CALIFORNIA STATE UNIVERSITY EAST BAY

ACADEMIC SENATE

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COMMITTEE ON ACADEMIC PLANNING AND REVIEW
ANNUAL PROGRAM REPORT

College	CoS
Department	Physics
Program Unit	
Reporting for Academic Year	2014-2015
Department Chair	Erik B. Helgren
Date Submitted	6/19/2015

1. SELF-STUDY (about 1 page)

A. Five-year Review Planning Goals

The last Five-year review occurred in the 2010-11 academic year. The planning goals set forth at that time were:

1. Add Physics 2004 (Modern Physics) to Physics Major/Minor curriculum.
2. Modify Physics Major Mathematics Requirement: add Math 2305 (Calculus IV) and remove Math 4361 (Partial Differential Equations).
3. Capstone projects/class for Physics Majors.
4. Develop Seminar course.
5. Develop Engineering Physics Major.
6. Continue strong General Education offerings.
7. Review/re-design learning objectives and assessment.
8. Maintain a high quality, rigorous offering of physics classes.
9. Provide undergraduate research experiences for all interested majors.
10. Develop and implement a marketing plan for student recruitment.
11. Add TT faculty with specialty in Atomic Physics.
12. Invest in upgraded laboratory equipment for teaching and research.

B. Five-year Review Planning Goals Progress

1. Physics 2004 – "Modern Physics," a fourth quarter of the Introductory Physics curriculum has been successfully introduced to the Physics major and taught from 2011-2014, and has been both popular and successful in better preparing majors for upper division physics.

2. The changes to the Math requirements for the Major have been made; adding Math 2305 (Calculus IV) and dropping Math 4361 (Partial Differential Equations).

3. After review of the feasibility of the Capstone projects/course, we have decided to maintain our current Physics 4950 (Capstone) curriculum and allow individual students to complete “capstone-like” projects with faculty members as part of their informal research activities. The Physics 4950 Capstone class now plays a critical role in our summative assessment of physics majors, so we have decided not to re-design it into a project class.

4. We have secured a $100k endowment, to be fully handed over in the next year, for our Seminar series and have maintained a strong level of outside speakers for the Seminars, but have decided not to pursue conversion of the series into a course, in part due to the restrictions faced by the Department in regards to the 180 unit cap for all majors.

5. Instead of developing an Engineering Physics major, we have significantly revised the Physics BA and Physics Education BA, to facilitate attracting majors who are late deciders or those wanting to double major. Prof. Erik Helgren has developed, with the aid of a Chancellor’s Office Campus as a Living Lab grant, an engineering-focused Advanced Experimental Laboratory course to accommodate students from the Engineering Department. Furthermore we have worked in conjunction with the Engineering Faculty to offer more sections of Physics 3280 (Electronics) which is now a requirement for the Computer Engineering degree.

6. Our General Education course offerings have continued to have strong enrollment, and we have significantly upgraded our Physics 1800 and 1880 (Astronomy) courses and Physics 1700 and 1780 (Elementary Physics) courses. We have developed two new First year Learning Community courses (PHYS 1810: Astronomy of Ancient Cultures and PHYS 1410: Physics for Future Leaders).

7. We carried out a comprehensive review of our learning outcomes and assessment, developed new learning outcomes and a number of new assessment tools. Full implementation of our assessment plan was implemented in 2013-14, and the following assessment report summarizes this year’s results.

8. We have been able to maintain the rigorous nature and high quality of our Physics Major curriculum.

9. All interested undergraduate physics majors have been able to be involved in meaningful research projects with faculty, several leading to regional/national conference presentations and publications in peer-reviewed journals. Students have provided feedback that the participation in undergraduate research has led to successful internships at local national labs and in industry.

10. This year we worked with university partners to create a list of incoming freshmen who had passed the ELM at a high level and were undeclared. We contacted these individuals last summer and early Fall in order to promote the Physics major. We will continue our recruitment plan, and will implement a re-design of our Department website, during 2015-16.

11. Dr. Jennie Guzman was hired in Fall 2013, specializing in Atomic Physics experiments involving ultracold atoms. We are hiring two new faculty to start in Fall 2015. Dr. Amy Furniss specializes in Astrophysics research and is a member of the world-renowned VERITAS program. She earned her undergraduate degree in Physics at Humboldt State University and has now returned home to the CSU system. Dr. Ryan Smith specializes in using ultra-fast laser spectroscopy tools to study renewable energy materials. Dr. Smith, who was hired under the new Affinity Hire program, will be joining us from CSU Maritime where he has taught for the last few years.

12. With both significant investment from A2E2 and funds raised through teaching self-support courses, we have made major upgrades to laboratory equipment for teaching and research.

C. Program Changes and Needs

(a) Curriculum: In order to continue our progress toward meeting our Five-Year Review Planning Goals, during the 2015-16 academic year we will focus on (1) continuing to implement our mulit-year Assessment Plan (Goal #7) and (2) continue to address marketing and recruitment needs for our department which will include implementing our re-designed Department website (Goal #10).

(b) Resources: Our most pressing need is office and laboratory space for our new tenure-track faculty members and lecturers. We will continue to aggressively pursue internal and external resources for teaching and research.

2. <u>SUMMARY OF ASSESSMENT</u> (about 1 page)

A. Program Student Learning Outcomes

Students graduating with a degree in Physics will be able to:

A. Understand the fundamental principles of physics and be able to apply these core ideas to analyze physical processes;

B. Apply quantitative reasoning and critical thinking to solve complex problems, both theoretical and experimental in nature;

C. Independently learn new technical subjects and skills;

D. Design and assemble experiments, quantitatively analyze the results using appropriate statistical procedures and tests of systematic errors, and draw meaningful conclusions;

E. Effectively communicate scientific ideas, both theoretical and experimental, to diverse audiences through written and oral presentations, both formal and informal;

F. Work effectively and inclusively as a member of diverse collaborations to solve problems.

(curriculum map showing alignment of the Program Student Learning Outcomes and CSUEB Institutional Learning Outcomes is attached)

B. Program Student Learning Outcome(s) Assessed

All SLOs were assessed.

C. Summary of Assessment Process

See attached Assessment Report.

D. Summary of Assessment Results

See attached Assessment Report.

3. STATISTICAL DATA (about 1 page)

California State University, East Bay

APR Summary Data

Fall 2010 - 2014

Physics	Fall Quarter				
	2010	**2011**	**2012**	**2013**	**2014**
A. Students Headcount					
1. Undergraduate	20	28	31	31	30
2. Postbaccalaureate	2	1	0	0	0
3. Graduate	0	0	0	0	0
4. Total Number of Majors	22	29	31	31	30
	College Years				
B. Degrees Awarded	**09-10**	**10-11**	**11-12**	**12-13**	**13-14**
1. Undergraduate	2	4	2	4	6
2. Graduate	0	0	0	0	0
3. Total	2	4	2	4	6
	Fall Quarter				
	2010	**2011**	**2012**	**2013**	**2014**
C. Faculty					
Tenured/Track Headcount					
1. Full-Time	4	4	4	5	4
2. Part-Time	0	0	0	0	0
3a. Total Tenure Track	4	4	4	5	4
3b. % Tenure Track	40.0%	40.0%	40.0%	33.3%	23.5%
Lecturer Headcount					
4. Full-Time	0	0	0	1	0
5. Part-Time	6	6	6	9	13
6a. Total Non-Tenure Track	6	6	6	10	13
6b. % Non-Tenure Track	60.0%	60.0%	60.0%	66.7%	76.5%
7. Grand Total All Faculty	10	10	10	15	17
Instructional FTE Faculty (FTEF)					
8. Tenured/Track FTEF	1.7	3.3	2.8	2.4	2.9
9. Lecturer FTEF	2.7	3.1	3.4	4.9	4.8
10. Total Instructional FTEF	4.3	6.3	6.2	7.4	7.7
Lecturer Teaching					
11a. FTES Taught by Tenure/Track	61.6	77.9	90.0	53.3	56.0
11b. % of FTES Taught by Tenure/Track	34.7%	46.1%	42.1%	23.5%	26.5%
12a. FTES Taught by Lecturer	115.9	91.0	123.9	173.4	155.4
12b. % of FTES Taught by Lecturer	65.3%	53.9%	57.9%	76.5%	73.5%
13. Total FTES taught	177.6	168.9	213.9	226.7	211.4
14. Total SCU taught	2663.5	2534.0	3209.0	3401.0	3170.5
D. Student Faculty Ratios					
1. Tenured/Track	37.0	23.8	32.4	22.1	19.2
2. Lecturer	43.5	29.7	36.4	35.1	32.3

3. SFR By Level (All Faculty)	41.0	26.7	34.6	30.8	27.4
4. Lower Division	44.9	25.4	34.0	27.6	26.8
5. Upper Division	27.5	31.7	36.7	41.9	29.1
6. Graduate	.	.	.	.	.
E. Section Size					
1. Number of Sections Offered	30.0	40.0	39.0	44.0	44.0
2. Average Section Size	35.1	28.4	33.7	30.9	29.9
3. Average Section Size for LD	36.5	28.2	33.7	28.5	29.1
4. Average Section Size for UD	26.8	29.6	34.0	44.5	34.7
5. Average Section Size for GD	0.0	0.0	0.0	0.0	0.0
6. LD Section taught by Tenured/Track	11	15	13	9	8
7. UD Section taught by Tenured/Track	3	5	5	7	6
8. GD Section taught by Tenured/Track	0	0	0	0	0
9. LD Section taught by Lecturer	14	16	16	24	25
10. UD Section taught by Lecturer	2	4	5	4	5
11. GD Section taught by Lecturer	0	0	0	0	0

Source and definitions available at: http://www.csueastbay.edu/ira/apr/summary/definitions.pdf

DEPARTMENT OF PHYSICS 2014-15 ASSESSMENT REPORT

PHYSICS MAJOR LEARNING OBJECTIVES

During one of our summer Department meetings, we revised our Physics Major Learning Objectives (specifically D and F) based on our assessment of a few additional areas of need. In particular we added experiment construction, assessment, and troubleshooting to the skill areas for D and professionalism to the skill areas for F.

Students graduating with a degree in Physics will be able to:

A. Understand the fundamental principles of physics and be able to apply these core ideas to analyze physical processes;
B. Apply quantitative reasoning and critical thinking to solve complex problems, both theoretical and experimental in nature;
C. Independently learn new technical subjects and skills;
D. Design, **construct**, **assess** and **troubleshoot** experiments, quantitatively analyze the results using appropriate statistical procedures and tests of systematic errors, and draw meaningful conclusions;
E. Effectively communicate scientific ideas, both theoretical and experimental, to diverse audiences through written and oral presentations, both formal and informal;
F. Work **professionally**, effectively, and inclusively as a member of diverse collaborations to solve problems.

RESULTS

Pre- and post-instruction tests/surveys: (SLOs: A,B,C)

These exams give us a snapshot of the students' working knowledge in physics, conceptual understanding, and ability to efficiently solve problems. These exams are a core part of our assessment of our first three SLOs. Since the tests are nationally normed they enable us to make quantitative comparisons of our students' performance to that of students from other institutions.

A subset of the exams are given before and after instruction (at the beginning of the course and at the conclusion of the course) to provide a quantitative measure of student improvement during the course. The gain is calculated as the difference between pre- and post-instruction scores divided by the number of incorrect answers on the pre-test.

1. <u>Physics 1001 (Force Concept Inventory, FCI, a nationally normed assessment tool)</u>

The Force Concept Inventory (FCI) instrument is designed to assess student understanding of the most basic concepts in Newtonian physics. This forced-choice instrument has 30 questions and looks at six areas of understanding: kinematics, Newton's First, Second, and Third Laws, the superposition principle, and types of forces (such as gravitation, friction). Each question offers only one correct Newtonian solution, with common-sense distractors (incorrect possible answers) that are based upon student's misconceptions about that topic, gained from interviews.

	2014	2013	2012	2011
Gain between post- and pre-test:	56	27	30	31
Overall post-test score:	66	47	52	48

Studies have shown that in a traditional, well-taught lecture class, the FCI gain is measured to be around 20% while in a class employing a wide range of active engagement and peer-to-peer instruction techniques, the FCI gain can approach close to 50%.

For the overall post-test FCI score, the generally acknowledged threshold for understanding the material is an average of about 60%.

In 2014, the General Physics students were able to achieve an FCI gain of above 50% and a post-test average of above 60%, indicating successful learning compared to national averages. Some relevant factors in the improvement may have been the frequent use of peer-to-peer instruction activities (such as think-pair-share), implementation of weekly quizzes and reviews, and a reduction of material covered in order to focus more classroom time on core subjects.

2. <u>Physics 1003 (Brief E&M Assessment, BEMA, a nationally normed assessment tool)</u>

The Brief Electricity and Magnetism Assessment (BEMA) assesses what students know about the most basic and central concepts of the calculus-based introductory E&M course. It is comprehensive, covering topics from the Coulomb force law to magnetic induction, but omitting radiation because it is very common for the introductory course not to get that far. It has been used by various instructors in various settings and has been judged an appropriate and fair assessment of introductory E&M by physicists experienced in teaching E&M at various levels. It is not aimed at any particular curriculum but contains only those elements common to all calculus-based introductory courses.

	2014	2013
Gain between post- and pre-test:	14	29
Overall post-test score:	37	47

Studies have shown that in a traditional, well-taught lecture class, the BEMA gain is measured to be around 20% while in a class employing a wide range of active engagement and peer-to-peer instruction techniques, the gain can be above 30%.

For the overall post-test BEMA score, the generally acknowledged threshold for understanding the material is an average of about 60%.

3. <u>Physics 4001-4003 (Brief E&M Assessment, BEMA, a nationally normed assessment tool)</u>

The BEMA was also used to assess upper division students' knowledge of electromagnetism in Physics 4001-4003. The exam was administered at the beginning of PHYS 4001 and again at the conclusion of PHYS 4003 with the results listed below:

	4001-4003 ($3^{rd}/4^{th}$ yr)	1003 (1^{st} yr)
Gain between post- and pre-test:	15	22
Overall post-test score:	45	42

Of concern, we did not observe significant gains between the lower and upper division performance.

4. <u>Physics 2004 (Physics GRE-based assessment, Physics GRE-9277, nationally normed for students applying to graduate school)</u>

The Physics Graduate Record Exam (GRE) test consists of approximately 100 five-choice questions, some of which are grouped in sets and based on such materials as diagrams, graphs, experimental data and descriptions of physical situations. The aim of the test is to determine the extent of the examinees' grasp of fundamental principles and their ability to apply these principles in the solution of problems. Most test questions can be answered on the basis of a mastery of the first three years of undergraduate physics.

In Physics 2004, we use a subset of questions from the GRE test centered around topics that students should have familiarity with through the General Physics sequence (including Modern Physics, PHYS 2004).

Subject area breakdown:

Subject	2014 results	2013 results	National Average
Classical mechanics:	29	25	52
Electromagnetism:	11	18	48
Optics:	30	25	40
Thermodynamics:	18	19	52
Quantum:	25	18	45
Special relativity:	24	22	39
Laboratory methods:	23	19	39
Special topics:	9	38	39

Results were largely consistent from year-to-year.

5. Physics 4950 (Physics GRE-0177, nationally normed for students applying to graduate school)

The Physics Graduate Record Exam (GRE) test consists of approximately 100 five-choice questions, some of which are grouped in sets and based on such materials as diagrams, graphs, experimental data and descriptions of physical situations. The aim of the test is to determine the extent of the examinees' grasp of fundamental principles and their ability to apply these principles in the solution of problems. Most test questions can be answered on the basis of a mastery of the first three years of undergraduate physics.

In Physics 4950, our Capstone class, we use a complete GRE test covering all subjects in Physics.

Subject area breakdown:

Subject	2014 results	2013 results	National average
Classical mechanics:	20	24	51.6
Electromagnetism:	21	27	48.2
Optics:	15	20	39.8
Thermodynamics:	15	21	51.9
Quantum:	25	11	45.4
Atomic:	29	29	52.1
Special relativity:	0	9	38.8
Laboratory methods:	33	39	38.5
Special topics:	20	20	38.8

6. Comparison of Physics 2004 (2nd year) to Physics 4950 (4th year) results:

Subject	Physics 2004 (avg)	Physics 4950 (avg)
Classical mechanics:	27	22
Electromagnetism:	15	24
Optics:	28	18
Thermodynamics:	19	18
Quantum:	22	18
Special relativity:	23	5
Laboratory methods:	22	36
Special topics:	24	20

Of concern, here too we did not observe significant gains between the lower and upper division performance.

Summary of assessment results from nationally normed exams:

A Department goal is for our students to achieve at least the national average on all nationally normed exams. (This goal, in the case of the GRE exam, may be aspirational as we are comparing all our students to a subset of students who applied to graduate school in Physics.)

There are certainly some bright spots as we have achieved or have come close to achieving that goal for the Physics 1000 series, indicating that our General Physics instruction is successful and our teaching strategies are working.

However, the performance of our upper division students falls short of our goals, and in fact the performance of the 3rd and 4th-year students shows little improvement compared to the 1st and 2nd-year students. On the other hand, one should be careful about reading too much into the results as relatively few students (< 10) have taken the exams each year.

The Department held a meeting of the tenure-track faculty over the summer to "close the loop" and strategize on what improvements might be made to curriculum and teaching methods.

It was the continued opinion of the faculty that based on these results, physics majors overall were suffering from a lack of a fund of knowledge about physics and had significant weaknesses in conceptual understanding and problem solving skills that needed to be addressed.

The following strategies were suggested:

(1) Basic physics knowledge taught in the General Physics sequence (PHYS 1001-1003, PHYS 2004) would be emphasized throughout the upper-division curriculum by additional "basic" problems added on to homework assignments to give students extra practice at the basic concepts. This could be done without sacrificing the advanced instruction that is part of the present curriculum.

(2) We will move away from allowing note sheets on upper division exams to further emphasize learning and remembering physics concepts, relations, and problem solving strategies to improve students' fund

of physics knowledge. Weekly quizzes without notes could be a useful tool for reinforcing basic knowledge and problem-solving skills.

(3) We will increase use of in-class presentations of problem solutions and peer-to-peer learning strategies in upper division classes to further emphasize and practice accessing the fund of physics knowledge.

(4) We will emphasize throughout lower and upper division the "Prepare-Solve-Assess" strategy of problem solving.

(5) We will expand use of peer evaluation to help teach students how to evaluate their own work.

When converting to semesters, we are planning to offer three semesters of General Physics and a writing class, *PHYS 230: Physical Reasoning*, to further emphasize and review fundamental knowledge and problem solving skills.

Problem Sets and In-class Problems (individual & group, rubric-based assessment): (SLOs: A,B,C,E,F)

A core part of the Physics curriculum is learning to apply the concepts of physics to solve complex problems and present the solutions in written form, and sometimes in oral presentations. The problems are solved both individually and in groups. This core part of the curriculum, related to five out of our six SLOs, is evaluated with the following rubric.

Each problem is graded out of 5 points according to:

- ☐ **5** The student clearly understands how to solve the problem. Minor mistakes and careless errors can appear insofar as they do not indicate a conceptual misunderstanding.
- ☐ **4** The student understands the main concepts and problem-solving techniques, but has some minor yet non-trivial gaps in their reasoning.
- ☐ **3** The student has partially understood the problem. The student is not completely lost, but requires tutoring in some of the basic concepts. The student may have started out correctly, but gone on a tangent or not finished the problem.
- ☐ **2** The student has a poor understanding of the problem. The student may have gone in a not-entirely-wrong but unproductive direction, or attempted to solve the problem using pattern matching or by rote.
- ☐ **1** The student did not understand the problem. They may have written some appropriate formulas or diagrams, but nothing further. Or, they may have done something entirely wrong.
- ☐ **0** The student wrote nothing or almost nothing.

The Department goal is for students to achieve an average of 4.0 or better.

1. <u>Physics 2004</u>

The fourth problem set of Modern Physics was assessed, with the following results:

2014 overall performance: 3.8/5.0, which is close to our goal of 4.0, which means that the students understand the main concepts and problem-solving techniques (but still have some non-trivial gaps in reasoning).

Problem 1: 3.0/5.0 (On relativistic energy, most students understood but a few were confused.)

Problem 2: 4.0/5.0 (On four-vectors, all students scored > 3 and demonstrated basic understanding.)

Problem 3: 4.6/5.0 (On mass-energy relation, all students scored > 3 and demonstrated basic understanding.)

Problem 4: 3.4/5.0 (On relativistic acceleration, velocity addition – rocket problem – most students understood but a few were confused.)

2. <u>Physics 3302</u>

The first problem set of Quantum Mechanics II was assessed, with the following results:

2014 overall performance: 3.5/5.0, which equates to somewhere between partial and general understanding of how to solve the problems. This falls short of our goal, but the students definitely show promise working on long-form, complex solutions.

Problem 1: 4.2/5.0 (This was a fairly complex tutorial on Bell's inequality and entanglement, and everyone scored > 3, demonstrating basic understanding.)

Problem 2: 3.2/5.0 (On time-dependence of quantum states, coupled vs. uncoupled angular momentum – involved combining two concepts and caused some confusion.)

Problem 3: 3.5/5.0 (On addition of angular momentum, some confusion over magnitude vs. projection.)

Problem 4: 3.8/5.0 (Conversion between coupled and uncoupled angular momentum bases, expectation values. Generally good understanding.)

Problem 5: 2.9/5.0 (Addition of 3 spins. Extension of ideas from class, most people had right ideas but struggled to carefully carry out the multi-step solution.)

3. Physics 4002

The 7^{th} problem set from Electromagnetism III was assessed, with the following results:

Overall performance: 4.0/5.0, which is on target with our goal of 4.0, which means that the students understand the main concepts and problem-solving techniques (but still have some non-trivial gaps in reasoning). However, this score represents the average of the scores for students who turned in the homework and attempted the problems. Assigning zeros to every problem which students did not attempt or to students who did not turn in homework, the score is reduced to 3.4/5.0. (The assignment was 7 problems, and with 12 students in the class this corresponds to 84 problems to be graded; 22 of the 84 were assigned a zero for not attempting or not turning in – only one student received all zeros i.e. did not turn anything in). The faculty have found similar results across a number of lower and upper division courses, namely that students are turning in homework sets with some small to large fraction of the problems left "blank", i.e., they are not even attempting the problems. This problem and our proposed plan of action is discussed below in the Summary of assessment results from problem set rubrics.

Summary of assessment results from problem set rubrics:

Lower division students in PHYS 2004 and upper division students in PHYS 3302 and PHYS 4002 performed reasonably well on the long-form problem sets, close to our Department goal of a 4.0/5.0 average. Extra effort needs to be placed on presentation and complex critical reasoning to work through problems to their conclusion. This has been a point of emphasis for the Department, and there is significant peer-to-peer interaction and learning in the solving of problems.

Increased emphasis throughout lower and upper division courses on the "Prepare-Solve-Assess" strategy of problem solving should serve to improve the problem solving and presentation skills. Also the increased use of peer evaluation and oral presentations should further enhance student performance on problem sets.

Finally, as discussed above, a number of faculty have noted that students are turning in homework with some small or large fraction of the problems left "blank", i.e., they are not even attempting the problem. Word problems in Physics, especially in the upper division courses, are meant to be thought provoking, long-term exercises that take repeated efforts to make progress. They are not intended to be simply an exercise in "knowing the right answer" immediately or not. Real world complex problems take time and these problems are supposed to emulate that. Thus, as stated above, we have implemented a "Prepare Solve Assess" problem solving strategy guideline that students are encouraged to follow. The first step being simply to "prepare" i.e. write down the given problem, sketch a diagram of their interpretation of the problem, writing down known information and what needs to be solved for, would already constitute an "attempt".

After discussion with the faculty, we have agreed to implement a limited "Specification Grading" strategy in some of our upper division courses. One of our Learning Outcomes includes state that students are to "work professionally" and we have interpreted this to mean that a student graduating with a degree in Physics should know how to act professionally, e.g., do the work you have been assigned to do. The Specification Grading scheme will require students to attempt all the problems they have been assigned for homework.

Specification grading is a grading technique presented by Linda B. Nilson uses mostly pass/fail assignments. As one of our faculty commented, it is a little like the "merit-badge approach!" Students are given clear guidelines of what need to be accomplished and turned in and then if the assignment meets the criteria students pass. Rather than re-designing the entire grading scheme of our upper division courses, the Physics faculty agreed to use this threshold criteria technique for homework assignments specifically to address students' unwillingness to even attempt problems or turn in incomplete homework sets. The criteria we will set is that professors will only accept the homework and thus give a grade if the student has 1) turned in a complete homework set, i.e. attempted all the assignments, and 2) the homework looks professional, i.e., staples, problems follow the "Prepare-Solve-Assess" structure and are free of coffee stains.

<u>Experiment with Presentation, Lab Notebook write-up (rubric-based)</u>: (SLOs: A,B,C,D,E,F)

Another core part of the Physics curriculum is learning to apply the concepts of physics to carry out laboratory experiments, analyze data, and present the conclusions in written form and in oral presentations. The experiments are carried out in teams. Laboratory work, a point of emphasis for the Department, is related to all six of our SLOs, and is of central importance to developing practical skills of interest in graduate school and industry.

We employ a similar experiment, scaffolded in difficulty, at three different levels: Physics 1001 (the first course for majors), Physics 2004 (the 2^{nd} year level course), and Physics 3281/3283 a $3^{rd}/4^{th}$ year course. The goal of the experiment is to measure the acceleration due to gravity, and students are given increasing levels of independence and less guidance from faculty as their experimental skills increase.

A variety of aspects of experimental work are assessed on a scale of 0-5 using the following rubric:

5 = Complete, independent mastery;

4 = Solid performance but with minor misunderstandings, needed some guidance;

3 = Grasped basic idea and mostly understood but made some significant errors, needed significant guidance;

2 = Poor understanding, made many errors;

1 = Did not demonstrate competence;

0 = No effort in this area.

1. <u>Physics 1001</u>

Laboratory Notebook (goal is an average of 3.0 or above in each area):

Evaluation area	2014 results	2013 results
Understanding of physics principles:	3.5	N/A
Experimental design/procedure:	4.0	N/A
Quantitative reasoning, data analysis:	4.3	N/A
Critical thinking, systematic errors:	3.6	N/A
Effective communication:	3.3	N/A
Inclusive collaboration:	4.8	N/A
Draws meaningful conclusion:	3.2	N/A

2. <u>Physics 2004</u>

Laboratory Notebook and Class Presentation (goal is an average of 4.0 or above in each area):

Evaluation area	2014 results	2013 results
Understanding of physics principles:	4.3	3.5
Experimental design/procedure:	4.2	3.0
Quantitative reasoning, data analysis:	3.6	2.6
Critical thinking, systematic errors:	3.7	1.9
Effective communication:	4.0	3.6
Inclusive collaboration:	4.8	4.5
Draws meaningful conclusion:	3.2	2.3

3. <u>Physics 3281/3283</u>

Laboratory Notebook and Class Presentation (goal is an average of 4.5 or above in each area):

Evaluation area	2014 results	2013 results
Understanding of physics principles:	3.6	3.9
Experimental design/procedure:	4.1	4.3
Quantitative reasoning, data analysis:	3.5	3.7
Critical thinking, systematic errors:	3.3	3.9
Effective communication:	4.2	4.7
Inclusive collaboration:	4.5	4.5
Draws meaningful conclusion:	3.6	4.3

Comparison between levels:

Laboratory Notebook and Class Presentation (goal is an average of 4.5 or above in each area):

Evaluation area	PHYS 1001	PHYS 2004	PHYS 3281/3
Understanding of physics principles:	3.5	4.3	3.6
Experimental design/procedure:	4.0	4.2	4.1
Quantitative reasoning, data analysis:	4.3	3.6	3.5
Critical thinking, systematic errors:	3.6	3.7	3.3
Effective communication:	3.3	4.0	4.2
Inclusive collaboration:	4.8	4.8	4.5
Draws meaningful conclusion:	3.2	3.2	3.6

The assessment indicates that in the area of experimental techniques, laboratory notebook write-up, group collaboration, critical thinking and data analysis, and presentation our students are performing reasonably well, but once again the data shows there is not significant improvement from year-to-year.

Many areas where students are below target relate to the students' deeper understanding of the physics involved in the experiments, a weakness reflected in part on the students' performance on the Capstone GTE Exam (PHYS 4950) assessment. This again indicates further work is required to help our students meet SLOs A, B, and C.

SUMMARY

During the 2012-13 academic year the Physics Department developed new Physics Major/Minor SLOs, a new Assessment Plan, and a Curriculum Map. In 2013-14 the Department refined these assessment tools. These efforts were essential in clarifying what we expect of our students and what the focus of our curriculum should be. Our Assessment Plan was only partially implemented in 2012-13, and in 2013-14 we have nearly fully implemented the plan. In 2014-15 we have fully implemented our Assessment Plan, providing annual assessment of all our SLOs.

Based on our 2015 Department Assessment and Curriculum Meeting we modified Physics Major SLOs (D) and (F) to include experiment construction, assessment, and troubleshooting to the skill areas for D and professionalism to the skill areas for F.

Our overall assessment of the Physics curriculum is that our students appear to generally be achieving success in meeting SLOs (D), (E), and (F), while they are falling short of our Department's goals for their performance related to SLOs (A), (B), and (C).

During our 2015 Department Assessment and Curriculum Meeting, we identified several areas to focus on with regards to SLOs and assessment during the 2014-15 academic year.

It was the opinion of the faculty that based on these assessment results, the students overall were suffering from a lack of a fund of knowledge about physics and had significant weaknesses in conceptual understanding and problem solving skills that needed to be addressed.

The following plans were adopted:

(1) Basic physics knowledge taught in the General Physics sequence (PHYS 1001-1003, PHYS 2004) would now be emphasized throughout the upper-division curriculum by additional "basic" problems added on to homework assignments to give students extra practice at the basic concepts. This could be done without sacrificing the advanced instruction that is part of the present curriculum.

(2) We will phase out use of note sheets on upper division exams to further emphasize learning and remembering physics concepts, relations, and problem solving strategies to improve students' fund of physics knowledge.

(3) We will increase use of oral exams and in-class presentations of problem solutions, and peer-to-peer learning strategies, to further emphasize and practice accessing the fund of physics knowledge.

(4) We will continually emphasize throughout lower and upper division the "Prepare-Solve-Assess" strategy of problem solving.

(5) We will expand use of peer evaluation to help teach students how to evaluate their own work.

(6) We will establish Specification Grading style criteria for homework assignments in some upper division courses to encourage students to turn in fully-completed and professional looking homework sets.