UNIVERSITY OF SAN FRANCISCO | College of Arts and Sciences

ASSESSMENT REPORT
FOR ACADEMIC YEAR 2021-2022

PHYSICS MAJOR, PHYSICS MINOR & ASTROPHYSICS MINOR

Department of Physics & Astronomy

University of San Francisco

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Submitted by Prof. Horacio E. Camblong

camblongh@usfca.edu

1 LOGISTICS, MISSION STATEMENT & PROGRAM LEARNING OUTCOMES

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

Name: Professor Horacio E. Camblong, Email: camblongh@usfca.edu

1.2 PHYSICS & ASTRONOMY DEPARTMENT MISSION STATEMENT

No changes were made to the program mission statement since the last assessment cycle in November 2021.

> 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 2021.

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 2021.

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 2021-2022

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: experimental procedures and analysis.

- **PLO 2.** (Physics major and minor)
  Conduct experiments for a comparison with physical models and theories, and *examine* the results with the statistical methods of error analysis.

- **PLO 2.** (Astrophysics minor)
  Conduct experiments for a comparison with physical and *astrophysical* models and theories, and *examine* the results with the statistical methods of error analysis.

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

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 2022-23: PLO 1

2 METHODOLOGY

2.1 Methodology.

Assessment activities in the Physics Major/Minor and Astrophysics Minor programs were undertaken as planned during the AY 2021-2022, following multiyear departmental guidelines.

2.2 Generic Assessment Procedures.

The program learning outcome PLO2 above was assessed in PHYS 341 (Upper-Division Lab) and in the laboratory sections of the following courses: PHYS 110 (General Physics I) and PHYS 210 (General Physics II). 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 the lecture or main sections of these courses were responsible for the required lab-instructor coordination and data collection of the students' work products: Milka Nikolic (PHYS 110 Lab and PHYS 210 Lab) and Seth Foreman (PHYS 341). For PHYS 110 and 210, the grading of the work products was conducted directly by the instructors of the multi-section lab components (Milka Nikolic and Seth Foreman for PHYS 110; and Aaron White for PHYS 210). In addition, the overall logistics and final re-grading of the work products was conducted by Horacio Camblong.

All of the selected courses are relevant for both the Physics major and Physics minor: PHYS 110, 210, and 341 are required for the major; in turn, PHYS 110 and 210 are required for the minor, with PHYS 341 being an important elective. For the Astrophysics minor, PHYS 110 and 210 are required courses, and PHYS 341 is a useful elective 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 using the results of the laboratory data analysis and interpretation, as well as specific questions associated with the laboratory procedures, as presented by the students in their lab workbooks and reports. The results were evaluated based on the overall presentation of the experimental procedures and data collection, and

on the detailed statistical analysis and interpretation of the experimental data.

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 laboratory experiments (usually one or two lab experiments per course). The specific labs and the cutoff numerical grades for each category were selected via a routine discussion among the faculty involved. 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) Lab, Fall 2021:

A representative lab experiment was selected: Lab 3, "Falling with (and without?) air resistance." This lab combines fundamental physics with detailed data analysis (including error analysis of the collected data) in the context of one of the most important examples of a universal law (free fall from universal gravitation). This selected experiment provides the essential ingredients for an effective learning-outcome assessment.

The assessment procedure involved 3 separate laboratory sections, for a total of 35 students. Of these, 1 student was absent; for the other 34 students who participated in both lab experiments, the results were graded and compiled as follows.

Number of Participants: 34 students;
Outstanding: 30 students (88.2%);
Proficient: 4 students (11.8%);
Satisfactory: 0 student (2.2%);
Inadequate: 0 students (0%).

Note on rubrics and grading: Lab reports were graded with the following parameters: full participation and "completeness" of the reports; answering of questions embedded in the spreadsheet templates; and "technical details" (data analysis, significant figures, units, plots, etc.)

- PHYS 210 (General Physics II) Lab, Spring 2022:

  The following representative lab experiment was selected: Lab 3, "Electrical Resistance." This lab is a good representative of the laboratory content of PHYS 210, with a combination of fundamental physics and applied concepts, and it also involves basic data analysis. Thus, it is useful for an effective learning-outcome assessment.

  The assessment procedure involved 2 separate laboratory sections, for a total of 21 students, with perfect attendance. The results were graded and compiled as follows.

  Number of Participants: 21 students;
  Outstanding: 20 students (95.2%);
  Proficient: 0 students (0%);
  Satisfactory: 0 students (0%);
  Inadequate: 1 student (4.8%).

  Note on rubrics and grading: Lab reports were graded with the following parameters: full participation and "completeness" of the reports; answering of questions embedded

in the spreadsheet templates; and "technical details" (data analysis, significant figures, units, plots, etc.)

- PHYS 341 (Upper-Division Lab), Spring 2022:

  This is an advanced class, where students perform some routine experiments and choose from a menu of options (including a variety of labs from optics, fundamental constants, solid state physics, atomic physics, and nuclear physics). The students have to write detailed research-grade laboratory reports for all the experiments they conduct throughout the semester, with advanced statistical data analysis and writing of final reports with the journal-quality LaTex document preparation system.

  For this cycle, the first technical report was selected for assessment. In this exercise, the students choose an experiment from a menu and write a rough draft, getting feedback from the instructor, revising it, and then submitting a final draft. The graded work product is a comprehensive report describing the experiment, the data, the data analysis, and the interpretation of the results.

  All the students participated in this submitting the experimental report, and the results were graded and compiled as follows. The results were excellent, as shown below; moreover, for context, the students submitted a second technical report later in the semester, where the quality of their writing showed additional improvement.

  Number of Participants: 15 students;
  Outstanding: 12 students (80.0%);
  Proficient: 2 students (33.3%);
  Satisfactory: 1 students (6.7%);
  Inadequate: 0 students (0%).

  Note on rubrics and grading: Lab reports were graded out of 100 points, based on (i) the experimental procedures and data collection; (ii) statistical analysis; and (iii) writing.

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 2022-23 Physics Department meetings.

The following conclusions were drawn:

- All in all, the results of the assessment activities show a very high level of performance by all students, with an excellent command of the experimental-physics skills relevant for PLO 2—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 2: Is the curriculum properly addressing the systematic use of the theory of errors in both lower- and upper-division experimental physics?

  We found that students, both lower- and upper-division, are learning the basic statistical tools and acquiring the data-analysis skills to interpret a variety of experiments over a broad range of physics fields.

- 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 2022-23.

It should be noted that the physics program has adjusted well to the constraints of the ongoing pandemic, and the PHYS 110 lab in Fall 2021 was conducted online. For now, no further adjustments are needed.