Learning Outcomes Summary

Program: Physics – Bachelor of Science

Department: Physics and Astronomy

Number of students enrolled in the program in Fall 2011: 54

Faculty member completing template: William DeGraffenreid   (Date: 1/29/2012)

Period of reference in the template: 2006-07 to present

1. Please describe your program’s learning-outcomes trajectory since 2006-07: Has there been a transformation of organizational culture regarding the establishment of learning outcomes and the capacity to assess progress toward their achievement? If so, during which academic year would you say the transformation became noticeable? What lies ahead; what is the next likely step in developing a learning-outcomes organizational culture within the program?

   Our current assessment plan was revised in 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. Our plan is used for all of our major programs, given the desired outcomes are identical. It is rather holistic and not very rubric driven. We have put a lot of emphasis on Senior Exit interviews and evaluation of the Senior Project reports that all BS students must complete as part of their degree program.

   Our current approach has for the most part been designed for a small number of majors. With the recent surge in the number of our majors, it has become clear that we need to augment our holistic approach with better structured, rubricated assessment instruments, especially in assessing the categories of Physics Knowledge and Analytical Reasoning. We look forward to working with the Office of Academic Program Assessment in developing a more rigorous, sustainable plan.

2. Please list in prioritized order (or indicate no prioritization regarding) up to four desired learning outcomes (“takeaways” concerning such elements of curriculum as perspectives, specific content knowledge, skill sets, confidence levels) for students completing the program. For each stated outcome, please provide the reason that it was designated as desired by the faculty associated with the program. [Please limit your response per outcome to 300 words or less]
a) Physics Knowledge

Students in this program 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 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.

b) Analytic Reasoning

In addition to Physics content, 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 reality is important. Here, it is important to make the students explicitly aware that the development of general analytical skills is at least as high a priority as the course material itself. We have identified three main focus areas in this outcome, namely theoretical, computational, and experimental physics. Not all courses lend themselves to all of these areas, but a student going through our program will have exposure to all of them.

c) Technical Skills

Physics 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. We strive to expose students to and develop proficiency in using a wide variety of instruments, tools, and software programs.

d) 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 as part of their Senior Project.

3. **For undergraduate programs only,** in what ways are the **set of desired learning outcomes** described above aligned with the University’s Baccalaureate Learning Goals? Please be as specific as possible. [Please limit your response to 400 words or less]

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. All students graduating from this program complete a Senior Project, a capstone experience that gives the students the opportunity to identify a problem to study, perform an experiment, analyze the results of the experiment, and present the results. The Senior Project requires both oral and written reports. The Senior Project ties together all of our learning outcomes and the Integrative Learning BLG.

4. **For each desired outcome indicated in item 2 above,** please: Describe the method(s) by which its ongoing pursuit is monitored and measured. Include a description of the sample of students (e.g., random sample of transfer students declaring the major; graduating seniors) from whom data were/will be collected and the frequency and schedule with which the data in question were/will be collected. Describe and append a sample (or samples) of the “instrument” (e.g., survey or test), “artifact” (e.g., writing sample and evaluative protocol, performance review sheet), or other device used to assess the status of the learning outcomes desired by the program. Explain how the program faculty analyzed and evaluated (will analyze and evaluate) the data to reach conclusions about each desired student learning outcome. [Please limit your response to 200 words or less per learning outcome]
(If the requested data and/or analysis are not yet available for any of the learning outcomes, please explain why and describe the plan by which these will occur. Please limit your response to 500 words or less.)

a) Physics Knowledge

The Physics Knowledge outcome is directly assessed in two ways, 1) analyzing exams and final course scores in upper division physics courses, and 2) analyzing examples of student work such as lab reports and journals, computational physics projects, and Senior Project reports.

For evaluating individual courses, instructors are asked to provide three exams from each course selected (on a rotating schedule), representing excellent, satisfactory, and poor performance. With names are redacted from the exams, the Committee reviews them to ensure that they properly reflect the required course content, and that the exams were neither too simple nor too difficult for the level of the course. Just as importantly, the Committee examines the student work for significant deficiencies in the core areas of physics, and recommends steps to be taken to remedy such shortcomings. The Committee also looks at the scores assigned to the students of the three examples to ensure that grading was fair and represented a real evaluation of the abilities of the students.

We do not currently have a specific rubric for evaluating physics knowledge. Our conclusions are based on the committee’s collective assessment of the work submitted. As stated above, we plan to develop a more structured process for evaluating this category.

b) Analytic Reasoning

Analytic Reasoning is directly assessed in two ways, 1) analyzing exams and final course scores in upper division physics courses and 2) analyzing examples of student work such as lab reports and journals, computational physics projects, and Senior Project reports. It is also indirectly assessed via Senior exit and alumni interviews.

As noted above, instructors provide name-redacted exams from each course, representing excellent, satisfactory, and poor performance. The sample student exams are studied by the Committee for evidence of mathematical reasoning and critical thinking. Exams are an excellent opportunity for this because the students are required to show their work, giving the Committee insight into their problem solving processes. When laboratory work is provided, the committee can readily assess the experimental and computation skills.

Given the size of our program, we have been able to have exit interviews [Appendix 1] with each of our graduates over the past five years. We send out alumni questionaries’ [Appendix
2] every half dozen years or so. Both surveys ask about the useful skills that the students acquired in their time at Sac State.

c) Technical Skills

Technical Skills are assessed by reviewing submitted laboratory work and Senior Projects reports (as applicable based on the nature of the project). By seeing how the wide variety of instruments and software used in their work is used while performing experiments, the committee is able to analyze how skillful they have become at using these tools.

d) Communication Skills

By reviewing the work submitted by our students, both the laboratory reports and Senior Project reports, we are able to assess the written communication skills of our students. Conclusions are based on the collective discussion of the faculty members on the assessment committee.

Oral presentation skills are assessed by reviewing the evaluation sheets [Appendix 3] provided by students and faculty at the talk that all students give as part of their Senior Projects.

5. Regarding each outcome and method discussed in items 2 and 4 above, please provide examples of how findings from the learning outcomes process have been utilized to address decisions to revise or maintain elements of the curriculum (including decisions to alter the program’s desired outcomes). If such decision-making has not yet occurred, please describe the plan by which it will occur. [Please limit your response to 200 words or less per item]

a) Physics Knowledge

Several years ago, our exit and alumni interviews indicated that our curriculum lacked breadth in the areas of classical and statistical mechanics. This led us to compare our programs to those similar to ours and we found that, at least in terms of material described in their catalogs, our graduates were at a disadvantage when preparing for graduate school. We developed a course (PHYS156) for our BS students that covers a range of advanced topics in both classical and statistical mechanics, rather than attempting to squeeze them into other courses. We now have more time to spend on the fundamental topics in the earlier courses (PHYS 110 and PHYS 124) and over the three semester series, a net expansion of topics covered. This course was added to the program at the expense of a required upper division elective.
Similarly, we noted that our students were not as prepared in the fundamentals of scientific computing as we would have liked. We had a Scientific Computing course (PHYS 162), but it lacked modern techniques. We revised the curriculum of this course and added a second semester elective course (PHYS 163) to further enhance our students’ skills.

b) Analytic Reasoning

In the review of Senior Projects and upper division laboratory reports, we noted several instances where error analysis was incomplete and/or incorrect. The instructors of courses where such material is taught were informed. As a result, the instructors adjusted the number of experiments required of the students and allocated more time to the teaching of this skill at the start of the semester and allowed more for students to apply these skills to individual assignments. The course instructors noted an immediate improvement in the quality of the individual lab reports in the first semester of these changes.

c) Technical Skills

Our analysis of the technical skills of our students has indicated that they are very adept at using the “tools of the trade” and that our instructors have kept the laboratories as well-equipped as possible given the resource challenges of recent years. Our senior exit interviews and alumni interviews indicated that our graduates’ technical skills were considered effective and appropriate by employers, both in industry and in graduate schools.

d) Communication

Several years ago, following an assessment analysis which called for improvement in the quality of student reports we began requiring an early review of the senior project report by the student’s mentor. The quality of writing has significantly improved with this additional layer of oversight.

6. Has the program systematically sought data from alumni to measure the longer-term effects of accomplishment of the program’s learning outcomes? If so, please describe the approach to this information-gathering and the ways in which the information will be applied to the program’s curriculum. If such activity has not yet occurred, please describe the plan by which it will occur. [Please limit your response to 300 words or less]

In 2010, we submitted a survey to our alumni. We received over 40 responses, of which approximately a dozen came from alumni in the past decade. Given the number of recent changes in our program, we focused on these.
The responses praised the introduction of our Senior Project (implemented in 2003). Those who completed Senior Projects found it to be an extremely valuable experience that reinforced the technical skills and physics knowledge learned in previous coursework. Those alumni who predated it, on the other hand, noted that they appreciated its introduction and felt it was very important.

A small number of respondents cited inadequate coverage of Physics topics in the curriculum as a weakness, especially for those students who go on to pursue a graduate degree in Physics. As noted earlier, similar comments had come out of our Senior exit interviews. We had, in fact, already developed our 156 class and 162-163 sequence in response to these previously raised concerns.

We will continue to survey our alumni in order to identify such long-term issues.

7. Does the program pursue learning outcomes identified by an accrediting or other professional discipline-related organization as important? Does the set of outcomes pursued by your program exceed those identified as important by your accrediting or other professional discipline-related organization? [Please limit your response to 300 words or less]

There is no accrediting body for physics programs. However, there is a remarkable consistency in the topics covered in physics programs. There is probably over an 80% overlap of upper division content in BS programs around the country. There is also a rather standard set of entrance requirements in physics graduate programs.

Most physics programs have a capstone research requirement, similar to our Senior Project. The American Physical Society has noted the importance of undergraduate research experience to the development of future physicists and suggests that departments provide such opportunities to their students.

8. Finally, what additional information would you like to share with the Senate Committee on Instructional Program Priorities regarding the program’s desired learning outcomes and assessment of their accomplishment? [Please limit your response to 200 words or less]

We are a small program of high quality with a very close knit group of faculty and students. Over the years, our program has evolved not just from suggestions from the Assessment Committee, but by casual, frequent, and productive discussions among our faculty members. As our faculty members are expected to be capable of teaching a wide variety of upper division courses, we are not “pigeon holed” into courses that become our sole domain. New ideas and techniques are frequently introduced as faculty members teach classes for the first time and courses maintain currency. Best practices are adopted and ineffective ones are abandoned.
We have had several significant program changes in the last decade to address issues that we felt were necessary to address. We created our Senior Project requirement, we have made our BS program more rigorous by adding two new required classes (at the expense of electives), reformed the curriculum of our gateway course (PHYS106), and we have significantly restructured our laboratory and computer courses (PHYS 115, PHYS116, PHYS175, PHYS162, and PHYS 163) to better prepare our students for graduate school or work in industry.
Appendix 1: Senior Exit Interview Questionnaire

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, 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?
Please respond to the following questions to the best of your knowledge and only if appropriate in your case.

Name (while @ CSUS):
Degree:
Years of attendance:

1. Internship, summer project, or senior project (P191) while @ CSUS 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.
SPEAKER EVALUATION FORMS

Presenter’s Name: ___________________________  Term: Fall 2011

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<tr>
<th>QUESTIONS AND COMMENTS</th>
<th>RANKING (Circle One)</th>
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<tr>
<td>1. Was the presentation well organized?</td>
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<td>2. Was the speaker clear and easy to hear?</td>
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<td>3. How well was the audience engaged by the presentation?</td>
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<td>4. Was the subject matter explained to you at an appropriate level?</td>
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<td>5. Did the presentation clearly exhibit the work that the speaker did on this project?</td>
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<td>6. Did the presentation exhibit evidence of background research on this subject?</td>
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Comments: