Attachment AA
Faculty Senate Meeting
May 17, 2012

Academic Program Review Report

Department of Physics and Astronomy

College of Natural Sciences and Mathematics

California State University, Sacramento

Spring 2012

Introduction

The Physics and Astronomy program is one of seven programs undergoing review in the 2009-2010 cycle and participated in a new pilot program for program review. Physics and Astronomy selected Option C, Focused Inquiry. The Physics and Astronomy self-study was divided into three parts:

- Overall program mission and goals; degree program information; and data on faculty, staff, facilities, and enrollment; changes, accomplishments, and challenges.
- Assessment efforts since 2001 when the department adopted its current assessment plan.
- Focused Inquiry of this self-study consisted of two parts: the Physics 5AB introductory sequence serving primarily health related majors, and the senior project which was introduced in Fall 2004.

Review Team Members:

Anne-Louise Radimsky, Computer Science Department (Chair)
Michelle Norris, Mathematics and Statistics Department
Tom Pyne, Philosophy Department
Maureen Smith, Kinesiology and Health Science Department

Documents Consulted:

The Department of Physics Self-Study, Fall 2010
The Department of Physics and Astronomy Program Review Report Summary, Spring 2003
The Department of Physics Assessment Plan, Revised January 2008
The Department of Physics Fact Book, 2010
Cognos Report provided by the department, Spring 2012
Report from the External Consultant Dr. Matthew Moelter
Physics Program Review Initial Response, April 23, 2012
Physics BS Learning Outcome Summary, Section 3 (from IPP document), March 2012

Persons Interviewed:

Department Chair:	Dr. Hossein M Partovi
Incoming Department Chair:	Dr. Bill DeGraffenreid
Faculty (tenured):	Dr. Vasili Sergan
	Dr. Jérôme Būrki
	Dr. Gary Shoemaker
	Dr. Christopher Taylor
	Dr. Vera Margoniner
	Dr. Tatiana Sergan

Office and Technical Staff: Ms. Heidi Yamazaki, ASC II
Mr. Robert Jolley, IST II

Students

Dean: Dr. Jill Trainer, College of Natural Sciences and Mathematics

External Consultant:

Dr. Matthew Moelter, Physics Chair, California Polytechnic State University, San Luis Obispo

Other:

Dr. Terry Underwood, University Assessment Coordinator
Dr. Sheree Meyer, Associate Dean for Undergraduate Studies

The review team wishes to thank all the people above who contributed to the success of this program review. In particular, the team acknowledges Heidi Yamazaki for researching and providing additional data.

Summary of Commendations and Recommendations

Commendations to the Department of Physics and Astronomy

1. The review team and the external consultant commend the faculty of the department for their recruitment efforts.
2. The faculty of the department is commended for their availability to the students and their willingness to include the students in their research.
3. The department is commended for its extensive use of laboratory courses.
4. The department is commended for its innovative use of certificates which provide the students with coherent packages and recognition of their accomplishments.
5. The department is commended for providing research opportunities to students which allow the students to participate in professional meetings.
6. The department is commended for incorporating a senior project requirement into its major curriculum.
7. The department is commended for its recruitment efforts which have led to a significant increase in the number of its majors.
8. The staff of the department is commended for its continued support for faculty and students, in spite of significant reductions in the staffing level.
9. The department is commended for its effective use of the Hu endowment to provide faculty support , student travel, and to acquire specialized equipment.
10. The department is commended for its consistent assessment activities and the implementation of the changes to address the problem that were identified as a result.

Recommendations to the Department of Physics and Astronomy

The Review Team recommends that the department:

1. Continue the successful efforts recruiting transfer students to increase and stabilize the number of Physics majors.
2. Request the University for an immediate tenure-track hiring.
3. Review the recent changes in the introductory sequences to scale back the size of the lectures, increase the number of discussion sessions while bringing back the size of both the discussion and the laboratory sessions.
4. Regularize the frequency and timing of course offerings.
5. Pay some attention to the current state of the demonstration facility in terms of technical support as well as organization and maintenance.
6. Incorporate the linkage between program outcomes and the Baccalaureate Learning Goals of the university into its Assessment Plan.
7. Develop metrics to evaluate the success of the program and the accomplishments of the students.

8. Assess student learning of specific topics by developing questions accompanied by rubrics for answers to be used on exams.
9. Examine Physics 5 series for content and pedagogy to develop a mode that afford coherence and consistency across sections.
10. Consider adding targeted study sessions or mathematics workshops instead of adding another introductory sequence.
11. Consider methods to assess the mathematical competence of incoming students in Physics 5A.
12. Examine the courses leading into the senior project to make sure that students have had the opportunity to practice designing and independently implementing investigations.
13. Review the current instructions given to the students in the capstone course to make sure that the expectations are clearly stated.

Recommendations to the Dean of Natural Sciences and Mathematics

The Review Team and the external consultant strongly recommend college support for the allocation of, at least, one additional faculty position to the department of Physics and Astronomy and that the college facilitates the search process.

Recommendations to the Provost

The Review Team and the external consultant strongly recommend that at least one additional faculty position be allocated to the department of Physics and Astronomy. "Less staff support, larger classes, active faculty, and a significant senior project have led to the faculty being overextended." (Moelter, p. 6). An additional permanent faculty is needed to allow the department to restore, in its introductory sequences, pedagogies which will facilitate student learning and increase their ability to meet the course standards.

Recommendations to the Faculty Senate

On the basis of this Program Review and the Department of Physics and Astronomy Self-study report, the Review Team recommends:

1. The Bachelor of Arts degree in Physics be approved for six years or until the next program review.
2. The Bachelor of Science degree in Physics be approved for six years or until the next program review.
3. The Bachelor of Art in Physical Science be approved for six years or until the next program review.
4. The Single Subject Teaching Credential in Physics be approved for six years or until the next program review.

General Information (Option C, Part 1)

Overview of the Department

The Department of Physics and Astronomy is housed in the College of Natural Sciences and Mathematics along with Biological Sciences, Chemistry, Geography, Geology, and Mathematics and Statistics.

The department offers the following programs:

- Bachelor of Arts in Physics (65-66 units)
- Bachelor of Arts in Physics with Concentration in Teacher Preparation (80-81 units)
- Bachelor of Science in Physics (74-75 units)
- Bachelor of Arts in Physical Science (76 units)
- Single Subject Teaching Credential in Physics
- Minor in Physics (21 units)
- Minor in Astronomy (18 units)
- Certificate in Scientific Computing and Simulation (14 units)
- Certificate in Scientific Instrument Development (11 units)

The degree programs account for approximately 10-15% of the teaching load. The department major responsibility is in teaching service and GE courses which together represent over 85% of the department teaching load. The service courses include primarily lower division physics requirements for science, engineering, and other disciplines. The GE offerings include six courses beyond those which also serve as service courses.

The department has graduated about 6 majors per year during the 2004-2010 period, primarily in the BS degree program as described in the table below:

Table 1: Degrees Awarded from 2004 to 2011

AY Year	BA Physical Sciences	BA Physics	BA Physics - Teacher Prep *	BS Physics	Physics Minor	Astronomy Minor
2010-2011		1	1	4	3	2
2009-2010		3	1	5		3
2008-2009		2		2	1	1
2007-2008				4	2	1
2006-2007				7	5	1
2005-2006		1		5		
2004-2005	1	1		6		
Total	1	8	2	33	2	8

** This program was only approved in 2008

This is larger than the national average of 3 a year for comparable institutions. The retention rates have improved in the last few years, especially for transfer students. A three-year old

recruitment effort has clearly resulted in a significantly increased interest in the Physics majors as indicated in the table below. The decline in the Physical Science major is, according to the department, due to the implementation of mandatory advising which highlighted the gross misunderstanding that many students had about physics in general and this major in particular and resulted in the majority of students switching to completely different majors.

Table2: Enrollment Figures in the Various Programs from Spring 2004 to Spring 2012

Semester	BA Physical Sciences	BA Physics	BA Physics -Teacher Prep**	BS Physics	Physics Minor	Astronomy Minor
Spring 2012	2	10	3	52		
Fall 2011	2	11	3	56	5	5
Spring 2011	3	5	3	35		
Fall 2010	3	7	3	34	6	6
Spring 2010	2	6	3	30	4	2
Fall 2009	4	9	1	36	7	1
Spring 2009	8	3	n/a	39	6	4
Fall 2008	8	3	n/a	39	6	4
Spring 2008	7	4	n/a	37	5	6
Fall 2007	14	8	n/a	23	5	9
Spring 2007	9	41*			4	8
Fall 2008	9	42*				
Spring 2006	5	40*				

* Prior to Fall 2007 the figures were not broken down for the programs offered by the department.
** This program was only approved in 2008

Commendation 1. The review team and the external consultant commend the faculty of the department for their recruitment efforts.

Recommendation to the Department 1. Continue the successful efforts recruiting transfer students to increase and stabilize the number of Physics majors.

Faculty

"The faculty comprises a group of well-qualified scientists with a broad range of interests and expertise. Faculty are active professionally and participate in both teaching and research" (Moelter p.1). Since the last review in Spring 2003 the department has seen many retirements, a significant reduction in the size of its faculty, and the hiring of a majority of the current faculty. It presently includes ten tenured and tenure-track faculty, two of whom are in the FERP program. A former member of the department has been administratively reassigned out of the department as Director of the Center for Teaching and Learning. In addition, the department currently employs seven part-time instructors. Since 2007-2008 the department has experienced a 40% decrease in WTUs with no change in FTES.

The sharp decrease in the size of the faculty has had some serious negative results. "The faculty is spread thin and is teaching larger courses with less support, supervising students, and engaging

in professional activities. Even as some courses have grown in size and there is less time in direct contact with students, yet the department has had to curtail the use of graders to assist with scoring student work." (Moelter, p. 5) Although the faculty is competent to teach additional courses important to students who wish to pursue advance studies, the lack of manpower precludes it. An unfortunate result of the decreased faculty size is the drastic changes in the mode of delivery of some of the introductory courses. Discussions sections have been replaced by lectures and the size of the laboratory sections have been increased, thereby reducing the interaction between faculty and students. The increased course size has occurred at a time when much less support has been available as half of the staff has disappeared and the availability of graders has diminished significantly. Although the faculty is very supportive of the students and active in their discipline, they are at this point stretched very thin. The material covered in the various courses, especially the service courses is regarded by the students as highly demanding and requires significant faculty consultation. In particular, in the largest service course offered by the department, the introductory sequence Physics 5AB supporting students in the biological and health sciences, the faculty in their focused inquiry identified the fact that "a number of students lack the mathematical background necessary to be successful." Similarly, the addition of the capstone course, reflecting a national trend and viewed as a significant improvement to the curriculum and the future success of the program graduates has to be covered as an overload.

All of these factors make additional calls on a faculty which is already overextended. An additional faculty position is crucial to the ability of the department to address these issues long term and to allow the department to restore, in its introductory sequences, pedagogies which will facilitate student learning and increase their ability to meet the course standards.

The service courses offered by the department relate to an important aspect of one of the Baccalaureate Learning Goals : "The ability … to demonstrate informed understandings of other fields, drawing on the knowledge and skills of disciplines outside the major." Physics is an especially demanding field requiring much higher than usual assistance on the part of the faculty to nurture student to master it. As stated in the University Mission statement: "… success is measured in terms of student learning. In addition, the University recognizes the vital connections between pedagogy and learning…" the current pedagogy the department has been forced into due to the reduced faculty size is not conductive to this goal.

Commendation 2. The review team and the external consultant commend the faculty of the department for their availability to the students and their willingness to include the students in their research.

Recommendation to the Department 2. Request the University for a tenure-track hiring, as soon as practical.

Recommendation to the Dean of Natural Sciences and Mathematics. The review team and the external consultant strongly recommend college support for the allocation of, at least, one additional faculty position to the department of Physics and Astronomy as soon as practical. In addition, it is recommended that the college facilitates the search process.

Recommendation to the Provost. The review team and the external consultant strongly recommend that at least one additional faculty position be considered a high priority for the department of Physics and Astronomy.

Curriculum

According to the external reviewer, Dr. Moelter, the physics curriculum provides course offerings and sequences similar to those typically found in undergraduate programs. Although the various introductory sequences are standard in general, the one exception is the Physics 5 A which was the subject of the focused inquiry by the department and will be discussed later. The upper-division courses are challenging and uphold high academic standards. The department has a greater selection of laboratory courses than might be typical and prides itself of the hands-on experience it offers to its students. The offering of two certificates is unusual and innovative and represents a valuable addition to the program. Since the last review a senior project has been added to the curriculum. This is a welcome addition to the curriculum which is in keeping with a recent emphasis in the national physics community and provides a capstone experience for students. Unfortunately, in recent years some required courses have been cancelled or postponed which has presented some difficulty for the students. Since the last review a senior project has been added to the curriculum. Recent changes in the mode of delivery of introductory sequences is cause for concern, going from (1 lecture – of 72 + [2 discussions + 1 laboratory] – of 24 each) to ([2 lectures + 1 discussion/lecture] – of 90 each + 1 laboratory – of 30). This has resulted in a significant reduction in the ability of students to directly interact with the faculty. According to the external reviewer "The need for discussion sections is critical in this introductory sequence so that students can engage difficult concepts, practice problem-solving skills, and get feedback. In addition, the student population for this course likely does not have strong quantitative skills and is in need of as much support as possible." (Moelter p.6). The increased size of the laboratory sections is also detrimental from both the standpoint of learning and the safety of students and faculty. As observed by Dr. Moelter "The current arrangement has 30 students in a laboratory section, which is too many. In most introductory experimental settings the largest a group can be, and still have effective student learning for all members, is three students. In a section of 30 students this would require 10 groups. With engaged students and even modest experimental complexity it is very difficult to "get around" to all 10 groups. In addition, there are likely some safety concerns with that many students in the same space that previously was used with groups of 24." (Moelter p.6)

Commendation 3. The department is commended for its extensive use of laboratory courses.

Commendation 4. The department is commended for its innovative use of certificates which provide the students with coherent packages and recognition of their accomplishments.

Recommendation to the Department 3. Review the recent changes in the introductory sequences to scale back the size of the lectures, increase the number of discussion sessions while bringing back the size of both the discussion and the laboratory sessions.

Recommendation to the Department 4. Regularize the frequency and timing of course offerings.

Students

The team and the external reviewer met with a group of students who lavished praise of the faculty for their accessibility. They felt that the laboratories were one of the strongest part of the curriculum. They indicated that the department provides good advising but would suggest that the initial orientation could be improved. In particular they felt that students should be strongly encouraged to take lower division courses in the major while still in lower division status. They indicated that the two certificates were extremely useful to work in industry. Although they liked the newly added senior project they felt that the requirements were not sufficiently clearly laid out and that, as far as the paper was concerned the rubric was vague and resulted in different instructors having different views on what was expected. The availability of research activities is particularly noteworthy. "Students are involved in projects and research on campus and at nearby UC-Davis, as well as in REU style summer internships on other campuses. As a result of these efforts they have attended professional meetings and presented posters. The students feel prepared to continue with graduate study or pursue employment in industry." (Moelter p. 2). The decrease in resources across campus has resulted in the cancellation or postponement of classes needed for the major, causing hardship for the students. "Current students and alumni both expressed the hope that the majors curriculum were more stable in terms of course offerings and their timing." (Moelter p. 2).

Commendation 5. The department is commended for providing research opportunities to students which allow the students to participate in professional meetings.

Commendation 6. The department is commended for incorporating a senior project requirement into its major curriculum.

Commendation 7. The department is commended for its recruitment efforts which have led to a significant increase in the number of its majors.

Staff

In the past, the department relied on 1.6 clerical staff positions supplemented by some student assistants. Since the last review a .6 clerical staff position has been eliminated. There is currently one administrative assistant (ASC II) who, among other things places hold on student records for lack of advising and adjust the schedule to meet the needs of the students. A recent example of such activity was the elimination of a conflict with a required Chemistry class.

Similarly, in the past the department had two full-time technical positions aided by two student assistants. One of the full-time positions has disappeared. There is currently one technical assistant IST II dedicated to the department. Additional technical support for electronics repair and IT is available at the college level. The primary focus is the lower division laboratories and the reduction in staffing has resulted in some backlog.

"Even with this significant decrease in total support staff capacity, they are contributing to the program and support the faculty and students in their teaching and learning. They are capable

and performing well and, given the constraints, doing a fine job. There appears to be strong working relationships amongst the staff, with faculty, and there is clear communication between staff, faculty, and students. " (Moelter p. 2). Unfortunately the reduction in staffing in both areas has placed additional responsibilities on the faculty, otherwise already overloaded.

> **Commendation 8**. The staff of the department is commended for its continued support for faculty and students, in spite of significant reductions in the staffing level.

Facilities

"At present the department seems to have adequate facilities available for teaching and learning as well as professional development. The department has the use of a reasonably well-equipped lecture hall (scheduled for some refurbishment) that includes a rotating stage and associated demonstration support area. The lab facilities for the introductory courses are typical and appear adequate except in those cases in which there are 30 students, which is likely too many. The lab spaces for the advanced courses are spacious and are equipped at a typical level and in some cases better than other schools. While there is some space for faculty professional development it is cobbled together from nooks and crannies here and there. However, if necessary, there appear to be some extra space that could, with some refurbishment, be transformed into suitable areas." (Moelter p. 2).

Although the teaching facilities were deemed generally more than adequate the demonstration facility was identified "…to need some attention in terms of technical support as well as organization and maintenance." (Moelter p. 6).

> **Recommendation to the Department 5.** Pay some attention to the current state of the demonstration facility in terms of technical support as well as organization and maintenance.

The Hu Endowment

Funded by the late physics professor Chien Hu this endowment funds specialized equipment, the department Colloquium Series, student travel, and a senior physics award (only awarded twice so far as it requires a perfect GPA). This has provided support for faculty supervision of senior projects . The student travel support has resulted in two students able to perform research at the CERN in Switzerland.

> **Commendation 9**. The department is commended for its effective use of the Hu endowment to provide faculty support , student travel, and to acquire specialized equipment.

Assessment (Option C, Part 2)

The department Assessment Plan was adopted in June 2001 and revised in January 2008. It defines a set of five learning goals for students majoring in Physics. It has identified areas of concern not only in curricular areas but also in advising, opportunity for undergraduate research, and program coherency. They have used student input in the form of a Student Assessment Committee and senior exit interviews. They have also solicited input from their alumni via a survey. To evaluate the coursework they have relied on review by the faculty of student work and grade distributions from a selection of required courses. The review team is pleased to see that the department has engaged in well-established assessment practices which have provided opportunity to make significant overall improvements to the program. Although the holistic approach adopted has provided significant insight into the programs learning goals, a more detailed analysis of the student performance on specific topics included in the overall performance would allow the program to identify potential areas of concern that, if addressed, would further strengthen the student learning experience.

The exclusive use of exams and course grades has some serious drawbacks. First, course grades often involve issues unrelated to the curriculum such as attendance and class participation. Furthermore, although exam grades may provide an overall evaluation that globally students achieve the intended course goals, they do not allow the department to identify detailed information about student performance on specific topics. This requires quantitative measures based on some defined metrics and focused on specific exam questions or other graded activities. The department should develop means to gather evidence which will answer the following question: "How many students understand this topic and at what level of understanding." Accordingly, the department should consider "…developing questions with answer rubrics for use on exams that can directly assess students learning of specific topics. This will provide detailed information about any areas that may need attention." (Moelter p, 9).

University Faculty Assessment Coordinator Terry Underwood recommended that a mapping of the core knowledge topics that students are expected to master and specific courses would be desirable. He also suggested the use of student portfolios which have the added benefit of involving students in providing evidence.

Associate Dean for Undergraduate Studies Sheree Meyer also suggested that the department connect their student learning goals with the university Baccalaureate Learning Goals (BALG). As part of the recent Learning Outcome Reports requested by the Provost this semester the department has demonstrated the strong correlation between its program outcomes and the BALG. Hopefully, this will be incorporated in the department Assessment Plan.

> **Commendation 10.** The department is commended for its consistent assessment activities and the implementation of the changes to address the problem that were identified as a result.

Recommendation to the Department 6. Incorporate the linkage between program outcomes and the Baccalaureate Learning Goals of the university into its Assessment Plan.

Recommendation to the Department 7. Develop metrics to evaluate the success of the program and the accomplishments of the students.

Recommendation to the Department 8. Assess student learning of specific topics by developing questions accompanied by rubrics for answers to be used on exams.

Focused Inquiry (Option C, Part 3)

The department chose to focus on two courses, the Physics 5AB sequence and the newly created capstone course Physics 191

Physics 5AB

This is the algebra-based introductory sequence serving primarily students majoring in biological and health-related disciplines and a number of other majors such as chemistry, business, and construction management. About 12 years ago that sequence was reorganized by a now retired faculty member to provide a more "active learning, student approach" to the delivery of the course. This was accomplished by using a format which included two three-hour discussion-laboratory (DL) sections of 24 students each which were held in a laboratory setting with appropriate equipment, and a one hour lecture involving all the sections and 72 students. An assessment of this new format made in the early years confirmed an enhanced student learning experience in the section taught by this instructor.

Since then the faculty member who was key to the reorganization as have those involved in the development and teaching with the new configuration. The number of students enrolled in the course has grown significantly. This course is currently by far the largest course taught by the department. In 2007 in response to budget pressure the format was modified to include two one-hour lectures and two two-hour DL sections. This resulted in a reduced amount of time devoted to laboratory activities. In addition class size has increased with now 30 students DL section, and 90 students lectures. The result of this evolution is that the course had drifted away from its original course plan and a lack of uniformity in teaching styles and practices. Currrently, 5A is taught in the lecture plus DL mode while 5B is taught in the traditional lecture, discussion, and laboratory mode. The department was interested in determining how well the two modalities in the 5A-B sequence are achieving their intended objectives as well as the possibility of the organization of a sequence in a single mode considering the limitation in available resources.

The inquiry was led by a committee of four, including the department chair, and relied on a detailed questionnaire intended for faculty with knowledge and involvement in the sequence. There was significant agreement on some of the issues: too much content, inconsistency among instructors, lack of coordination, uneven science and math background among the students, some of whom had an inadequate background, large class size in inadequately furnished rooms, lack of a good lab manual, not enough student engagement, and different instructors for DL and lectures. A number of recommendations were made :

- Promote and ensure student engagement.
- Promote effective communication among instructors.
- Strengthen the laboratory in 5A and develop a new manual.
- Consider reducing the materials covered in the sequence.
- Reduce class size for discussion and DL sections back to 24.
- Assess the student learning in the two courses.
- Require the first semester of either calculus sequence (Math 26A, or Math 30) for Physics 5A and create a new introductory sequence with current pre-requisite of high-school algebra for students not required to take calculus.

The external examiner expressed concern that another introductory sequence might create confusion and problems with scheduling, staffing and sequencing and suggested targeted study sessions or math workshops instead. The team also suggests that testing the mathematical background of students as a pre-requisite to Physics 5A might also be appropriate.

Recommendation to the Department 9. Examine Physics 5 series for content and pedagogy to develop a mode that afford coherence and consistency across sections.

Recommendation to the Department 10. Consider adding targeted study sessions or mathematics workshops instead of adding another introductory sequence.

Recommendation to the Department 11. Consider methods to assess the mathematical competence of incoming students in Physics 5A.

Physics 191

Physics 191, the senior project course was made a requirement for both the BS and BA degrees in 2004 to provide a capstone where students, drawing from the knowledge acquired in courses taken as part of the curriculum, would carry out a project of research and discovery, and to organize, compose, and report the results of their work. The department was interested to know how well this course was at serving its intended objectives. A focused inquiry was designed and carried out by a four-member committee including the department chair. It relied on a questionnaire given to faculty members with knowledge and involvement with the course, an alumni survey, and a senior exit interview to gather data. The responses were generally favorable but highlighted some problems most of them associated with a lack of initiative and responsibilities for the project on the part of the students. Based on those data the committee recommended that it be made clear that the students assumed the primary responsibility for the project. This entailed the choice of the project, the development of a timeline, and meeting deadlines. Although faculty members are available to provide guidance and encouragement "the students must be the primary owner and performer of their project." To that end the consultant and the team recommend that the department "Examine the courses leading into the senior project to be sure students have had the opportunity to practice at designing and independently implementing investigations." (Moelter p. 6). The department might also consider making the expectations of the course clearer to the students.

Recommendation to the Department 12. Examine the courses leading into the senior project to make sure that students have had the opportunity to practice designing and independently implementing investigations.

Recommendation to the Department 13. Review the current instructions given to the students in the capstone course to make sure that the expectations are clearly stated.