Department of Physics and Astronomy

Assessment Plan

June 2015

Assessment is a long-term process that allows departments and faculty members to ensure that our students are leaving our program with useful and marketable skills to become successful members of the scientific and general community. This document is provided as an outline for process to ensure this process is done in a meaningful and efficient manner.

Mission, Background, and Goals

Mission Statement

The mission of the major programs of the Department of Physics and Astronomy is to help our baccalaureate graduates attain the knowledge, skills and attitudes that are the foundation for success in Physics and related careers. More specifically, we support three broad groups of students: those who plan to attend graduate school in Physics, Astronomy or technical disciplines such as Engineering and Computational Science, those who seek technical industrial or laboratory employment, and those who intend to pursue a career in K-12 teaching.

Department Background

We have approximately 100 majors in four degree programs. Our BS in physics provides a rigorous physics background that is designed for students interested in pursuing graduate studies in Physics or Astronomy. The BS – Applied Physics Concentration is designed to prepare students for careers in high technology or for graduate school in related fields. The BA is a traditional "liberal arts" degree that provides a solid background in Physics, yet provides flexibility in the degree for students looking for a well-rounded education. The BA – Teacher Preparation Concentration is designed for those interested in a career in secondary education. About half of our graduates move on to graduate studies in Physics or a related field (most notably Electrical Engineering).

Student Learning Outcomes

The mission of the Department is highly aligned with the Sacramento State Baccalaureate Learning Outcomes. These are described in more detail in Appendix A. Specific to the nature of our programs, there are four learning outcomes that we desire our students to be highly proficient in upon graduation. While the relative weighting of these areas may vary between our degree programs, they are in fact common to all programs. For this reason, at this point, we do not see any reason to develop different outcomes for our degree programs.

- Physics Knowledge – Students will develop a broad understanding of the basic principles of Physics and have a firm foundation for acquiring new knowledge and applying it in a variety of situations. We desire our students to be well schooled in the theories and laws of Physics. In addition to classroom and laboratory experiences, all students in this program are required to attend a minimum of twenty physics colloquium where they are exposed to current research subjects in Physics and Astronomy as well as occasional talks on the history of Physics. We wish the future evolution of our curriculum to keep course content and laboratories as modern as feasible with available resources.

- Analytic Reasoning – Students should develop problem solving, critical thinking, and analytical skills and be able to learn new skills as needed. This is an especially important area since quantitative "critical thinking" is badly needed in all technical pursuits and a good Physics background is extremely effective in providing this. It is no accident that people with Physics training are found in every field in which the connection between mathematics and the real world is important. We make the students explicitly aware that the development of general analytical skills is at least as high a priority as the course material itself.
- Technical Skills – Students must be exposed to a broad range of technical skills and should become proficient in most. Not too many years ago there was a fairly large distinction between theorists (working with pencil and paper) and experimentalists (in the lab with equipment and instruments). This is not as true today. A theorist may be heavily involved in developing real-world simulations and an experimentalist will likely need to have to build their work on very complex models. Our students will develop proficiency in using a wide variety of instruments, tools, and software programs. Many will demonstrate advanced technical skills by participating in one of our Certificate Programs.
- Communication Skills – Scientists must be able to share their ideas and work with others in their field. The demands of such technical writing (and speech) are generally beyond the scope of the writing requirements as defined in the University General Education program. Very complex theories and experiments must be described in unambiguous terms often peppered with large amounts of mathematics and technical jargon. Large data sets, measured or theoretically generated, must be presented clearly and succinctly in tables and graphs. Scientists must also be able to effectively share their results in other forms, such as conference presentations and poster sessions. Our students learn about all of these modes of communication and gain experiences in them through their work in classes and Senior Projects.

Assessment Strategies

As noted in Appendix B, our previous Assessment Plan was rather holistic and based on the small number of majors that we had at the time (approximately 40). From the results of our 2009-10 Program Review and the 2011-12 Learning Outcomes Report, we've determined that we need a more data-driven and sustainable plan.

We will measure the effectiveness of our Programs and the Learning Outcomes as described below.

Systematic Assessment

We have historically found great value in our graduating senior and recent-alumni surveys. We will continue to do these to gauge the student/alumni perception of our programs as well as to provide us with information about experiences that have proven particularly useful in their careers or deficiencies that have been noted. We used to do our exit interviews in person, but with the increase in the number of graduates, this is proving to be a scheduling problem. We will now do this electronically. Each graduate will be sent a survey (Appendix C) within a month of graduation. Every five years, we will perform an alumni survey (Appendix D) for graduates 4 – 8 years from graduation. The Assessment Committee will review these surveys and issues identified by the Committee will be brought to the Department's attention.

Physics Knowledge

Graduating seniors will be asked to take the Major Field Test in Physics. This comprehensive physics examination is given by departments nationwide to assess physics knowledge. Student test results are compiled by ETS and will be returned to us along with data about comparable institutions. This data will help us identify areas in our curriculum that are proving ineffective. Due to the relatively small number of students taking the examination each year (~10), we will use multiple years to identify trends. We expect that our students will perform in the upper half of comparable (public, baccalaureate) institutions.

If a particular subject area is determined to be less effective than others, we will initiate a more specific investigation into the appropriate courses in an attempt to identify why the outcomes are not being met.

Analytic Reasoning

We have developed a rubric (Appendix E) to assess the analytical skills of our students. The rubric is designed to measure the problem solving, critical thinking, and numerical analysis skills expected of our majors. In the years that we collect data for this learning outcome we will request copies of the final exams of our core physics classes: PHYS 110, 135, 150, 151. We will also request copies of the "formal" lab report for students in PHYS 175. For students in the BA programs, the 110 and 135 exams are particularly useful as they are the highest level theory classes taken by these students. For those in the BS program, 150 and 151 are the highest level. PHYS 175 serves both audiences. We expect that students in the BA program will have average scores of "intermediate" or higher and the BS students will be "advanced" or higher.

Technical Skills

We have developed rubrics (Appendix E) for assessing the technical skills of our students, one for experimental skills, the other for computational skills. Students will be assessed in appropriate classes (115, 116, 145, 162, 163, and 175) during the years when this learning outcome is selected. We expect that, on average, students will be advanced in either experimental skills or computational skills.

Communication Skills

We have developed rubrics (Appendix E) for assessing the communication skills of our students. The rubrics examine written, oral, and data presentation skills. The rubrics will be applied by faculty in their review of Senior Project written and oral reports, as well as in the final written and oral reports in 175.

Implementation Timeline

Annually

Senior Exit Interviews

Students take Major Field Test

Rotating Schedule

Analysis of Physics Knowledge, Analytical Knowledge, Technical Skills, Communication Skills on staggered rotating plan; one per year.

Recent alumni survey, every four years.

As Determined Necessary

Detailed inquiry into Physics Knowledge subject area

General alumni survey

Appendix A: Baccalaureate Learning Goals and Us

Sacramento State Baccalaureate Learning Goals for the 21st Century
Competence in the Disciplines: The ability to demonstrate the competencies and values listed below in *at least one major field of study* and to demonstrate informed understandings of other fields, drawing on the knowledge and skills of disciplines outside the major. **Knowledge of Human Cultures and the Physical and Natural World** through study in the *sciences and mathematics, social sciences, humanities, histories, languages, and the arts.* Focused by engagement with big questions, contemporary and enduring. **Intellectual and Practical Skills, Including:** *inquiry and analysis, critical, philosophical, and creative thinking, written and oral communication, quantitative literacy, information literacy, teamwork and problem solving,* practiced extensively, across the curriculum, in the context of progressively more challenging problems, projects, and standards for performance. **Personal and Social Responsibility, Including:** *civic knowledge and engagement—local and global, intercultural knowledge and competence*, ethical reasoning and action, foundations and skills for lifelong learning* anchored through active involvement with diverse communities and real-world challenges. **Integrative Learning**, Including:** *synthesis and advanced accomplishment* across general and specialized studies. ***All of the above are demonstrated through the application of knowledge, skills, and responsibilities to new settings and complex problems.***

Figure 1: Sacramento State Baccalaureate Learning Goals from http://goo.gl/abfQDp

Our program has a very strong overlap with the Baccalaureate Learning Goals (BLGs). Our primary learning outcome, Physics Knowledge, aligns with the first two BLGs, Competence in the Discipline and Knowledge of Human Cultures and the Physical/Natural World. Physics majors are exposed to subjects that have been fundamental in the understanding the universe and the development of the modern world. They are exposed to contemporary research that is shaping our future. The third BLG is Intellectual and Practical Skills. By the very nature of studying physics, our students gain mathematical, computer, instrumentation, and problem solving skills that are not only useful in their professional preparation, but in all aspects of their lives. We emphasize the portability of such skills as they effectively constitute our second learning outcome. Our desire to develop communication skills in graduates also aligns with the third BLG.

The fourth BLG focuses on Personal and Social Responsibility. The process of doing science has significant ethical issues which are addressed in all of our laboratory courses. Students are held to rigorous ethical standards and are taught how to process the data that they collect appropriately. Most laboratory work is also done in groups, as in the “real world,” and students learn how to work with others. The final BLG is Integrative Learning. The majority of students graduating from our programs participates in an independent project, either through a Senior Project or in their advanced lab courses (PHYS 116 or 163). These projects give students the opportunity to identify a problem to study, perform an experiment, analyze the results of the experiment, and present the results. These projects tie together all of our learning outcomes and the Integrative Learning BLG.

Appendix B: Brief History of Assessment Activities

Our previous assessment plan was from January of 2008, and is based in large part on the 2001 plan. The changes in 2008 were intended to focus the plan on our academic program as a whole, and away from individual courses. This plan was used for all of our major programs. It was rather holistic and not very rubric driven; this decision was based on our very small numbers of majors that we had at the time. We put significant emphasis on Senior Exit interviews and evaluation of the Senior Project reports.

Since the development of the 2001 plan, we've made several significant changes to our programs. They are briefly summarized here.

- Created *Teacher Preparation Concentration* option for our BA degree to better prepare high school teachers.
- Created *Certificate in Scientific Instrument Development* and *Certificate in Scientific Computing and Simulation* to better prepare students for careers in academia and/or industry.
- Eliminated the languishing and unnecessary Physical Science BA degree program.
- Created PHYS 191, Senior Project, to provide a capstone experience for our students.
- Created PHYS 136 and significantly revised PHYS 156 to better prepare students for graduate studies in Physics.
- Updated PHYS 162 to reflect modern approaches to scientific computing and created PHYS 163 to teach more advanced computing techniques.
- Updated PHYS 115 and PHYS 116 to better reflect the current state of the art in electronics and instrumentation.
- Updated and standardized the PHYS 11-series curriculum to ensure adequate preparation of physics majors and students from Engineering and Chemistry that take this sequence.
- Standardized the curriculum of PHYS 106 to ensure uniform expectation of background of our students in the upper-division. We had found wide disparities in topics covered in this gateway upper-division course.

With the recent surge in the number of our majors, coupled with the desire by the campus and WASC to become more data driven, we have developed this new plan.

Appendix C: Senior Exit Survey

1. Why did you choose to major in Physics, and did your experience here fulfill your expectations that you had of your physics education?

2. What do you consider the greatest strength of our program?

3. What do you consider to be our greatest weakness?

4. What is your assessment of the Senior Project course, and did it give you a genuine experience of research and discovery?

5. Do you think the department sufficiently encourages engagement in physics related activities outside the classroom, for instance, seminars, read papers, field trips, things like that?

6. How do you feel the department has assisted you in learning programming, interfacing, and computation in general?

7. Do you think that the department does an adequate job encouraging student engagement in physics and astronomy, as the case may be, related activities through its student organization?

8. Rate three physics courses that you feel have been, or will be, most beneficial to you, and also, rate three which will be the least beneficial.

9. Was academic advising provided by the department adequate and helpful to you during your time here?

10. Did you take the GRE exam? If so, how well prepared were you for it?

11. Did our lab courses provide sufficient hands on experience?

12. Did you get enough help and guidance to obtain off campus work experience such as REUs, summer internships, and so forth?

13. How accessible and helpful did you find the faculty in the department?

Appendix D: Recent Alumni Survey

1. Internship, summer project, or senior project (P191) while @ Sac State Physics:

2. Current position/occupation:

3. Highlight your professional experience since graduation:

4. Generally, how would you rate the effectiveness of your physics education at Sacramento State?

5. How would you rate the effectiveness of our upper division laboratories?

6. How would you rate the effectiveness of our colloquium/seminar programs?

7. What would you consider as the main strength of your physics education at Sacramento State?

8. What would you consider as the main weakness of your physics education at Sacramento State?

9. What did you feel was most lacking in your physics background as you started working?

10. How would you assess the effectiveness of the Senior Project (P191)?

11. Did you have enough exposure to computer related skills while here?

12. Please comment on any other matter that you deem important.

Appendix E: Rubrics

Our rubrics for Analytic Reasoning, Technical Skills, and Communication Skills begin on the next page.

Analytic Reasoning

	Mastery	Advanced	Intermediate	Simple
	4	**3**	**2**	**1**
Comprehension of the Problem	Problem to be considered clearly understood and the student undertakes a clear strategy to solving the problem. Subtle details are clearly described and considered on how they affect the results.	Problem to be considered critically is stated, described, and clarified so that understanding is not seriously impeded by omissions.	Problem to be considered is stated by description leaves some terms undefined, unclear, or misunderstanding that can prevent fully solving the problem.	Problem to be considered is poorly addressed. Work takes student down a path that is unsuitable for the problem.
Mathematical Skills	The student shows a mastery of the mathematical techniques needed to solve the problem.	The student shows a very sound understanding of the mathematical tools needed to solve the problems at hand. Errors may exist but are generally not a significant issue in the understanding of the problem.	The student's mathematical work shows some regular difficulties in solving problems.	Student is unable to demonstrate an understanding of the mathematical scaffolding behind the physics problems they are facing.
Connection Between Physics and Mathematics	The student demonstrates that he/she has a complete understanding of how the mathematical results connect to the physical problem being examined. Any discrepancy between the two is clearly and thoughtfully explained.	The student understands the general idea of the connection between the mathematical results and the problems under examination. There may be some incomplete connections that prevent a masterful connection between the mathematical and physical model.	Student makes limited connections between the mathematical and physical world. There may be significant mistakes in the connection and interpretations may also be incorrect.	Student makes no or completely inappropriate connections between the physical problem and the mathematical results used in solving the problems.

(Continued on next page)

(cont)	**4**	**3**	**2**	**1**
Limitations of Analysis	Student clearly defines assumptions made in the model and/or mathematical approach to solving the problem. The implications of these assumptions are clearly described and there is an attempt to show how the inclusion of these subtle effects would change the results.	Student identifies some of the issues that could affect the results of the analysis. There may be little or no attempt to explain the effect of the assumptions on the analysis	Marginal attempt to discuss the accuracy of the model and the limitations of it. A simple acknowledgement that this is a model (without its limitations) is typical for this score.	No attempt to mention any assumptions made in the physical model used to solve the problem.
Accessing Information	Accesses reliable information from a wide variety of sources.	Accesses reliable information from a small number of sources.	Knows what sources of information are reliable	Determines when information is needed.

Technical Skill – Experimental

	Mastery	Advanced	Intermediate	Simple
	4	**3**	**2**	**1**
Use of equipment	Broad and appropriate use of equipment. Used safely.	Generally well used. Good choice of equipment, but perhaps not best possible use.	Not using equipment to potential or inappropriate choice of equipment for job at hand. Use may put equipment in harm's way.	Inappropriate use, unsafe.
Design of experimental apparatus	Student can independently design and use a multicomponent experiment using a variety of components to make a meaningful measurement.	With minimal assistance, student can design and use a multicomponent experiment using a variety of components to make a meaningful measurement.	With moderate assistance, student can design and use a multicomponent experiment using a variety of components to make a meaningful measurement.	Student is generally unable to design and use a multicomponent experiment to make a meaningful measurement.
Use of computer in running an experiment	Student can design appropriate software and hardware to control experiment and log data.	Student can customize appropriate software and hardware to control experiment and log data.	Student can use appropriate software designed by others and hardware to control experiment and log data.	Student cannot effectively use appropriate software or hardware to control experiment or log data.

Technical Skill – Computation

	Mastery	Advanced	Intermediate	Simple
	4	**3**	**2**	**1**
General Level Computer Skills (i.e. word processing, spreadsheets, illustrations, etc.)	Student can use standard computer software to put together compelling documents, reports, etc.	Student uses standard computer software reasonably well. Perhaps doesn't use to full potential or makes less than ideal choices to tackle some aspects of the documents and reports.	Software is used in a marginally effective manner. The way the software is used significantly impacts readability and effectiveness of the work.	Software is used very poorly and the quality of the work is completely hindered by it (even if the physics is done correctly).
Specialized Software (i.e. LabVIEW, C++, FORTRAN, Mathematica, etc.)	Student demonstrates high level under-standing of how software tools can be effectively used in solving technical problems. The "code" is clear, easily read, and understood by others.	The software is well used by the student to solve problems but may not be as easily used by others due to insufficient documentation or poor layout of the code.	The software is used to tackle solving problems, but there are gaps in the full implementation. May also be poorly documented and structured.	The software is ill-used and makes little contribution to solving of the problems at hand. Generally poorly documented and lacking in structure.

Communication Skills – Written

	Mastery	Advanced	Intermediate	Simple
	4	**3**	**2**	**1**
Physics Content	Uses appropriate and relevant physics concepts in a clear and compelling fashion to display mastery of a particular subject in physics. Mathematical work is elegant and easy to follow.	Uses appropriate and relevant physics concepts in a clear and compelling fashion to display or explain sophisticated and/or complicated ideas. Mathematical work is clear and easy to follow.	Uses appropriate and relevant physics concepts to develop or explain more sophisticated ideas. Mathematical work is understandable.	Uses appropriate and relevant physics concepts to develop or explain simple ideas. Mathematical work is confused and/or confusing.
Use of written language	Uses straightforward language that skillfully communicates meaning to readers.	Uses straightforward language that generally conveys meaning to readers.	Uses language that generally conveys meaning to readers, with occasional errors.	Uses language that sometimes makes it difficult to understand meaning.
Formatting of documents	Demonstrates successful use of a wide range of physics-specific conventions in written communication.	Demonstrates consistent use of physics-specific conventions in written communication.	Follows format, organization, and style expectations for the given writing task.	Attempts to use a consistent system for organizing and presenting written information.

Communication Skills – Oral

	Mastery	Advanced	Intermediate	Simple
	4	**3**	**2**	**1**
Conveying of Scientific Content	Scientific concepts are presented in a compelling fashion, with strong supporting evidence.	Scientific concepts are presented in clear, understandable fashion with supporting evidence.	Scientific concepts are presented in an understandable fashion.	Scientific concepts are presented in a confusing fashion.
Organization	An organizational structure is observed consistently through-out the presentation, and its use makes the content very coherent.	An organizational structure is observed consistently throughout the presentation.	An organizational structure is observed intermittently in the presentation.	No organizational structure is observed in the presentation.
Language and Delivery	Language choice and delivery are audience appropriate, and enhance the conveying of important ideas. Presenter appears confident.	Language choice and delivery are audience appropriate and support the conveying of important ideas. Presenter appears comfortable.	Language choice and delivery are understandable by the audience and do not interfere with the conveying of important ideas. Presenter appears tentative.	Language choice and presentation are inappropriate for the audience and obscure the significance of important ideas. Presenter appears uncomfortable.

Communication Skills – Visual Representation of Data

	Mastery	**Advanced**	**Intermediate**	**Simple**
	4	**3**	**2**	**1**
Presentation of data	Presentation of data in graphical, tabular, or image form enhances understandability through accuracy, elegant formal and effective labels.	Presentation of data in graphical, tabular, or image form is accurate, with appropriate format and labels.	Presentation of data in graphical, tabular, or image form is partly accurate but confusing in format, labelling, etc.	Presentation of data in graphical, tabular, or image form is inaccurate.