for now, no further adjustments are needed.