University of San Francisco
College of Arts and Sciences

Self-Study for
Academic Program Review

DEPARTMENT OF PHYSICS & ASTRONOMY

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1. USF Physics & Astronomy Department's Mission and Goals

The Physics & Astronomy Department at the University of San Francisco blends the ideals of a rigorous foundational physics and astronomy curriculum with the principles of Jesuit higher education.

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.

As an integral part of a Jesuit institution of liberal learning, the Physics and Astronomy Department seeks to provide students—both science and non-science majors—with: (i) an appreciation for science and its relation with and responsibility toward society; (ii) the understanding that a college degree is not an end in and of itself, but only the beginning of a person's journey through a life of learning and service.

Moreover, as highlighted in our mission, we need to prepare our students for the intellectual challenges of the 21st century, and strengthening the University's vision of educating leaders who will make a societal difference. The physics major and related minors have traditionally addressed this dimension through its rigorous foundational core, supplemented by applied tracks and courses, including the 3/2 physics-engineering dual degree and our recently created engineering physics minor. This versatile training allows our graduates to be players in the fast-moving world of science and technology.

Appendix A summarizes all the learning goals and learning outcomes of the various programs we offer.

2. Physics & Astronomy Programs and Curriculum

2.1 General Overview

The Physics & Astronomy Department academic offerings include a physics major and a flexible set of minors. Our expanding set of offerings is expected to provide multiple paths for subsequent development, as outlined in Section 1. In addition to the Physics Major (and Honors Major) program, we offer tracks leading to technology-related fields via the 3/2 Physics-Engineering program and the recently created Engineering Physics Minor. And the list of offerings is further enhanced by our minor programs in physics, astronomy, and astrophysics.

2.2 Physics Major Program

The major in physics leads to a BS degree that involves a number of physics and mathematics courses. These are equivalent to the physics-program standards adopted at most US colleges and universities. Within those constraints, at USF, we offer a minimalist version (based on "core physics courses"), in addition to an expanded version with additional requirements (see below).

2.2.1 Major in Physics

The basic major in physics consists of a minimum core of physics and mathematics courses. It provides a rigorous background combined with maximum flexibility for students who have a strong interest in an additional field of study. The major program requires completion of a total of fifty-eight (58) units, of which forty-two (42) units correspond to Physics, and 16 to Mathematics and CS support courses, as follows:

- MATH and CS supporting courses (16 units):
  - Three semesters of Calculus and Analytical Geometry (MATH 109, 110, 211).
  - Introduction to Computer Science I (CS 110).
- Lower-division required PHYS courses (12 units):
  - General Physics I (PHYS 110);
  - General Physics II (PHYS 210);
  - Modern Physics (PHYS 240).
- Upper-division required PHYS courses (30 units):
  - Analytical Mechanics (PHYS 310);
  - Statistical and Thermal Physics (PHYS 312);
  - Electromagnetism (PHYS 320);
  - Quantum Mechanics (PHYS 330);
  - Optics (PHYS 340);
  - Upper-Division Laboratory (PHYS 341);
  - Physics Colloquium (PHYS 350; two units are required);
  - Methods of Mathematical Physics (PHYS 371).

As outlined above, this program covers all basic areas of physics (both classical and quantum; and theoretical, computational and experimental). A number of ideas are currently being discussed to further enhance the academic standards and usefulness of the degree (see Section 3).

In terms of the logistics of program implementation, the required upper-division courses (with the exception of PHYS 371, which is taken during a typical sophomore year) are offered in two-year cycles. Due to faculty understaffing and changing student enrollments, frequent adjustments and modifications of the cycles have been forced upon us over the past few years.

2.2.2 Honors Major in Physics and Physics Electives

The Honors track of the physics major is recommended for students choosing physics as their main professional field, or students planning to pursue graduate studies in physics or related fields.

This track requires the completion of a total of seventy (70) units, i.e., twelve (12) additional units above and beyond the requirements of the basic major in physics. The additional units involve a minimum of: 4 units of Computational Physics (PHYS 301); 4 units of Directed Research for Advanced Undergraduates (PHYS 299 or 399); and 4 units of an upper-division elective, from at least one of the following offerings: Electronics (PHYS 261 or 262); Astrophysics (PHYS 343); General Relativity (PHYS 422); Solid State Physics (PHYS 333). Incidentally, the Directed Research course is open-ended, but it sometimes leads to an undergraduate thesis.

The Department objects to the recent arbitrary removal of the following courses from the online Catalog listings: Nuclear Physics (PHYS 332); Advanced Classical Dynamics (PHYS 410); Advanced Electrodynamics (PHYS 420); Advanced Quantum Mechanics (PHYS 430); Advanced Materials (PHYS 450); and Foundations of Computational Neuroscience (PHYS 380). The problem originated from the fact that the electives listed above are only offered intermittently, with the possible exception of the courses tied to minor programs. We certainly would like to reinstate these courses with support from the administration, but we do acknowledge that we probably need to stabilize and/or increase our current major numbers.

2.3 The 3/2 Physics-Engineering Dual-Degree Program

The 3/2 Physics-Engineering Program is administered jointly by the University of San Francisco and the University of Southern California (USC), following an articulation agreement in effect since 1997. Under this program, an undergraduate student attends USF for typically three (3) academic years and USC for approximately two (2) academic years—the actual times vary according to pre-existing transfer credits and satisfactory progress. This is a dual degree program: after satisfying the academic requirements of these two institutions, the student is awarded two BS degrees: one in physics from USF and one of the several designated degrees in engineering by USC. Currently, 3/2 dual degree candidates are eligible to seek any of the following majors from USC: Aerospace Engineering, Aeronautical Engineering, Chemical Engineering, Civil Engineering, Computer Engineering, Electrical Engineering, Industrial and Systems Engineering, and Mechanical Engineering.

Students satisfy USF's 3/2 physics/engineering requirements for the BS degree in physics by successfully completing all the requirements for our regular Major in Physics. Additional courses required for the successful continuation of the dual degree program at USC are recommended for some majors (e.g., Chemical and Computer Engineering); moreover, other adjustments are made on a case-by-case basis. The general outlines of the program, including specific physics requirements at USF, have remained basically unchanged over the years (simply adjusting to our PHYS major requirements). More substantial changes have taken place at the level of USC, especially in terms of their admission requirements (globally, with all of their 3/2 programs with about 20 liberal arts schools). Originally, the agreement guaranteed admission with a 3.0 GPA; currently, every case is examined individually, a 3.2 GPA is recommended as a minimum in the science courses, and satisfactory performance in their final year at USF is scrutinized closely.

At USF, our students follow a more comprehensive sequence of courses than is typical at 3/2 programs of liberal arts colleges, and then complete their engineering requirements in the final two years at USC. The rigorous nature of this academic program is noteworthy: the USF part of the degree is comparable to that of a typical B.S. degree in physics, with the same required courses for our regular degree program. As a result, in most cases, the students need to take a few courses during summer sessions, while at USF; and the program leaves no room for electives (either at USF or at USC). From the administrative viewpoint, some desirable departmental outcomes are realized:

- While the overall effectiveness of the 3/2 program has been a fluctuating function of time, in recent years it has established itself as the single most important *effective recruiting tool* for the physics major. At present, about half of our students are known to have joined our program because of the 3/2 option.

- The highly constrained curriculum leads to increased enrollments in our required upper-division courses.

- A considerable fraction of the students stay as physics majors for 4 years, and take additional electives. Indeed, most of the students that start with the 3/2 program eventually decide not to transfer to USC (and many switch to other majors when realizing that physics and engineering require a huge investment of time and effort).

Furthermore, the number of students pursuing this 3/2 program has varied from year to year. Several factors have contributed to this: the population involved is small, the emphasis placed on advertising this program and recruiting students (by the Admissions Office) has not been steady, and a stringent selection process operates in our physics courses. In any case, by the time they finish their junior year, they are fully prepared for the demanding experience of 2 years of engineering. As for the students who do not transfer to USC, we advise them to pursue our engineering physics minor and to consider plans for graduate studies in engineering (indeed, engineering schools actively recruit qualified physics majors).

2.4 Minor Programs

2.4.1 Physics Minor

The Minor in Physics requires the completion of twenty (20) Physics units, as follows:

- PHYS lower-division core (12 units): General Physics I (PHYS 110); General Physics II (PHYS 210); Modern Physics (PHYS 240).

- 8 units of upper-division PHYS courses.

The minor in Physics is conceived to enhance the career options of other science majors; in practice, due to curriculum overlaps, it is usually pursued by a Mathematics or Chemistry majors.

2.4.2 Astrophysics Minor

The Minor in Astrophysics (ASTO) requires the completion of twenty (20) Physics units, as follows:

- Foundational Physics Sequence (12 units): General Physics I (PHYS 110); General Physics II (PHYS 210); Modern Physics (PHYS 240).
- 8 units of upper-division PHYS courses selected from the following astrophysics-related courses: Astrophysics (PHYS 343); General Relativity (PHYS 422); or Special Topics in Physics Courses (with a focus on major topics in Astrophysics, PHYS 386).

2.4.3 Astronomy Minor

The Minor in Astronomy (ASTR) requires the completion of twenty (20) units of Physics and Astronomy courses, as follows:

- Astronomy Core Courses (12 units):
  - Astronomy: From the Earth to the Cosmos (PHYS 120);
  - Planetary Astronomy (PHYS 121);
  - The Geometry of the Cosmos: Einstein, Black Holes, and the Big Bang (PHYS 122).
- Physics/Astronomy Elective courses (8 units): selected from any two courses from
  - The elective Astronomy menu: Ancient Astronomy (PHYS 221) and The Extreme Universe (First-Year Seminar, PHYS 195).
  - The introductory physics menu consisting of: Concepts in Physics (PHYS 130); Masterpiece Physics (PHYS 135); Physics by Inquiry (PHYS 201); Introductory Physics I (PHYS 100); Introductory Physics II (PHYS 101); General Physics I (PHYS 110); General Physics II (PHYS 210).

The set of two introductory astronomy courses are standard in content and delivery. PHYS 120 covers stellar, galactic, and extragalactic astronomy; while PHYS 121 is focused on planetary astronomy (solar system and extrasolar planets). These courses involve a lab component that integrates physics and astronomy, and satisfy the USF lab science (core B-2) requirement. They are also supplemented by observing nights that offer direct exposure to observational techniques, using the telescopes and other high-quality instruments in our Fromm observatory.

The Geometry of the Cosmos course is an exploration of the frontiers of physics and astronomy with general relativity and cosmology as central themes. The course is mainly taught at the conceptual level, but further supported with enough math (geometry and some algebra, mostly scaling and proportionality) to justify the USF math (core B-1) attribute. The course uses clever thought experiments and an arsenal of conceptual and historical tools to develop a comprehensive overview of the theory of relativity, spacetime, gravitation, and elementary particles, with astrophysical applications centered on black holes and the Big Bang. While the course is conceived for non-science majors, the material covered is so deep and fascinating, that it is often taken by some science majors (just for fun!) And, over the years, it has also become a *recruiting tool for the physics major*.

Finally, for the astronomy minor, the elective courses (astronomy and/or physics) provide a deeper insight into the physical basis of contemporary astronomy as grounded in the universal laws of nature. The most appropriate combination of courses from this menu is selected in consultation with an advisor, depending on background and interests. The two courses FYS: The Extreme Universe and Ancient Astronomy are especially attractive for completion of the minor, and further reinforce their basic astronomy foundation.

2.4.4 Engineering Physics Minor

The Minor in Engineering Physics involves the completion of the following twenty (20) Physics/CS units (plus associated math pre- or co-requisites), with the following scheme:

- Required Courses (12 units): General Physics I (PHYS 110); General Physics II (PHYS 210); Introduction to Computer Science (CS 110).

- Elective Courses (8units): One 4-unit computational course, from the menu Computational Physics (PHYS 301) and Computational Physics II (PHYS 302); and one 4-unit electronics course from the menu Analog Electronics (PHYS 261) and Digital Electronics (PHYS 262).

For students planning to continue in engineering programs, we encourage them to take as many of these courses as possible.

The Engineering Physics Minor, developed by Profs. Böttger and Huang, is designed for the students who desire a firm foundation in physics as well as a background in engineering science. It provides students with an introduction to the latest development in analog & digital electronics and scientific computation, skills that are in high demand in many technical fields today, including but certainly not limited to physics, astronomy, and engineering. Moreover, in the computational and electronics courses, students have shown a high level of enthusiasm for learning applied science through modern equipment and programming techniques.

The elective courses offered from the Engineering Physics Minor are targeted at students as early as their sophomore year and hence can draw enrollment from students spanning from sophomore to senior year (3 years). These courses will be continually updated to reflect recent trends in the fields and incorporate feedback from students to make them more effective. Specifically, the nature of these courses is complementary to those offered in the Computer Science Department, which has an emphasis of software development while our courses focus on hardware (digital & analog) and scientific computing and machine learning skills. Conversation with CS faculty indicates a strong support for the courses. There may be potential interest also among students in other departments other than Computer Science, and, most especially, Chemistry and Mathematics; but scientific computation is also an emerging interest for biology and kinesiology students. In addition, the Analog & Digital Electronics are also appealing. for the students in the new Tech and Design certificate program at USF.

The up-to-date computational and electronic equipment are described in Section 4.

2.5 Physics & Astronomy Service Courses and the Core Curriculum

The Physics & Astronomy Department offers introductory physics courses for all the other science programs (Biology, Environmental Science, Chemistry, Mathematics, Computer Science, and Exercise and Sport Science) and for the Architecture program; and physics and astronomy courses for non-science majors.

In terms of course offerings, the most important curricular constraint is set by the university Core Curriculum. This is a learning-outcomes-based set of "general-education" requirements that includes 6 major areas; of these, area B corresponds to science in two forms: B-1 (math) and B-2 (laboratory science). The Physics & Astronomy Department offers courses in both, as it is uniquely positioned at the interface between lab science and math. Indeed, most of the service courses also apply to the USF core, science area, either B-1 or B-2. In what follows the courses will be listed in three categories: targeted to specific programs, "Astronomy core courses," and other service courses.

First, our current list of courses targeted to specific programs consists of:

- Introductory Physics I and II (PHYS 100/101):
  the standard two-semester algebra-based introductory physics sequence. It serves as the default intro physics sequence, especially for the life sciences—required or recommended as part of the Biology, Environmental Science, and Exercise and Sport Science programs [PHYS 100 earns B-2 core credit].
- General Physics I and II (PHYS 110/210):
  the standard two-semester calculus-based introductory physics sequence (modern physics excluded), which serves mainly the Chemistry and Physics programs, and to a lesser extent the Mathematics and Computer Science programs (their students can satisfy the lab science requirements from a menu of courses from all science departments) [PHYS 110 earns B-2 core credit].
- Concepts in Physics (PHYS 130):
  a mostly conceptual introductory physics course, which serves the Architecture track within the Fine and Performing Arts program [earns B-2 core credit].

Second, a special dual role is played by the "Astronomy Core courses:"

- Astronomy: From the Earth to the Cosmos (PHYS 120)
  introductory topics plus stellar, galactic and extragalactic astronomy [earns B-2 core credit].
- Planetary Astronomy (PHYS 121)
  introductory topics plus astronomy of the solar system and other planetary systems [earns B-2 core credit].

- The Geometry of the Cosmos: Einstein, Black Holes, and the Big Bang (PHYS 122).
  mostly conceptual introduction to special and general relativity, with astrophysics and cosmology applications [earns B-1 core credit].

In their dual role, these three courses: (i) provide a much sought-after path for completion of core B credit among non-science majors; (ii) in addition, they form the core of our Astronomy Minor. At present, PHYS 120 and 121 are offered every semester each (with numerous lab sections, and often with multiple lecture sections); PHYS 122 is typically offered once a year. The record enrollment numbers in the astronomy courses provide a significant fraction of the student credit hours (they account for about half of the bulk of the SCHs within the past decade, with the other half contributed by the regular introductory physics sequences).

Finally, other physics courses taken by students from other majors (and with core B-2 credit) include:

- Masterpiece Physics (PHYS 135):
  a conceptual physics course, with some math and lab exercises, using art and music as central themes—with emphasis on the concepts of sound, light, color, and how the brain perceives them; and applications to musical instruments, photographic cameras, and paintings [earns B-1 or B-2 core credit].
- Physics by Inquiry (PHYS 201)
  a step-by-step introduction to physics and the physical sciences. From their own observations, students develop basic concepts for simple physical systems and their interactions, interpret different forms of scientific representations, and construct explanatory models with predictive capability [earns B-2 core credit].

Masterpiece Physics is a laboratory science course covering the physics of sound and light, through the lens of music and art. It has become one of our regular core B-2 offerings, typically offered during every academic year once. Originally developed by Prof. Marcelo Camperi, it was re-introduced and re-imagined by Prof. Foreman shortly after his arrival at USF. The new version of the course fits Prof. Foreman's strengths as a laser experimentalist and as a classical pianist. The course involves an intensive array of lecture demonstrations—for example, a clarinet built from a carrot and saxophone mouthpiece, a beautiful wooden demonstration organ, polarization rotation demos using an 8-foot-long tube of corn syrup, etc. The laboratory sessions are noteworthy blends of an artistic component with a scientific objective (for instance, when experimenting with standing waves on strings, students also stretch strings over resonator boxes and explore the physics and math of musical intervals, etc).

Physics by Inquiry was introduced to USF by Professor Böttger. The inquiry-based learning approach to teaching has been successful at USF and elsewhere. It is centered on experimentation as an active process of inquiry in which the students can participate. The main focus is on the discovery process and the questions it triggers, as opposed to the usual structured approach based on memorization and problem solving. At USF, this course is most often taught once a year during one of the Summer sessions—this current scheduling scheme proves convenient for the departmental distribution of courses, and provides an excellent option for core B-2 during the summer.

(It should be noticed that the university has been increasingly encouraging summer teaching. This is, in large part, to allow students to get their undergraduate degree within four years. But, in Physics & Astronomy, we are not yet ready to expand our summer offerings beyond Physics by Inquiry.)

3. Curriculum Delivery and Statistics

3.1 Student Numbers

The Physics & Astronomy Department student numbers, both student credit hours (SCHs) and numbers of majors, are discussed below; and detailed tables are shown in Appendix B, providing a historical and science-wide perspective to appreciate our current situation and ongoing struggles.

The Department had made tremendous progress over the decade leading to our previous Program Review in 2011, by doubling both the SCHs and the number of majors. In the past seven years, as the statistics reveal, we have remained at a level similar to 2011, with a small increase in SCHs on the average, and a fluctuating number of majors, with total count close to the 2011 value.

3.1.1 Student Credit Hours

The total number of student credit hours (SCHs)—associated with all courses taught in our Department—has markedly and steadily increased over the years since the 1990s. In Appendix B, Table 1 (displayed as a graphical trend chart) and Table 2 display the statistics over the past nine and seven years, for PHYS and for all science departments, respectively. During this period, we seem to have reached a ceiling with only a small percent increase comparable to the rest of the science departments. The drop this semester, Fall 2017, is due to a significant decrease in the astronomy numbers, which remains largely unexplained and is probably a temporary glitch.

For a long time through the 1990s, the number was well below 1,000 SCHs and did not pass that mark until after our 2004 Program Review. It then doubled from 2004 to 2011. We now seem to have reached a Fall target number of approximately 2,000 to 2,100 SCHs and a somewhat lower Spring number, of the order of 1,800. This is of the order of a 10 to 15% increase within a seven year period, at least looking at averages of numbers over two years. (Parenthetically, there is a curious pattern associated with science enrollments in introductory physics courses that leads to larger Fall and smaller Spring numbers.)

Our challenge has been, and remains, to be able to maintain such numbers in the foreseeable future. And with enough planning, ideally continue the upward trend. In any case, the Fall 2017 low (this semester) remains unexplained. As mentioned above, it is essentially due to a significant drop in the Astronomy numbers (we even cancelled a few lab sections and reduced caps for lab number control). We consulted various faculty and administrators, and no satisfactory single explanation has been proposed. Possible causes may be: time choices (all Monday, Wednesday, Friday), but a significant drop remains inconsistent with earlier numbers and projections with similar times; the Admissions problem that the university experienced around 2015 (the dates are consistent, as most of the students take astronomy around their junior year); a readjustment in the core B-2 population (still possible, but unlikely by itself). Perhaps a combination of these factors led to an unusual statistical fluctuation. As a result, we will be extra careful with planning in the near future. One obvious generic guiding principle is to systematically offer more scheduling options; however, it is unclear whether we will be able to do this with the upcoming sabbaticals.

Incidentally, most of the moderate increase in SCHs has been due to increased enrollments in the introductory physics numbers (algebra- and calculus-based). While this is mostly due to external factors, we have made an effort to retain those students in the appropriate courses. It is hard to predict how these numbers will evolve, though there is still an upward trend due to greater numbers of science majors overall.

3.1.2 Number of Majors

The number of physics majors at USF over the past 7 years is given in Table 3 (graph trend) and Table 4, for PHYS and for all science departments, respectively. In addition, the number of degrees awarded per academic year is given in Table 5; the most common major changes, to PHYS in Table 6 and away from PHYS in Table 7; and the breakdown by gender in Table 8.

It seems that our number of majors has reached a relatively steady plateau of around 40+ with maxima near 50. There was a maximum near 2011 and the number is getting close to those values again.The current number after the Census Date, Spring 2017 is:

45 PHYS majors
(with about 25% female students).

It should also be noticed that we are losing our physics majors mainly to CS and various majors within the Business School. The common denominator is the practical components offered by those fields leading to satisfactory jobs upon graduation. Even though physics has this component as well, it appears that we need to do a better job conveying the message to students.

3.2 Advising

Our Department has a long tradition of one-on-one student-faculty interaction: advising of majors is given high departmental priority. Physics juniors and seniors benefit from this system, particularly when planning their post-USF careers.

This advising system has been revised and systematized in recent years, both at USF generally and in the Physics & Astronomy Department in particular. Our Program Assistant, Amanda Machi, has done an exemplary job helping our faculty gather all the relevant information, and meeting with us in formal Department meetings to upgrade and improve the departmental procedures. This has helped track progress and detect problems within an increased number of majors.

Despite these efforts, it is understood that, in the near future, the faculty collectively and/or the Department Chair individually will have to deal with numerous cases of "exceptions" (i.e., substitutions and waivers) to facilitate graduation within a reasonable time framework. This is an inevitable consequence of current faculty understaffing and curricular restrictions (motivated by administrative and financial constraints):

- required upper-division courses are only offered in two-year cycles;
- their natural cycles are often modified and reset;
- and the limited number of faculty reduce the permutations that would allow certain courses to be offered at appropriate times without hurting other curricular areas (for example, generic SCHs and courses for the minor programs).

And these structural problems are amplified by erratic student behaviors, including attendance and study habits. These are not limited to Physics & Astronomy, and seem to be exhibited by a significant fraction of the student population.

4. Facilities & Physical Equipment

The Physics & Astronomy faculty offices, research labs, and some teaching spaces are located on the first floor of the Harney Science Center (HR). Additional, more modern laboratories are housed in the Lo Schiavo (LS) Center for Science and Innovation (subsection 4.7).

4.1 Physics & Astronomy Lecture Classrooms

Physics and astronomy instruction for lecture courses is conducted primarily in two classrooms, Harney G56 and Harney G75, (though the Department does not have exclusive use of those rooms). The strategic location of these rooms on the Physics & Astronomy level of Harney is ideal for the consistent use of lecture demonstrations, with easy access to the physics equipment stored in G64 (prep room) and G33 (stockroom). Harney G56 is the main Physics & Astronomy Lecture Hall, with theater-style seating capacity of about 150, mainly used for the large introductory physics and classes (PHYS 100, 101, 110, 120, 121, 122, and 210). The demos are usually planned and set up ahead of time in the prep room, with direct access to HR G56. Harney G75, with a seating capacity of approximately 30, is used for small- to medium-sized lecture classes. To facilitate the delivery of demos, both HR G56 and G75 have a built-in lecture bench with electrical outlets (AC and DC), a sink, and compressed air. In addition, they are both smart classrooms with multimedia presentation tools (lcd projector, computer with Windows XP and Mac OS, laptop-ready capabilities, DVD player, and other features). Another lecture hall, HR 136, almost identical to G56 is located on the first floor, just right above it; as it as similar capabilities and seating capacity, it is sometimes used as a backup, especially if the class or instructor does not rely as heavily on large demos (a smaller number of setups can be moved via the elevator with carts if needed).

Physics and astronomy courses have been historically given priority for the assignment of HR G56 and G75 through the Dean's office. However, since the last Program Review, USF has moved to a system with general-inventory classes (these are essentially all classrooms, except for the ones owned by individual departments, such as dedicated labs). As a result, room priority has been formally lost, though the current Director of Academic Planning of the College of Arts & Sciences, Courtney A. Resnick (Ed.D.), has been unbelievably helpful in facilitating the assignment of rooms as required by educational needs (for us, the use of demos in our lecture courses). With her expert assistance (planning the official scheduling in several rounds), we have been able to navigate this overly complex system with reasonable success. However, in recent years, a few small- to medium-sized courses have been scheduled elsewhere or in the Department's own rooms (including the physics labs, the Computational Physics lab, and the "conference room," HR G78-A). With the growth of the Physics & Astronomy program over the past decade, these university trends are worrisome, especially if Dr. Resnick were to leave her current position and departmental needs were not factored in within a new distribution of administrative assignments.

On a different front, a generic problem with Harney is the growing need for maintenance. Harney G56 has recently enjoyed some very basic upgrades: improved seating, new paint, and a smart podium interface that some of our faculty enjoy using. Harney G75 has a projector with basic connectivity, but it has received little attention in 50 years. It is our workhorse for upper-division Physics major courses, but for most participants, it is a dismal little room.

4.2 Lower-Division Laboratories

Laboratory instruction for physics and astronomy lower-division courses is conducted in three dedicated rooms: Harney G74 for the algebra-based Introductory Physics sequence, Lo Schiavo Center G09 (in the new building) for the calculus-based General Physics sequence, and Harney G36 for the introductory astronomy courses. For logistical reasons and computer accessibility, the Concepts in Physics labs are also conducted in G09, and Masterpiece Physics laboratories are conducted in G36. The lab rooms have provision for water, steam, compressed air, and gas (though in Harney these supply lines are not too reliable). Overlapping equipment is used for several experiments in G74 and G09, especially for both physics sequences, requiring careful planning and coordination.

In addition, G36 is equipped with 12 and G09 with 10 iMac computers connected by a wireless network and a shared printer. Each computer has Microsoft Office, a dual-boot mode for PC software, and instructional lab-specific programs. For General Physics in G09, each computer serves as a platform for Pasco Science Workshop software with an SW 500 Interface and its assortment of probe ware and associated equipment; computer data acquisition and analysis are used in most experiments. At present, G74 lacks any computer infrastructure, and we anticipate no change to this in the near term.

The G36 computers (described above) have various astronomy simulation software, such as CLEA (Contemporary Laboratory Experiences in Astronomy), and internet access for online astronomy tutorials (Mastering Astronomy). We have faced significant obstacles in recent years keeping this software running on campus-mandated newer operating systems.

In addition to this computer-based laboratory equipment, the astronomy lab contains all the resources of the other labs, allowing for more traditional physics experiments to be used in this course, as well as hands-on (more elementary) labs. At present, both the Astronomy: Earth/Cosmos and Planetary Astronomy classes share this lab, with typical scheduling of ten or more lab sections per semester.

The Department reuses some lab exercises extensively, though it has pursued many avenues for revamping and upgrading lower-division laboratories. Part-time faculty sometimes earn extra income for revamping labs in summers, and our full-time faculty also periodically make edits and changes. In recent years, General Physics laboratories, in particular, have received ample new attention and revamping from Prof. Seth Foreman.

Each spring, the department compiles a list of lower-division equipment wishes, on the one hand, and dire replacement needs, on the other, and our budget allows a yearly outlay that is neither impressive nor trivial. Most of the laboratories are in basic working order.

4.3 Upper-Division & Electronics Laboratory

Laboratory instruction for both upper-division physics and electronics is conducted in one dedicated room. This is in the modern laboratory environment afforded by the Lo Schiavo Center for Science and Innovation, room G07. This lab room has adjacent spaces for storage of equipment and additional activities. The courses taught in this space are the Upper-Division Laboratory required for the major in Physics and the Electronics courses, which serve the dual role of electives for the major and for the course menu of the minor in Engineering Physics. These labs moved to G07 starting in early 2014, after the new building was up and running; they had formerly convened in HR G69, which is now our dedicated Astrophysics research laboratory.

The Upper-Division Laboratory enjoyed several waves of upgrades in the last eighteen years. First, with the acquisition of advanced laboratory equipment from a Fletcher-Jones Grant (close to $800,000) and related developmental work by Prof. Brown, with materials physics emphasis; and second with the developmental work done by Prof. Böttger (he took over the Upper-Division Lab after our 2004 Program Review). Most recently, Prof. Foreman has brought his own ideas and expertise to bringing a series of new experiments (cobbled together from existing equipment, in many cases) for our upper-division students. During the first phase, an array of experiments were introduced, including film-deposition experiments and X-ray diffraction. Some of these experiments, in addition to the earlier existing gamma-ray spectroscopy and speed of light labs, are still available as part of a significantly expanded menu. For the second phase, the following labs have been added as well: Fabry-Perot cavities, Frequency Modulation spectroscopy, Optical Amplifier, Erbium doped fiber laser, Michelson Interferometer, Reflection and Refraction on an optical interface, Saturation absorption spectroscopy of Rubidium atoms, Laser frequency stabilization, Data storage on a CD and DVD, Principles of optical wave guiding, and Optical communications. ' Finally, for electronics, this lab room, LS G07, is big enough to accommodate and support comfortably up to 16 students per course. Due to our recently expanded

Electronics course offerings, now centered on Analog Electronics and Digital Electronics—critically important for our new Engineering Physics Minor, and with the expert leadership of Prof. Böttger—we have secured continued investment by the Department of Physics and Astronomy and the Dean's Office. As a result, we have research-grade instrumentation and tools, including 5 digital Techtronics oscilloscopes, computers with data acquisition software for the oscilloscopes (GPIB), electronic bread board trainers, digital millimeters, probes, a large assortment of electronic components (IC and passive), and other basic electronics tools (soldering irons, alligator clips, power supplies, variable resistance boards, variable capacitance boards, wire cutters, needle nose pliers, and various cables). A partial list of recently added pieces of equipment includes: Altera FPGA DE22115 boards, Digital/Analog Trainer ETS7000, Tektronix TBS1000 series scopes with probes, Agilent E3630A DC Power Supplies, BK precision 4012A 5MHz function generator, TTech CNC circuit mill. And the following software packages: Quartus II Software, National Instruments Multisim Software, National Instruments Ultiboard Software, Origin 9.0, Tektronix Open Choice, Tektronix Wavestar.

4.4 Computational Physics Laboratory

The Computational Physics Laboratory, in HR G27, supports both of the Department's current Computational Physics courses, in addition to supporting computational research. This laboratory was introduced by Professor Camperi in the late 1990s; along with the Computational Physics upper-division course, and now Computational Physics II, it has also been used previously for Computational Neuroscience.

HR G27 is now equipped with 13 iMac computers, a laser printer, and a ceiling-mounted projector. The computers run up-to-date Python programming language-based, open-source, scientific computation and machine learning software packages (including but not limited to Numpy, Scipy, Matplotlib, Scikit-learn, Sympy, Jupyter Notebook).

The physical space and equipment can currently comfortably support the education of a maximum of 13 students. An increase in student enrollment would require additional hardware and/or the use of a bigger physical space and potentially the addition of extra laboratory sections/instructors to the courses. For instance, computational courses can be taught in modern computer laboratories in LCSI with higher seating capacity.

4.5 "Observatory," Astronomical Equipment, and Campus Observing

Over the last several years, our astronomy equipment and housing has undergone great flux. There are two main components worthy of review: (1) our smaller telescopes and supporting equipment used for "observation evenings" in our Core astronomy courses offered predominantly to non-science students, and (2) our larger 20" custom telescope and its dome housing, purchased via a large, university-wide NASA grant.

4.5.1 Campus Observing

Our current teaching-centered astronomy observation equipment is primarily located in two separate locations: the Fromm observatory, which is essentially an observing platform that extends over a large open area with a fairly unobstructed view of the sky, on the roof of Fromm Hall; and in a locked shed on the university's soccer field (on the western edge of campus). We primarily use these facilities for course-related observations by astronomy students and training of our observation teaching assistants (mainly Physics majors). Rarely, we have used one or the other for an outreach event (e.g. to alumni of the university), but there is interest is expanding this type of activity.

For the Fromm observatory, an array of electrical outlets is available for telescope use, along with a protected storage shed for our telescopes and other astronomical equipment. The facility opened in 2005, following an unfortunate sequence of events that disrupted our earlier observing platform in Lone Mountain (originally established in 1998 along with the start of the astronomy part of the program). Several upgrades and the addition of new instruments followed, especially with the acquisition of a large NASA grant specifically secured for this purpose. However, in the interim, the roof has periodically flooded in winter, and the long-duration standing water, while not damaging equipment, has rendered the site unusable for long stretches of time.

The Fromm storage shed is a controlled environment, with weather sealing and a dehumidifier running continuously. This protective, low-humidity, low-dust environment was carefully planned to extend the lifetime of our telescopes and other sensitive astronomical equipment.

Meanwhile, in response to our concerns about the flooding rooftop observatory, the university proposed the soccer field as a possible solution. (The site is surprisingly dark in the evening, when the stadium lights are off.). Here, we have faced another set of issues. Though we tried to locate it in a "safe" spot, it is still routinely struck by fast-moving soccer balls, and the equipment here needs regular recalibration. In addition, it has already been moved, via crane, twice in the last few years, in conjunction with major soccer field renovations.

A partial list of our current astronomical equipment includes: three 12-inch Meade LX200-ACF (Advanced Coma-Free optics); one 1- inch Celestron Newtonian reflector; one 4-inch Questar; one 7-inch Questar; one 6-inch refracting Celestron; one 8-inch Meade LXD55 refracting telescope; and a large number of binoculars (various magnifications and fields), two CCD cameras (one research-grade), and various accessories.

4.5.2 The 20-inch Telescope

As noted in the last program review, we purchased a 20-inch RC (Ritchey-Chrétien) telescope with Astro-Physics 3600GTO German Equatorial Mount, and a dome. These were placed in storage for many years, as we worked with the university administration to agree upon a site for permanent installation. The roof of the new science building was one option, at one time, but permitting the building, we are told, forbade an habitable structure on the roof. Thus, this was unresolved for several years owing to a number of administrative factors.

Several attempts were made during the intervening years by Profs. Huang and Venkatesan. Finally, in 2016, after considering many options, the University entered a partnership with the Robert Ferguson Observatory (RFO) located in Sugarloaf Ridge State Park in Sonoma, CA. RFO is a well-funded organization with several optical/solar/radio telescopes, operated almost entirely by over 250 volunteers. They typically host 12 to 20 events a month, each drawing up to 200 or 300 people, so they too were looking for an additional telescope to accommodate the scale of their events. In Fall 2016, we drew up an agreement of shared annual observing and joint student/faculty projects, as well as annual USF events at RFO. The formal process involved transferring the above equipment including the 20-inch telescope, dome, mount and associated cameras/accessories to RFO.

4.6 Stockroom, Prep Room, and Shops

Harney G64 is the Physics & Astronomy Department's demo prep room and the main office for our Physics & Astronomy Instrumentation Technician and laboratory student assistants. As mentioned in subsection 4.1, it is located adjacent to our main Physics & Astronomy lecture hall HR G56. All of the department's demonstrations are stored and set up in this room prior to lecture time. The basic demonstration equipment is organized according to subject matter. In addition to the physical equipment, the department also keeps a large library of DVDs, laserdiscs, and VHS tapes in HR G64, including most of the well-known educational physics and astronomy series and documentaries (such as NOVA documentaries, Cosmos, The Mechanical Universe, and The Video Encyclopedia of Physics Demonstrations, among many others).

Harney G33 is the Physics & Astronomy Department's stockroom. This facility serves as main organizational storage unit for all equipment of the physics and astronomy lower-division labs, as well as generic multipurpose and old equipment, and miscellaneous supplies. The equipment is organized by subject matter in several large cabinets.

There are also two machine shops in our Physics & Astronomy area: a metalworking shop and a woodworking (and plastic) shop. HR G33 connects through an internal door to the Physics Metalworking Shop, G37, which contains miscellaneous tools for repairing or building laboratory equipment, including two lathes, a milling machine, and two band saws. Due to changing space needs, the Woodworking Shop, which has several tools and a table saw, has been moved a number of times within the past decade, and is now in HR G41. The shops can be used as needed by physics faculty and the technicians in all science departments. The university supported substantial renovation and repair of the major machine shop pieces circa 2015, and this effort was led by Prof. Seth Foreman, with the assistance of our technical staff. The shop now enjoys a 2-axis computer-controlled bridge mill capable of producing some fairly sophisticated parts. Professor Foreman also ran several training sessions for various faculty and staff to teach them basic machining techniques on the new machine. As an example, he has produced many machined parts for his own research, lecture demos, and lab courses.

4.7 New Labs: Lo Schiavo Center for Science and Innovation

In 2004, USF began in earnest to investigate the addition of new science facilities. This process responded not only to the previous Physics program review, where facilities and space were cited as significant challenges, but also to similar reviews of all science departments at the University.

The new center opened in Fall of 2013, and we have made steady use of our two new spaces there.

The two new spaces for our department are both housed on the G level of the Lo Schiavo Center, and this floor aligns with our current floor of the Harney Science Center.

- Lower-Division Laboratory. After much study and discussion, the department decided to prioritize a new lower- division laboratory. The flexible space resulting should serve all of the 100-level laboratory courses as we see fit. We particularly hope to prioritize our General Physics sequence (calculus-based, for physics and chemistry majors) for this space, in an effort to attract, impress and retain new physics majors. For the first time, such a laboratory will have a dedicated preparation and storage space adjacent to it. And for the first time, such a laboratory will feature flexible, movable furniture to maximize the number of distinct laboratory activities (or even departmental functions) that can be carried out in the space.

  The square footage of this space (over 1200 sq. ft.) expanded on our previous lower-division laboratory for majors, (just over 900 sq. ft.). Therefore, lab sections of, say, 20-24 students (and even 30 in extreme cases) can be held if necessary.

- Upper-Division Laboratory. The second highest priority for the department was an upper-division laboratory space that conforms to modern standards and supports modern advanced techniques. The new center features a dedicated space for this purpose as well, supporting our Upper Division Laboratory course, as well as the newer Electronics offerings (Analog, plus two Digital Electronics courses).

  Primary upgrades included in the new upper-division laboratory include most notably:

  - Vibration isolation plate for optical measurements.
  - A fume hood.
  - Dedicated storage and preparation space.
  - Access to advanced instrumentation from other departments—see instrument corridor in figure.
  - Deionized water supply.
  - Proper bench depths for modern instruments.

4.8 Research Spaces

Since our last program review, three labs have been repurposed for specific research needs: G65 for Prof. Seth Foreman's ultra-fast electron imaging facility; G69 for Prof. Xiaosheng Huang and Prof. Aparna Venkatesan's Astrophysics research work; and G70 for Prof. Milka Nikolic's plasma physics laboratory. These join the existing G39 which functions as a laser spectroscopy laboratory for Prof. Thomas Böttger.

These spaces are adequate for the research needs, and the administration has supported funding for cleaning, revamping, resupplying, reducting, and in some cases, rewiring these spaces. However, it has been a struggle to make G65 a reliably clean enough work space for Prof. Foreman's precision needs.

4.9 Space Flux and Student Space

Over the last 20 years, the department has experienced significant changes in our assigned facilities and spaces. As science offerings in the old Harney building have expanded, the pressures on Physics and Astronomy to lose space have been substantial. Harney G23 (a laboratory), G24 (formerly one of our larger teaching labs), and G82 (a research space), have all been repurposed to other programs or administrative needs within the last 20 years. We also lost one of our few office spaces in 2011 during the construction of the new building, (making a new adjoining hallway).

At the same time, we acknowledge the two modern spaces added for our program's use in 2013 (G07 and G09 in the Lo Schiavo Center), including the new dedicated support spaces.

Finally, we must mention that we have struggled to create a space, with the administration, for our students: the Physics majors, our various minors, the Society of Physics Students, and the Astronomy club. Informal student spaces were a priority in the new Lo Schiavo Center, and while we acknowledge that, most of our faculty in the department believe a dedicated space for our majors and clubs would be of great benefit to our departmental community and our efforts to retain and train our majors in particular.

5. Faculty

5.1 Full-Time Faculty

The Physics & Astronomy Department has eight full-time tenured or tenure-track faculty, with seven currently working in the Department (plus another one, Marcelo Camperi, Dean of Arts and Sciences, holding a full-time administrative job removed from the Department): Thomas Böttger, Brandon Brown, Horacio E. Camblong, Marcelo F. Camperi, Seth Foreman, Xiaosheng Huang, Milka Nikolić, and Aparna Venkatesan.

Like many other departments, we have persistent long-term problems caused by our faculty understaffing. This becomes painfully clear when the faculty take sabbaticals, and especially when two faculty are on simultaneous leaves (either sabbaticals or otherwise). Such occurrences have a high probability—under the current setup, for two academic years years out of seven we face two simultaneous sabbaticals. This unbalanced situation would not be so serious if sabbatical replacements were the norm. However, this is not a valid assumption, especially in the ongoing climate of financial crisis. As a result, we have increasingly adjusted to rely on a large pool of part-timers, especially to cover the laboratories, but also to often cover other, lecture courses. In particular, one of the full-time architecture faculty members (Prof. Hana Mori Böttger) regularly helps our program as part of her teaching load—see below. Most importantly, the current situation regarding faculty, combined with administrative pressures to increase caps, have led us to not offer all the required courses with sufficient regularity. While we have been able to maintain two-year cycles in the past three years, it is unclear whether these rational cycles are sustainable with overlapping sabbaticals and other factors.

The full-time faculty research interests and other relevant information are listed below.

5.1.1 Thomas Böttger
Professor, Department of Physics and Astronomy

Professor Thomas Böttger studies optical, dynamical, and magnetic properties of solids, specifically optical materials doped with rare earth ions. This work is centered on understanding the fundamental material physics at the microscopic scale but also geared towards the development of optical materials for optical signal processing, optical memories, quantum computing, and laser frequency stabilization. He has been specifically interested in Erbium, Thulium, and Ytterbium-doped materials at diode laser wavelengths. This work is carried out using a variety of linear and nonlinear optical methods, such as stimulated photon echoes, spectral hole burning, time-resolved spectroscopy and more conventional methods such as optical absorption and site-selective spectroscopy. Professor Böttger is also interested in laser development and has built continuously tunable diode lasers at a variety of wavelengths for his research. In this context he has worked on the technique of frequency stabilizing external cavity diode lasers to the narrow frequency references found in rare-earth-doped materials. By locking the laser frequency to an ultra-narrow spectral hole, experiments have reached the limits of precision in the optical spectroscopy of solids.

5.1.2 Brandon R. Brown
Professor, Department of Physics and Astronomy

Professor Brandon Brown earned his Ph.D. in condensed matter physics from Oregon State University and pursued postdoctoral work in science communication at UC Santa Cruz. After joining the Physics Department at USF in 1998, he transitioned from research in HTSC materials to work on the electric sense of sharks and their relatives. This work resulted in a number of high profile interdisciplinary papers (e.g. Nature, 2003). From 2004-2008, Brown served as Associate Dean for Sciences and led the planning for the Lo Schiavo Center. In 2008, he returned to the Physics Department but assisted major fundraising for the Center for a number of years. He is now serving full-time in the department, has shuttered his laboratory to provide space to newer faculty members, and is focused on book-length projects, such as his 2015 biography, *Planck: Driven by Vision, Broken by War* (Oxford U. Press).

5.1.3 Horacio E. Camblong
Professor, Department of Physics and Astronomy

Professor Horacio Camblong's research deals with miscellaneous topics in quantum field theory, gravitational physics, and many-body theory. He identified the first quantum anomaly in low-energy systems: the conformal anomaly in dipole-bound anions of molecular physics. This work is part of much larger program that uses effective-field theory concepts for conformal quantum mechanics. Applications involve a variety of physical realizations, including the three-body Efimov effect, QED, nanowires, black holes, and graphene. His ongoing work involves two major areas: black hole thermodynamics and singular quantum

mechanics—both involve collaborative work with scientists and students at the University of Houston and Universidad Nacional de La Plata. The work on black holes aims at providing a deeper insight into the quantum nature of gravity and black holes and the emergence of black hole thermodynamics and the emission of Hawking effect from the near-horizon conformal symmetry. The search for a more general framework for singular quantum mechanics is underway, including the role played by unitarity; and applications to the exciting material graphene are being pursued.
Professor Camblong is currently the Department Chair.

5.1.4 Marcelo F. Camperi
Professor, Department of Physics and Astronomy

Professor Marcelo Camperi's early research involved topological field theory and some phenomenology of elementary particles. He subsequently became interested in the study of the brain from a physicists' point of view. In recent years, he has worked on various topics in the field of computational neuroscience, including the simulation of very large network of biologically feasible neurons using parallel computer architectures, the development of models of prey detection and navigation in elasmobranch, and the use of information theory for networks of neurons. He is also interested in computational physics, mathematical physics, and in computers in education.
Professor Camperi currently holds the position of Dean of Arts and Sciences.

5.1.5 Seth Foreman
Assistant Professor, Department of Physics and Astronomy

Professor Seth Foreman interests include ultrafast fiber lasers, frequency combs, and femtosecond emission of electrons from field emission tips. At USF, his work relies on focusing precision-controlled few-cycle pulses of laser light onto atomically-sharp needles in order to generate electron pulses. Such pulses have a unique combination of properties: the electrons have a long transverse coherence (allowing for high-quality interferometric, holographic, and diffraction techniques), have wavelengths short enough to resolve atomic features (unlike visible light), and have durations suitable for capturing the timescale of fundamental electronic processes in molecules and materials.

5.1.6 Xiaosheng Huang
Assistant Professor, Department of Physics and Astronomy

Professor Xiaosheng Huang's recent research has been centered on the use of computational models for observational cosmology, to probe some of the key cosmological parameters of the standard model of the universe and its variations. Eighteen years after the discovery of the accelerating expansion of the universe, observations are still consistent with Einstein's cosmological constant. With collaborators at the Nearby Supernova Factory, he has been studying how extragalactic dust affects the brightness and color of type Ia supernovae (SNe Ia), which remain a premier cosmological probe to determine whether the cause of the cosmic acceleration is indeed the cosmological constant. In particular, their work showed that the level of dust obscuration (or "extinction") changes very little over time due to dust in the interstellar medium with non-uniform density, through making use of the SN spectroscopic twinning technique and theoretical modeling of the interstellar dust column density. He is working at other applications of the analysis techniques to SNe Ia with has high extinction. He is also working on the modeling of gravitational lensing with his collaborators at the Supernova Cosmology Project.

5.1.7 Milka Nikolić
Assistant Professor, Department of Physics and Astronomy

Professor Milka Nikolić's research focuses on the development and application of non-intrusive, in situ, spectroscopic techniques for characterization of fundamental plasma parameters. In particular, she is interested in combining laser diagnostics, such as laser induced fluorescence (LIF), with widely used optical emission spectroscopy (OES) technique to obtain time resolved plasma diagnostics and to increase overall precision of data collection. Additionally, she has developed a two-dimensional plasma tomography method based on the numerical solution of the inverse Radon transform in order to observe the internal dynamics of plasma. She is also planning to perform surface analysis of the etched materials by using a scanning microscope available at College of Sciences. She has been working with USF undergraduate research assistants to build an automatized detecting system for her laboratory, and to develop a Monte Carlo simulation of argon plasma. In addition, she has continued her collaboration with the research group of her former supervisor at Old Dominion University, Dr. Leposava Vuskovic, on developing various spectroscopic techniques based on optical emission spectroscopy and laser diagnostics.

5.1.8 Aparna Venkatesan
Associate Professor, Department of Physics and Astronomy

Professor Aparna Venkatesan is a cosmologist working on a number of research topics including studies of the first stars and quasars in the universe and the physical conditions in early universe galaxies. In recent years, she has been a Co-Investigator on two NSF grants, the PI on a Cottrell College Science Award, and Co-Investigator on a number of successful observing proposals at NSF or NASA facilities/observatories, and the recipient of the USF Dean's Scholar Award and the USF Jesuit Foundation grant. Her undergraduate research group has been featured in Mercury magazine (2015) and the Council of Undergraduate Research Quarterly (2016). Aparna currently serves on a number of USF and national committees to increase the participation of women and underrepresented minorities in STEM fields and astronomy, including the American Astronomical Society's Committee on the Status of Minorities in Astronomy, and the Committee on the Status of Women in Astronomy. She is deeply committed to increasing the participation and retention of underrepresented groups at all career stages in astronomy, physics and the sciences. She has been active in Native American/indigenous education programs/issues, as well as in recruiting and retaining women and minorities over her entire research and teaching career.

5.2 Part-Time Faculty

A number of part-time instructors are critically needed every semester to deliver our whole program of courses. They are enlisted from a pool that mostly includes continuing instructors (with extensive teaching experience) and applicants through the USF/UCSF

Partnership for Undergraduate Mentoring and Teaching (PUMT). Four of the continuing instructors, Dr. Terrence Mulera, Dr. Minhua Zhu, Dr. William Golightly, and Andrew Fittingoff, have been teaching in the Department for several years and have become an integral part of our academic program.

Dr. Terrence Mulera received his Ph.D. in experimental elementary particle physics from Purdue University, and had early research career with work on strong interaction dynamics, spin dependence in the strong interactions, relativistic heavy ion collisions, neutrino oscillations and rare decays of the pion. He came to the USF Physics & Astronomy Department after working in the semiconductor industry for a number of years—and he is also teaching modern physics courses at the USF-affiliated Fromm Institute for Lifelong Learning. At USF he has taught a broad range of courses from Introductory Physics to Modern Physics, and most of the laboratories. In recent years, he has been teaching many of our labs every semester.

Dr. Minhua Zhu received Ph.D. from Case Western Reserve University in the area of soft condensed matter physics, with specific work on liquid crystals. She also worked at University of California, San Francisco; and has been teaching in the Bay Area for a number of years. In recent years, she has become one of the adjuncts with the largest number of assignments per semester, as she is a thoroughly reliable and flexible instructor.

Dr. William Golightly received a Ph.D. from the University of California at San Diego, on the physics of free-electron laser. He has extensive teaching experience at several Bay Area institutions, including UC Berkeley; and has been routinely teaching in our department since 2007—courses taught by him include Modern Physics, occasionally an upper-division course, and a variety of labs.

Andrew Fittingoff has increasingly played a central role in the delivery of astronomy courses and other large-lecture courses, such as Introductory Physics. He is a most versatile and efficient adjunct that can deliver a lecture course effortlessly, or teach any lab as needed by the Department. With a thorough background in astrophysics from San Francisco State University, he is uniquely passionate and knowledgeable about astronomy topics, and has been successful in his flawless course delivery since 2011.

Finally, since 2007, the PUMT partnership with the University of California, San Francisco (UCSF) has consistently provided a large pool of UCSF graduate students and post-doctoral researchers/clinicians, hired as part-time faculty for Biology, Chemistry, and Physics & Astronomy. The stated goal of the program is to give the PUMT instructors a valuable teaching experience at the undergraduate level. The USF Physics & Astronomy Chairs have worked over the years with a PUMT coordinator at the UCSF Office of Career and Professional Development to hire qualified instructors from this pool for physics and astronomy labs, and occasionally for lecture courses. More recently, their UCSF office was reorganized, and these efforts are channeled through our local coordinator, Prof. Deneb Karentz of the Biology Department. We have been in contact with her, and anticipate an increase in hiring over the next couple of years. In practical terms, this program has made it possible for our department to significantly increase the SCHs, offering a broad range of courses with 20 or more lab sections every semester (most of these labs are taught by our continuing part-time faculty and PUMT instructors, and a varying but small number by our full-time faculty).

5.3 Other Faculty

Professor Hana Mori Böttger has been a critical contributor to our teaching delivery. She holds a full-time position as Associate Professor in the Architecture & Community Design program within the Deparment of Art & Architecture. She teaches design, structural analysis, construction materials, integrated design and international development courses for architecture students. She has developed and directs the Architectural Engineering Minor program, and a thesis project-based Honors program for exceptional ARCD majors. In the Physics & Astronomy program, she teaches the Concepts in Physics course for the architecture students every Fall (along with its lab sections)—this is in addition to her occasional teaching of other physics labs. Her research interests include structural materials analysis, seismic behavior of adobe brick wall systems, and engineering education.

6. Administrative Support Staff

The Department's day-to-day operations critically rely on the support personnel. Our support staff includes our full-time Physics & Astronomy Laboratory Technician, Elizabeth Andrus, and our full-time Program Assistant, Amanda Machi—in addition to the student assistants supervised by them for specific tasks. Thanks to their work ethics, diligence and skills, we currently enjoy a smooth and efficient working environment. To a great extent, this environment is based on the principle that team work is encouraged and practiced at all departmental levels. Amanda Machi started her current position in 2012, and Elizabeth Andrus (USF alumn) in 2015.

The Physics & Astronomy Laboratory Technician has an open-ended job description centered on all experimental and technical aspects of the delivery of the physics and astronomy curriculum: laboratories, lecture demos, and ongoing organization and maintenance of the equipment in a managerial role. Day-to-day tasks include assembling lecture demonstrations, repairing equipment, taking inventory of supplies and equipment, ordering routine supplies for laboratories, setting up and taking down laboratories, and providing minimal computer support within the Department. Many of these tasks are implemented under her supervision by one or two student assistants. In addition, our technician has successfully provided infrastructural assistance to our various research programs; and also provided support for astronomy-related activities.

Even though the official supervisor of the technical staff, including the Physics & Astronomy Laboratory Technician, is the Associate Dean of Sciences, daily and effective supervision takes place through the Department Chairs. This anomalous situation probably originated from the peculiar distribution of tasks implied by the USF Faculty Association, but has caused painful conflicts at several points in the past few decades. However, it is noteworthy that the current situation is excellent and appears to be stable; and it is understood by both parties that our technician still provides assistance for targeted tasks outside Physics & Astronomy on a non-priority basis. Moreover, this setup has tradeoffs, and it has recently allowed for additional help to Physics in specific targeted tasks through another college technician, Jeffrey F. Oda, who has partially supported our technical efforts in a variety of ways, working closely with Elizabeth Andrus (e.g., for the astronomical equipment generically, and for the transfer of the 20" telescope specifically). There is also another recent addition to the Arts & Sciences College's team, Matt Helm, who has proved invaluable in supporting some of the highly technical jobs in Physics & Astronomy. Matt Helm has been hired earlier this year as Instrumentation Specialist, coming to USF with extensive experience in engineering after having worked in a variety of industries.

A positive development over this past decade has been a Physics & Astronomy trend towards departmental integration of tasks, whereby our Program Assistant and Instrumentation Technician work as a team to help resolve new problems and challenges under the supervision of the Department Chair. As a result, we enjoy a relatively efficient environment, with a smooth delivery of routine departmental tasks.

Unfortunately, this state of affairs can be easily disrupted by external pressures stemming from the Dean's Office without departmental consultation—again, from the fact that our Program Assistant's supervisor is not officially the Department Chair. Specifically, the external pressures have involved increasing volumes of work given to Amanda Machi to assist other departments, and a poorly conducted attempt to change the nature of her job to officially assist other departments—this happened over this past Summer 2017. At the moment, and after some vigorous protests, this intervention has been partially discontinued, though we cannot anticipate its status by the time of the official visit of the Program Review team. Further reasons to be concerned are preliminary comments made in various forums of a possible College-wide proposal to create a completely centralized system of clerical support, removing all (or at least some) of the Program Assistants from their main departments and physically housing the team in a central office detached from the individual departments. (Approaches of the sort are unanimously rejected by our Physics & Astronomy Department, though we are fully aware that such decisions can be made without our input. It is known from similar experiments elsewhere, both in academe and in the private sector, that such approaches rarely work, either generically or specifically.)

7. Students and Departmental Activities

Students are offered many opportunities for active participation in our program, as described below. The "Departmental Activities" mentioned below integrate students and faculty in a nurturing, interactive environment.

7.1 Student and Teaching Assistantships

We employ students as teaching, administrative, and research assistants, as is common practice in most Physics Departments. The research kind is usually covered via other sources of funding (Faculty Development or grants), but the teaching and administrative appointments are arranged at the departmental level. For this purpose, there is a student budget that is adequate for the coverage of most of our introductory physics and astronomy courses plus student assistantships to support administrative or technical work.

Specifically, the delivery of our curriculum involves student assistants as an integral part of the educational experience for targeted courses (mainly lower-division, introductory physics and astronomy). This system facilitates the smooth delivery of our courses; and it also provides invaluable training and teaching experience for our students. The available positions are typically announced at the end of the semester prior to the hiring and decisions are made based on experience, GPA, and other factors leading to an optimal distribution of limited resources. The available positions typically involve hiring as: tutors or problem-discussion assistant for the introductory physics courses (PHYS 100, 101, 110, 210, and sometimes 240); graders for most of the lower-division courses with sufficiently large enrollments; observation teaching assistants; and administrative student assistantships (for the Physics & Astronomy Office and for the Stockroom/Lab management). Sometimes we also hire laboratory teaching assistants for lower-division introductory physics and astronomy courses (PHYS 100, 101, 120, 121, 130, 135, 210)—this is likely to become more common in the near future with the upcoming sabbaticals.

7.2 Student Research

Exposure to scientific research is an important component of the programs administered by our Department. Our undergraduate students have engaged in research projects both in our on-campus labs and off-campus. For the latter, students have been encouraged and supported to participate in NSF's Research Experience for Undergraduate students program (REU). Over the years, several of our students successfully completed intense 10-week summer REU programs; and also internships at national laboratories.

In addition, a partial list of students who worked in our USF Physics & Astronomy labs follows. Some of these projects have been featured at the annual USF Creative Activity and Research Day (CARD). In Prof. Böttger's laser spectroscopy lab: Cameron Chavez, *Simulation, Design, and Construction of a Low-Noise Diode Laser Driver* (20152017); Jacob Baca, *Solar Charge Controller Design* (2013–2014) and Digital Electronics Laboratory Experiments (Summer 2014–2015); Alexander Mausolff, *Frequency Modulation Spectroscopy: Theoretical and Experimental Lines Shapes* (Thesis in partial fulfillment of the requirements for Bachelor of Science in Physics with Honors, 2013–2014); Barry Martin, *Frequency Modulation Spectroscopy of a High Finesse Cavity* (2011–2012). In Professor Foreman's lab: Benjamin Rand, Erbium femtosecond fiber laser alignment and building of prism-pair pulse compressor (2016–present); Ian Cone, design and original build of Erbium femtosecond fiber laser and measurement of sub-100-fs pulse duration using autocorrelator (2014–2016); Sofia Jimenez, fabrication and characterization of field emission tips (2016). In Nikolić's lab: Benjamin Rand and Mitchell First, building an automatized detection system (2017); Ivan Sepulveda, a Monte Carlo simulation of argon plasma (2017). With Prof. Venkatesan: Haley Sharp, *Sloan DSS and ALFALFA data constraints on the primordial stellar mass function* (2011-2012); Chris Downing, *Constraining the First Stars Using Metal-Poor Halo Stars and ALFALFA Data* (2011-2013); Benjamin van Kleeck, *Signatures of pair-instability supernovae in low-mass ALFALFA galaxies* (2013-2014); Long Yan Yung, *Constraints from local dwarf galaxies and low-mass ALFALFA galaxies on the first stars* (2011-2014); Catlen Camacho-Light, *The Escape of First Light from Early Galaxies*

(2014-2015); Meera Arora, *The Role of Low Mass Galaxies in Cosmic Reionization* (2017-present); Mario Olivieri Villalvazo, *The Role of Low Mass Galaxies in Cosmic Reionization* (2017-present). With Prof. Huang: Zach Raha and Andrew Stocker, *The Extinction Properties of and Distance to the Highly Reddened Type Ia Supernova 2012cu*; Astrophys. J. 836, 157 (2017); Moriah Biederman and Brendan Herger, *On the Time Variation of Dust Extinction and Gas Absorption for Type Ia Supernovae Observed Through Non-uniform Interstellar Medium*, arXiv:1710.11115 (2017).

7.3 Departmental Activities and Outreach

Regular departmental activities organized by faculty, students, and/or the Department's Office include: the Physics & Astronomy Colloquium Series, and related the Physics & Astronomy Coffee Hour; social gatherings, hosted at the beginning and end of each semester and around special events (visitors and annual info session on the 3/2 Program); and activities of the Society of Physics Students local chapter, Astronomy Club, and Women in Physics.

The Physics & Astronomy Colloquium Series follows a long-standing tradition of physics departments around the world: to provide an ongoing series of talks for the faculty and the students. Unlike highly specialized seminars, the physics colloquia are intended to cover a broad spectrum of physics topics at a reduced technical level. Moreover, because of the size of our department and the nature of our curricular offerings (only undergraduate), our invited speakers are given explicit instructions to make their talks accessible to as wide an audience as possible. First conceived as a "Physics Colloquium Series" in 1994, it has been organized (at different times) by most of our faculty; in 2009, it was renamed (along with the Department's name change) "Physics and Astronomy Colloquium." All in all, the Colloquia provide our students with an overview of current physics research and with invaluable opportunities to meet informally with a variety of scientists—we know such contacts have been critical for many students later pursuing summer research opportunities, internships, and graduate school work.

The feeling of being a part of the community is important to all of our students. The local chapter of the Society of Physics Students (SPS USF), has been active intermittently; and this Fall semester, we have reinstated the SPS USF after several years of inactivity. Our undergraduate students worked on writing the constitution for the society and already had their first meeting. Currently, students are working on designing the website for the society that will be hosted by the university. Professor Nikolić has been active in fostering these student activities. In addition to the SPS, she has gathered enough interest and momentum, with the full support of the Physics & Astronomy Department, to start Women in Physics gatherings (as of Spring 2017). Having women in science, and especially in physics, is very important for our department. This initiative has led to two meetings in the Spring semester and one this Fall. We are hoping that, with these meetings, our female students will create bonds and friendships that will help them feel accepted and part of the physics community. On a professional level, discussions centered on possibilities for undergraduate scholarships for female students and an option to attend the national Women in Physics conference.

In addition, our Department has started discussions (among our faculty members) with the goal of eventually organizing workshops for high school students in the area. This would be a Physics & Astronomy Open House, where the high-school students would have a chance to visit the research labs of our faculty, attend a lecture on a popular physics topic, and enjoy various demonstrations describing physics concepts. The organizational tasks would be led by faculty and assisted by our undergraduate physics majors.

(Parenthetically, USF used to have a College-wide Science Open House in the 1990s, involving all science departments. It was eventually discontinued around the year 2000, when it was argued that it had not been a successful recruiting tool to attract the best science majors to USF.)

8. Physics & Astronomy Challenges and Opportunities: Conclusions and Outlook

Since the 2011 Program Review, our Physics & Astronomy Department has maintained its strong academic foundation and expanded its educational offerings. We have been been able to increase the SCHs and maintain a respectable number of majors to deliver the program with regularity, and despite recent Admissions glitches.

There are at least three related areas where our Department of Physics & Astronomy faces major challenges, which, with enough out-of-the box thinking and administrative support could be turned into wonderful opportunities. These core ideas are listed below.

- Recruitment and Retention of Physics Majors.

  This is an ongoing issue not only at USF but also at the great majority of colleges and universities in the USA. In addition to the perception of physics by students as an impenetrable subject, we are subject to unpredictable admissions fluctuations (e.g., our major numbers have been significantly and adversely affected as a result of the well-known Fall 2015 university admissions episode).

  For this generic recruitment issue, two additional variables need to be examined separately (engineering and astronomy, as itemized below).

- Physics Program Planning vis-a-vis the Anticipated Engineering Program/School at USF.

  This involves an evaluation of the existing physics major curriculum and of our recently developed engineering physics minor. Most importantly, it requires an examination of the role of "engineering physics" in two formats: the existing 3/2 Physics-Engineering USF-USC program (which is currently a critical recruitment tool) and the possible development of an engineering physics or applied physics program housed at our Physics & Astronomy Department.

  A serious discussion needs to take place with the administration to assess whether we can assume that the 3/2 program will remain in place after the USF Engineering program begins. An argument to keep this option is that USF does not seem likely to offer strong mechanical and electrical engineering programs—these are the core areas selected by most students to transfer to USC.

Another, not mutually exclusive option, is to start a Physics-Department housed Engineering Physics Program. This would be an extension of our current Physics major combined with the Engineering Physics Minor and a few additional applied courses. Such programs exist in many other respectable Physics Departments—and the menu of electives could be expanded with the Program or School of Engineering. We do have considerable expertise and resources within our department: such track would provide learning opportunities in materials science and nanotechnology, solid state physics, digital and analog electronics, applications of plasma physics for surface modification and medicine, and so forth.

- Role Played by Astronomy and Astrophysics within the Department.

  This issue has multiple dimensions, from the healthy and steadily increasing number of departmental student credit hours to the enhanced educational opportunities afforded by astrophysics (including our astrophysics minor). While the Department has been relatively successful in this area, unexpected challenges have surfaced in recent times in terms of student numbers and scheduling conflicts.

  Moreover, we need to be more consistent in the offering of as many introductory astronomy sections as possible, to reach an operational cap that maximizes the SCHs.

  Questions about the frequency of the course cycles for astrophysics-related upper-division courses needs to take place (including their interaction with the Engineering Physics Minor program offerings). This process is inextricably complicated by large fluctuations in student numbers, faculty sabbaticals, administrative pressures, and other factors.

All in all, our departmental goals remain strikingly similar to our last Program Review. This is beacause the administrative numbers are comparable and the larger problems remain basically the same, revolving around physics-major recruitment, engineering factors, and astronomy initiatives. But it has become increasingly clear that the envisaged USF Engineering Program is a completely new variable that will play the most dominant role in various departmental decisions in the near future. Thus, a partial list of the most important goals follows, ordered hierarchically (with the first two items being the highest priority):

- Evaluate the two engineering-related questions:
  (i) continuation of the 3/2 program in its present form as a dual degree with USC;
  (ii) possible development of an Engineering Physics Major—including risks and benefits.

- Strategize and experiment with effective ways to increase the administrative student numbers, i.e., the number of PHYS majors and the SCHs.

- Strengthen the academic program at all levels, including a systematic revision and upgrade of experimental physics. This goal has been finally achieved to some satisfaction, but could be viewed as an ongoing process, especially regarding new engineering-related developments.

- Expand the introductory astronomy component of the program (by increasing the number of individual courses and the total SCHs).

- Enhance the visibility of our Department by multiple means, including outreach activities.

- Develop a more nurturing and efficient working environment through improvements in the physical appearance of classrooms, labs, and hallways; and by fostering team work with the faculty, staff, and students.

- Continue expanding and upgrading the departmental computing facilities.

In short, our academic program has a rigorous and modern undergraduate curriculum in physics, and has been expanding in astronomy as well; and our research programs are strong and offer some opportunities of undergraduate research for our students. If we were able to further increase the current student numbers, and possibly develop additional applied and/or engineering options, the future may hold interesting opportunities for further development for both the faculty and the students.

APPENDICES.

A. Physics Program Learning Goals and Learning Outcomes.

A.1 Physics Program Learning Goals

Upon completion of the Bachelor of Science degree in Physics, graduates will be able to:

- LEARNING GOAL 1.
  Demonstrate proficiency in the basic subfields of physics (classical mechanics, electromagnetism, quantum mechanics, statistical mechanics, and thermodynamics) as well as areas of application (e.g., solid state physics, astrophysics, etc).

- LEARNING GOAL 2.
  Construct and assemble experimental apparatuses, conduct and analyze measurements of physical phenomena, and make meaningful comparisons between experiment and theory.

- LEARNING GOAL 3.
  Apply 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.

A.2 Physics Major Learning Outcomes (PLOs)

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.

A.3 Physics Minor Learning Outcomes (PLOs)

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.

A.4 Astrophysics Minor Learning Outcomes (PLOs)

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.

A.5 Astronomy Minor Learning Outcomes (PLOs)

1. - **PLO 1.**
     Demonstrate mastery of the core concepts and general principles of astronomy.
2. - **PLO 2.**
     Conduct experiments and observations with the proper use of equipment for a detailed comparison with physical and astronomical models and theories.

A.6 Engineering Physics Minor Learning Outcomes (PLOs)

1. - **PLO 1 (a).**
     Demonstrate competent knowledge of the core concepts, principles, and applications of *electronics*.
   - **PLO 1 (b).**
     Demonstrate competent knowledge of the core concepts, principles, and applications of *computational 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.

B. Physics Department and Physics Major Statistics

B.1 Physics & Astronomy Department Student Credit Hours (SCHs)

PHYS-Physics

Student Credit Hour Trend

	Fall 2009	Spring 2010	Fall 2010	Spring 2011	Fall 2011	Spring 2012	Fall 2012	Spring 2013	Fall 2013	Spring 2014	Fall 2014	Spring 2015	Fall 2015	Spring 2016	Fall 2016	Spring 2017	Fall 2017
Lecture	1,792	1,500	1,768	1,536	1,476	1,572	2,064	1,836	2,036	1,580	2,044	1,452	2,092	1,812	2,048	1,832	1,496
Seminar	28	10	16	12	64	17		12	12		17	15	12			19	16
Independent Study		4	10	1	5	11	2		1	3	3	5	7	12	14		
Lab	0	0	0	0	0	60	0	0	0	56	0	40	0	64	0	0	0

Table 1: Physics & Astronomy Department Student Credit Hours (SCHs)

SCH per department per semester

	PHYS	BIO	CHEM	ENV SCI	ENV STUDIES	COMP SCI	MATH	KIN/ESS
Spring 2011	1545	3193	1509	736	368	1621	2992	
Fall 2011	1545	3492	1898	753	404	1844	3546	1829
Spring 2012	1660	3416	1710	646	958	1918	2859	2315
Fall 2012	2066	3595	2041	643	711	1838	4048	2070
Spring 2013	1848	3641	1803	507	698	1932	3486	2393
Fall 2013	2049	3838	2128	696	625	2183	4193	2043
Spring 2014	1639	3891	1895	601	914	2363	3068	2318
Fall 2014	2064	4179	2051	728	736	2708	4240	2336
Spring 2015	1512	4023	1749	777	849	2408	3379	2234
Fall 2015	2111	4021	2000	894	634	2814	4287	1904
Spring 2016	1888	4025	1793	823	627	2619	3386	2002
Fall 2016	2062	4028	2160	852	658	3068	4960	1894
Spring 2017	1851	4210	1804	764	775	2809	3391	1947
Fall 2017	1512	4338	2511	1158	930	3665	5231	1667

Table 2: Student Credit Hours (SCHs) of USF science departments for the last 7 years.

B.2 Number of Physics Majors—Timeline.

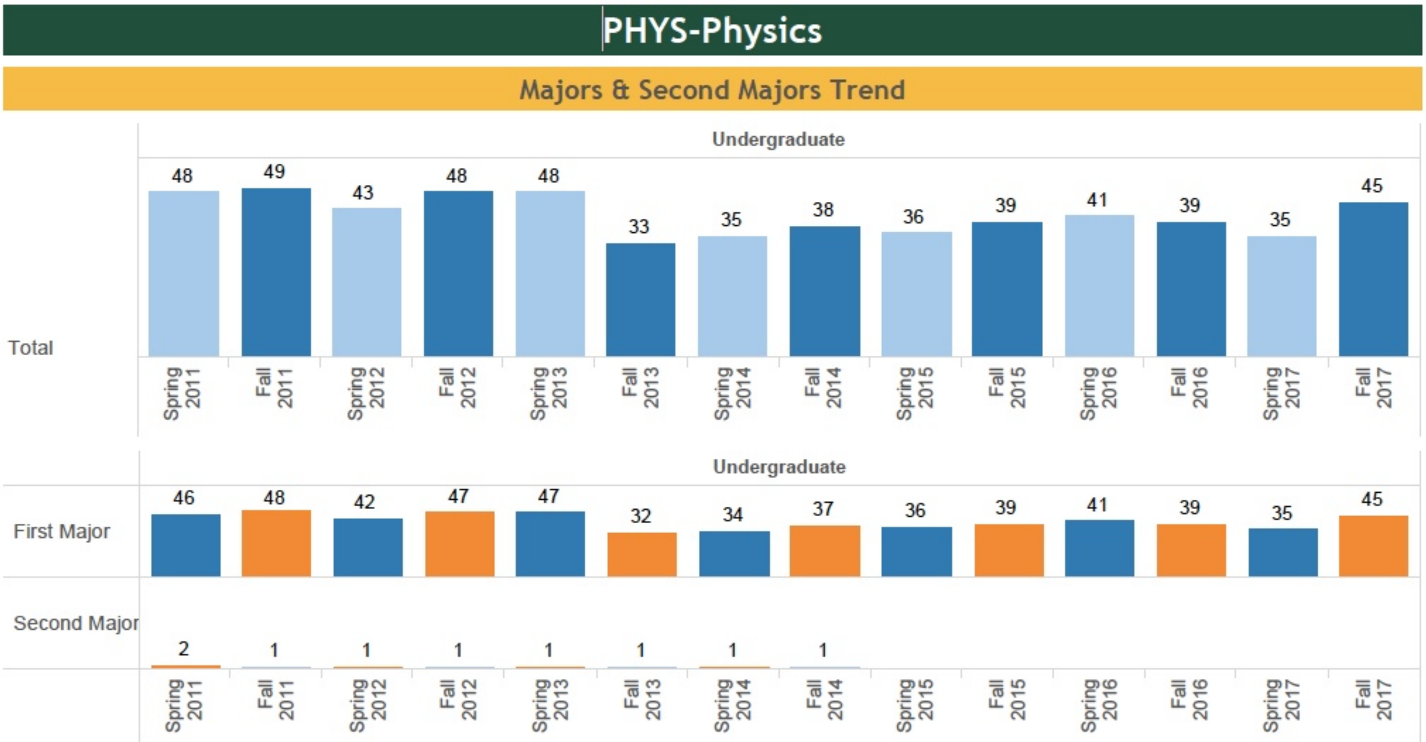

Table 3: Physics-Major count since Spring 2011.

B.3 Number of Physics Majors: Comparison within the Sciences—Timeline.

Number of Science Majors

	PHYS	BIOLOGY	CHEMISTRY	ENV SCI	ENV STUDIES	COMP SCI	MATH	KIN
Spring 2011	48	253	61	51	58	56	36	
Fall 2011	49	286	74	52	69	81	50	
Spring 2012	43	265	78	53	75	90	40	
Fall 2012	48	308	93	46	66	93	44	
Spring 2013	48	318	92	47	62	79	54	
Fall 2013	33	340	85	52	57	120	62	
Spring 2014	35	318	68	58	47	133	61	
Fall 2014	38	407	72	61	57	161	57	138
Spring 2015	36	371	61	64	55	164	49	189
Fall 2015	39	384	64	59	47	212	41	190
Spring 2016	41	343	51	61	47	197	42	187
Fall 2016	39	382	75	50	67	247	54	210
Spring 2017	35	348	76	56	69	231	54	183
Fall 2017	45	445	98	60	78	290	57	188

Table 4: Number of majors of all USF science programs since Spring 2011.

B.4 Number of Physics Graduates—Timeline.

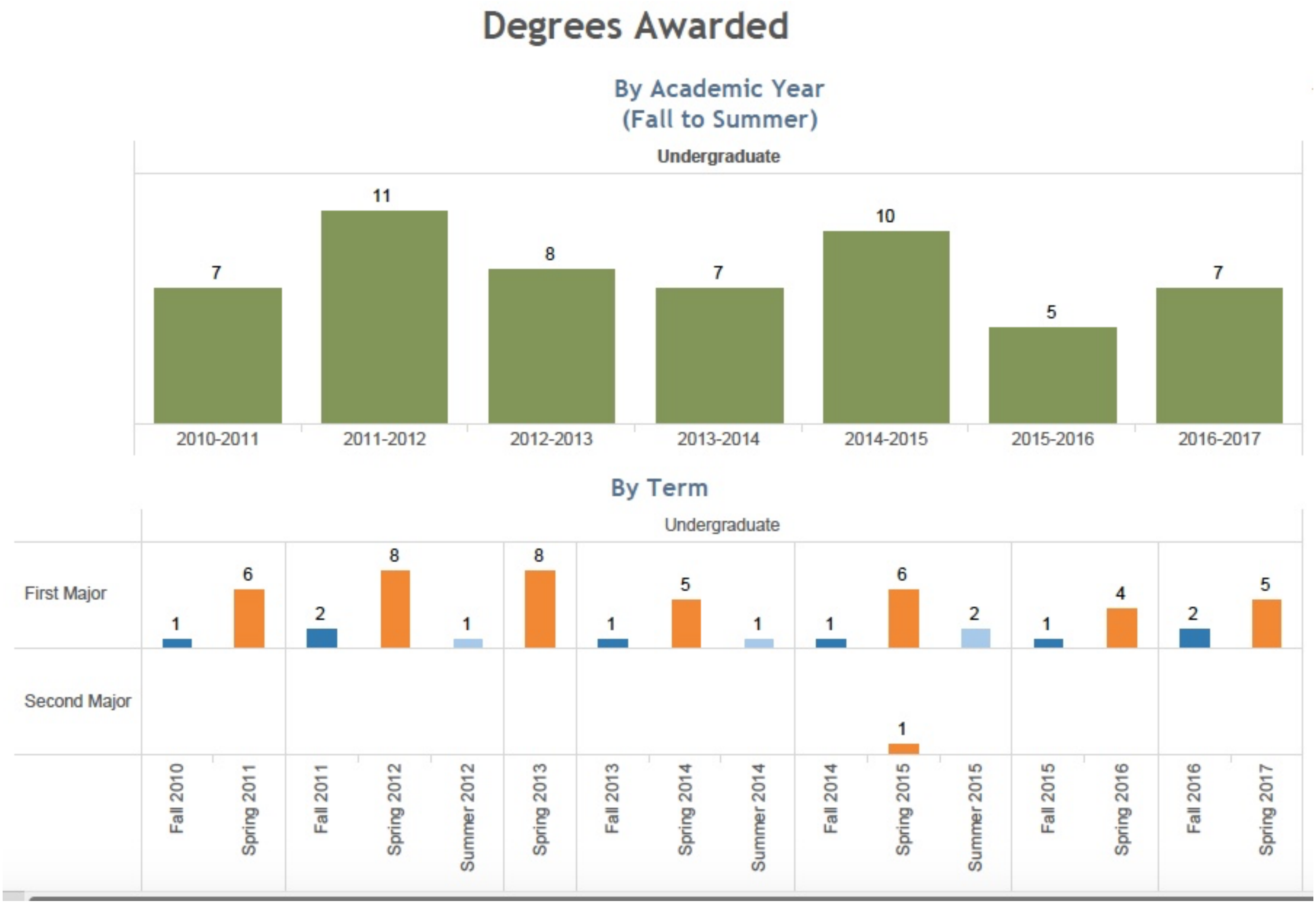

Table 5: Number of Physics graduates since academic year 2010-2011.

B.5 Changes of Major to and from Physics.

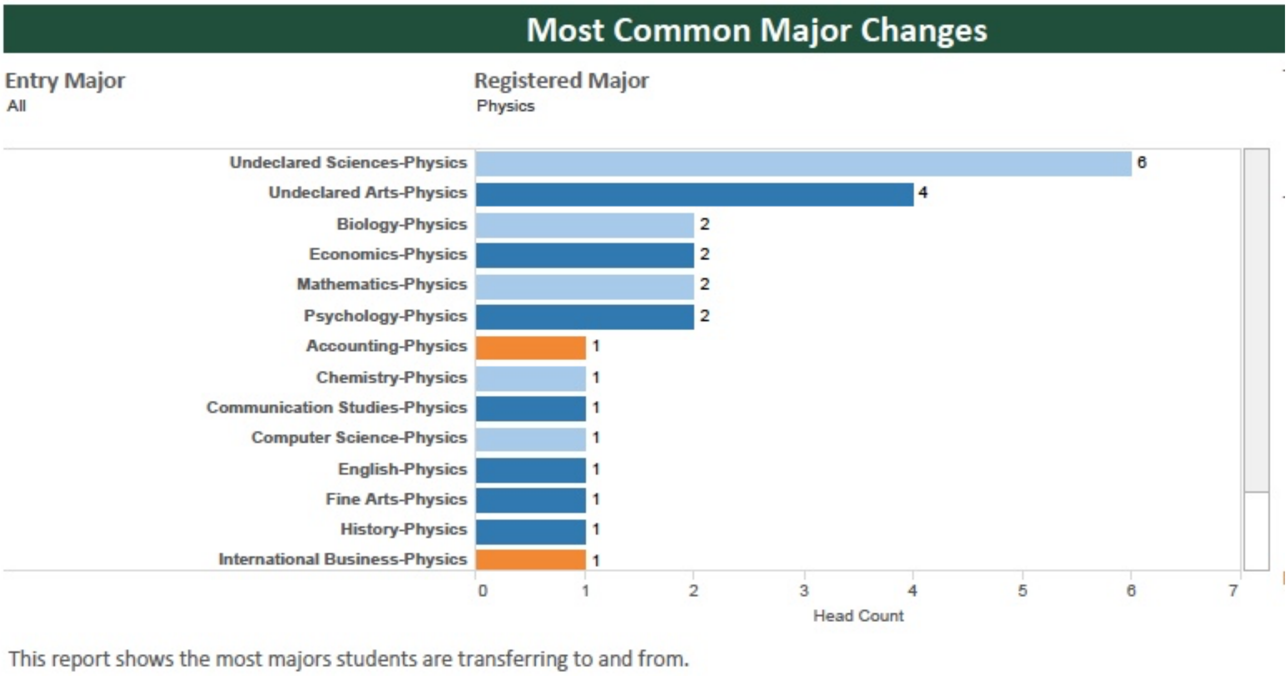

Table 6: Number of students changing major to Physics. The available data covers the period from Fall 2008 to Fall 2015.

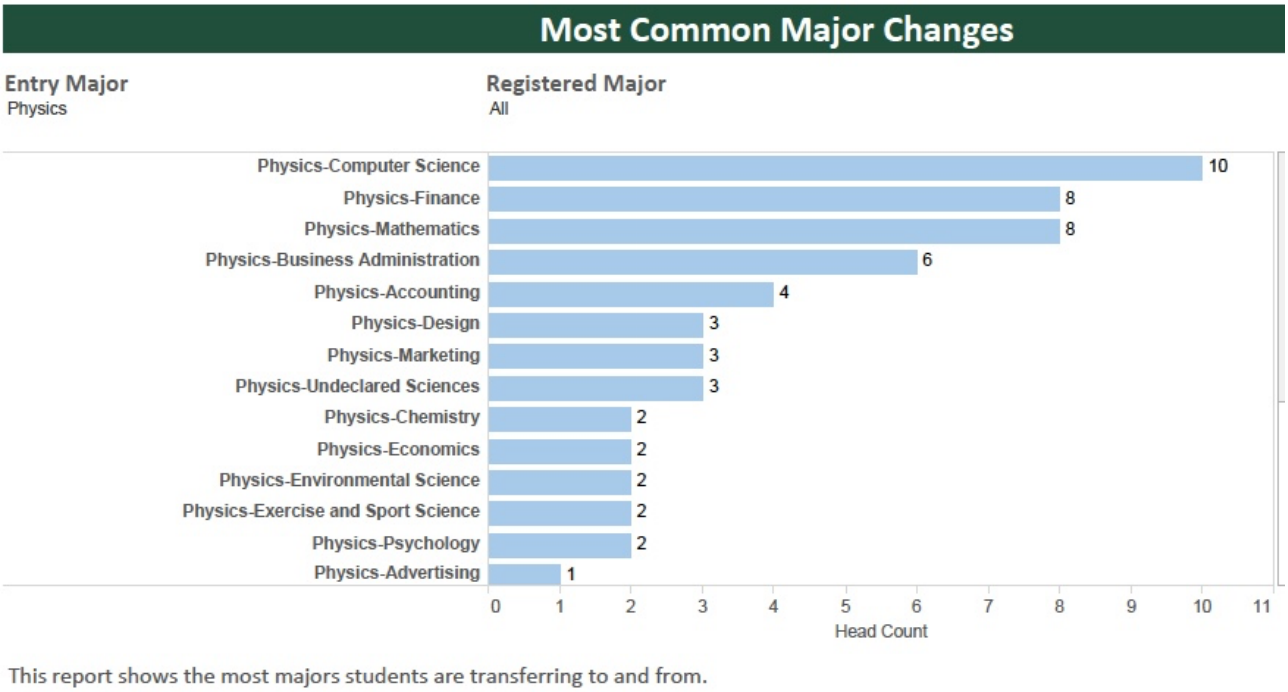

Table 7: Number of students changing major away from Physics. The available data covers the period from Fall 2008 to Fall 2015.

B.6 Physics Major Count by Gender.

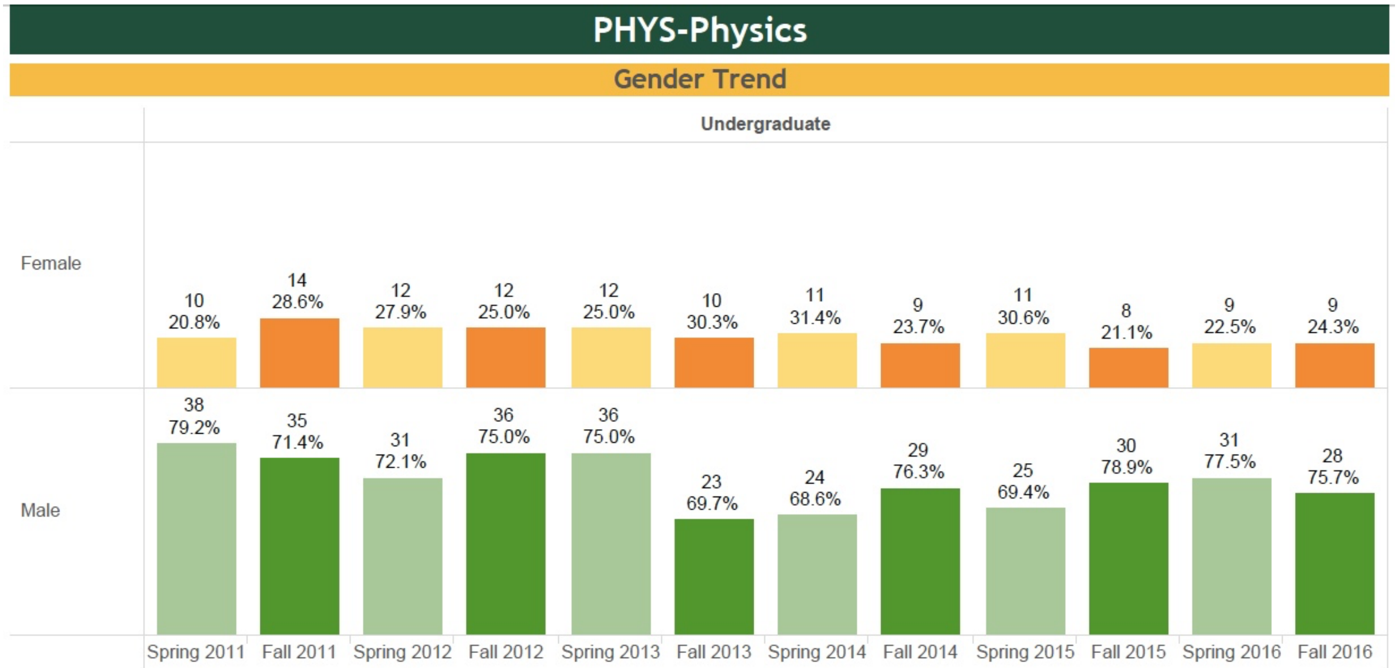

Table 8: Number of USF Physics Majors—Breakdown By Gender.