UNIVERSITY OF SAN FRANCISCO | College of Arts and Sciences

ASSESSMENT REPORT
FOR ACADEMIC YEAR 2022-2023

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 November 2022.

> 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 November 2022.

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 in November 2022.

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 2022-2023

The Program Learning Outcomes assessed for this one-year period—in the Physics major, Physics minor, and Astrophysics minor—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.
- **PLO 1 (b).** (Astrophysics minor)
  Demonstrate competent knowledge of the specific concepts, principles, and problems of the main *astrophysics* areas and applications.

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
- AY 2021-22: PLO 2
- AY 2022-23: PLO 1

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 2023-24: PLO 3

2 METHODOLOGY

2.1 Methodology.

Assessment activities in the Physics Major/Minor and Astrophysics Minor programs were undertaken as planned during the AY 2022-2023, following multiyear departmental guidelines.

2.2 Generic Assessment Procedures.

The program learning outcomes PLO 1(a) and (b) above were assessed in the following courses: PHYS 110 (General Physics I), PHYS 210 (General Physics II). 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: Brandon Brown (PHYS 210), Horacio Camblong (PHYS 320), Milka Nikolic (PHYS 310), and Aparna Venkatesan (PHYS 110). 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, 210, 310, and 320 are required for the major; in turn, PHYS 110 and 210 are required for the minor, with all the other ones being important electives. For the Astrophysics minor, PHYS 110 and 210 are required courses, and PHYS 310 and 320 are useful electives (covering a significant range of related astrophysical concepts) 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 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.

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.

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 2022: A final exam consisting of a combination of conceptual multiple-choice questions and separate problems was administered. The selected problems were typical multi-step classical-mechanics problems at the level of General Physics I, involving a set of fundamental concepts (Newton's laws, energy, oscillatory motion) of introductory Newtonian mechanics; the questions covered the whole range of topics, with several questions involving scale analysis. The grades were assigned for the entire final exam.

  The assessment procedure involved 26 students; the results were graded and compiled as follows.

  Number of Participants: 26 students;
  Outstanding: 17 students (65.4%);
  Proficient: 8 students (30.8%);
  Satisfactory: 1 student (3.8%);
  Inadequate: 0 students (0%).

- PHYS 210 (General Physics II), Spring 2023: A final exam consisting of problems with calculations and conceptual questions was administered. From the whole final exam, a representative embedded problem was selected and graded. The selected problem was a typical problem magnetic fields, with applications.

  The assessment procedure involved 16 students; the results were graded and compiled as follows.

  Number of Participants: 16 students;
  Outstanding: 12 students (75.0%);
  Proficient: 2 students (12.5%);
  Satisfactory: 2 students (12.5%);
  Inadequate: 0 students (0%).

- PHYS 310 (Analytical Mechanics), Fall 2022: A multiple-choice final exam with challenging questions and problems was administered. All the problems were at or above the level of a Physics GRE exam, and their content is typical of Analytical Mechanics, covering the whole range of topics (Newtonian, Lagrangian, and Hamiltonian approaches, with applications) of this course. The grades were assigned for the entire final exam.

The assessment procedure involved 11 students; the results were graded and compiled as follows.

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

- PHYS 320 (Electromagnetism), Spring 2023: A multiple-choice final exam was administered. All the problems were at or above the level of a Physics GRE exam, and their content is typical of Electromagnetism (Maxwell's equations and applications), covering the whole range of topics of this course–and with partial emphasis on scale and dimensional analysis. The grades were assigned for the entire final exam.

  The assessment procedure involved 12 students; the results were graded and compiled as follows.

  Number of Participants: 12 students;
  Outstanding: 5 students (41.7%);
  Proficient: 7 students (58.3%);
  Satisfactory: 0 students (0%);
  Inadequate: 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. The discussions included a review of our assessment plan, the learning outcomes, and the results of this and last assessment cycles. In addition, follow-up discussions are planned for the ongoing 2023-24 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, scales, and orders of magnitude) and associated approximation and semi-quantitative techniques?

  From the assessment of this learning outcome, we found that students, both lower- and upper-division, are learning this crucial dimensional approach properly at all levels, in addition to mastery specific topics within each subject.

- 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 2023-24.