<u>Institutional Effectiveness Report</u>

Name of Program/Department:	**Physics, Industrial Engineering/Physics and Astronomy**
Year:	**2017-2018**
Name of Preparer:	**Joe H. Mehaffey**

Program Mission Statement

The mission of the Department of Physics and Astronomy is to provide a quality background in the principles of physics and health physics that will result in our graduates being well prepared for careers in industry and scientific research or for graduate school. Additionally, the department supports the University's general education goals by providing all students with an exposure to the fundamental natural laws of the physical universe and to the methods of scientific inquiry.

<u>Computational Physics and Health Physics</u>

Program Learning Outcomes

The department seeks to produce Computational (CP) and Health Physics (HP) graduates who

1. possess a thorough understanding of the physical principles on which the universe operates.
2. can apply physical principles in solving problems related to the physical world, which includes using computers to model physical systems and processes (CP).
3. are experienced in research activities, including the interpretation and communication of results.
4. possess a thorough understanding of the types, sources, detection, and measurement of ionization radiation, the biological effects of such radiation, and of the methods of reducing human exposure (HP).
5. recognize the importance of intellectual honesty, professional ethics and personal integrity in the pursuit of knowledge and personal goals alike.

Executive Summary

In regard to the introductory courses and the assessment of basic physics concepts, an increased emphasis has been placed on certain aspects of Newton's Laws of Motion and the vector nature of acceleration. The established benchmarks were met and significant student improvement was demonstrated. A laboratory experiment has been modified which should help address any related deficiencies. In the Physics 202 course, a pre-instruction/post-instruction test has been implemented to assess fundamental concepts of electricity and magnetism. Preliminary results suggest significant gains in student

performance, but the post-instruction results still fell short of the 75% benchmark for each tested item.

In the upper level courses, students demonstrated in both direct and indirect assessments that they were both competent and at least fairly confident in their technical and computational skills and in their preparation for future endeavors. One student suggestion was that we consider offering an additional course in Quantum Mechanics.

Concerning the Industrial Engineering program, assessment activities follow the ABET guidelines as the program works toward accreditation. Of the eleven criteria (SLO), student performance met all of them: a significant improvement over the previous year's results. The Industrial Engineering faculty did note that improvements might be sought in the areas of 'student understanding of professional and ethical responsibilities' and with 'demonstrating effective communication skills'. Strategies to improve these outcomes are being considered.

For the General Education courses, an assessment of the students' experimental skills and their interpretation of experimental results can be found in the appropriate attachment. While noticeable improvement is demonstrated in the pre/post test of each item, students still have trouble reaching the benchmark of 75%, most notably in the areas of 'curve-fitting" based on experimental results and with the concepts of random and systematic experimental errors. Modifications of instruction and experimental design have been implemented in an attempt to address this problem.

Student Learning Outcomes (Physics)

SLO#1.0: Students will demonstrate knowledge of introductory physics concepts.
Baseline performance: Students in Physics 201 will, on average, answer 70% of the post-test questions correctly in each category.

SLO#2.0: Students will demonstrate knowledge in upper-level physics concepts.
Baseline performance: 90% of students will demonstrate gains in post-test scores given at the end of PHYS 418 and PHYS 406 compared to pre-tests administered at the start of PHYS 316 and PHYS 306.

SLO#3.0: Students will be able to use modern laboratory techniques to measure and analyze experimental data.
Baseline performance: 90% of our graduates will indicate on an exit survey that they feel very competent or fairly competent with regard to their laboratory skills.

SLO#4.0 Students will be able to competently present technical information via both oral and written communication.
Baseline performance: 90% of the students in Physics 419, and will receive a score greater than 80/100 based on a faculty assessment of their oral presentations.

SLO#5.0 Students will demonstrate competency in physics-relevant computer skills.
Baseline performance: 90% of our graduates will indicate on an exit survey that they feel very competent or fairly competent with regard to their computational skills.

SLO#6.0: Students will have an appreciation for physics including its significance and practical relevance.
Baseline performance: Greater than 70% of the responses given by our graduates on the Colorado Learning Attitudes About Science Survey will be "expert-like".

SLO#7.0: Students will be prepared for a career or further study upon completion of the program.
Baseline performance: 90% of our students will indicate on an exit survey that they feel very competent or fairly competent as to how well they think the program has prepared them for a career or further education after college.

SLO#1 Students will demonstrate knowledge of introductory physics concepts.

A short pre-test concerning Newton's Laws of Motion and the concept of acceleration was administered to 22 students in Physics 201 followed by a post-instruction test later in the semester. The percentage of correct responses increased from 45%, 14%, and 64% on the pre-test to 94%, 77% and 94%, respectively. These results demonstrate a dramatic improvement in student performance by the end of the course. The established benchmark for this item was met or exceeded. More detailed information is presented in the accompanying attachment.

SLO#2 Students will demonstrate knowledge in upper-level physics concepts.

Assessment of this SLO proved to be problematic for this academic year. Due to low enrollment, PHYS 318 (Environmental Radiation Physics) was not offered this year and PHYS 418 (Practical Applications of Health Physics) had but one student. Additionally, PHYS 306 (Computational Physics) has been deleted from the department's course offerings. As a substitute, a computer-based mini-project was administered with the PHYS 406 (Advanced Computational Physics) course and temporarily serves as our only assessment of these criteria. For the computational physics assessment, a similar computer-based project is now being given in PHYS 220 (Computational Methods for Physics and Engineering) and will serve as a pre-test for these same students, but last year's class would not have benefited from this recently revised plan.

The faculty members responsible for these courses are aware that for the last couple of years students demonstrated deficiencies in the areas of numerical assessment and code implementation, though last year's group contained a small sample size of 2 students. It is anticipated that the next student group will show the gains expected from an increased emphasis on these topics earlier in the curriculum.

Given that the assessment for this item involves courses taken early and later in the students' program, data is pending.

SLO#3 Students will be able to use modern laboratory techniques to measure and analyze experimental data.

The ability of students to connect a fairly simple electric circuit containing resistors in parallel was measured in the PHYS 202 Laboratory. This activity included the insertion and proper use of a meter to measure the electric current delivered to a specified resistor. This assessment took place after the students performed experiments in the lab dealing with DC circuits. It was disappointing that only 36% of the students could accomplish this task. One possible explanation for this outcome is that students routinely work in pairs, and that perhaps one student took the lead role in circuit construction. Current data is pending for this item.

On an exit survey, both of the graduating seniors indicated that they felt very competent in their acquired experimental skills. The department has also begun to develop a list of recent graduates that includes contact information so that we may ask similar questions of them in the future (2 and 5 years post-graduation, for example). It is felt that this survey may be even more meaningful than the exit survey, assuming an adequate response rate.

SLO#4.0 Students will be able to competently present technical information via both oral and written communication.

Due to the small number of graduates this year, we were not able to use the Physics 419 course to assess this item. While somewhat anomalous, this lack of students is not to be unexpected with a major of this size.

In an exit survey, our two graduates indicated that they felt at least fairly competent in giving presentations of scientific work in both oral and written fashions.

SLO#5.0 Students will demonstrate competency in physics-relevant computer skills.

There were 2 Physics majors that graduated with a concentration in Computational Physics in Spring 2018. Two students completed a computational project that was delivered to them electronically at the end of their final exams. These submissions were separately scored by Drs. Engelhardt & McDonnell.

The two students averaged 70% on the measured criteria (see attachment), but due to the small sample size, conclusions are limited. The faculty involved with teaching the relevant courses plan to continue to utilize and develop this project as a valid measure of their computational skills.

On the administered exit survey, the two graduates both indicated that they felt at least fairly competent concerning their computational skills and with their skills in giving technical presentation, both written and oral.. This exceeds the benchmark, though the sample size is small. (See CLASS attachment.)

SLO#6.0: Students will have an appreciation for physics including its significance and practical relevance.

The Colorado Learning Attitudes About Science Survey (CLASS) was administered to two graduating seniors majoring in Computational Physics. Though the sample size is small, the percentage of ‘expert-like’ responses increased from 60% in their freshman/sophomore year to 74% as seniors. Thus the benchmark was met for this item.

SLO#7 Students will be prepared for a career or further study upon completion of the program.

Both graduates indicated that they felt at least fairly competent in their preparation for future studies or for employment. Though a small sample size, the 90% benchmark was achieved.

Industrial Engineering Program

Program Learning Outcomes (PLOs)

The Program Learning Outcomes for the Industrial Engineering program at FMU have been developed as Program Educational Objectives (PEO's). These were developed as a representation of acknowledged and anticipated constituency needs and also serve to support the educational mission of Francis Marion University and the IE Program. These objectives are statements of expected accomplishments of Industrial Engineering graduates within 3-5 years of graduation.

a) **Obtain an advanced degree (e.g., MS, MBA, PhD) at an accredited institution.**
b) **Spearhead/lead a corporate project or research initiative (e.g., Six Sigma, facility acquisition/location).**
c) **Organize or significantly support structured community outreach/education efforts and activities.**
d) **Acquire skills/knowledge through certification in areas not on the IE degree plan.**

With an emphasis on development and retention of local talent (e.g., Pee Dee Region), the PEOs emphasize career responsibility and advancement, dedication to life-long learning, and a desire to support and develop the social and community structures where program graduates reside. Repeatedly, these three areas (pursuit of career opportunities, life-long learning, and community service) became the focal point of conversation with program constituents when discussing their ideal FMU IE graduates.

Student Learning Outcomes (SLOs)

The industrial engineering program assesses students on the following eleven outcomes, following the expected outcomes from the Accreditation Board for Engineering and Technology (ABET). These outcomes represent expected student capabilities upon graduation.

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multidisciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

The Student Outcomes are designed to enable students to achieve our PEOs within 3-5 years of completion of the BSIE degree. As illustrated in Table 1, each student outcome supports at least one PEO, with many supporting more. When interpreting the importance of student outcomes in achieving PEOs, it is helpful to consider how the absence of a given, mapped, outcome may influence attainment of the corresponding PEO. As an example, students unable to demonstrate proficiency in student outcome a) 'an ability to apply knowledge of mathematics, science, and engineering' would almost certainly be unable to obtain an advanced degree (Masters, PhD, MBA) and would likely be deemed unfit to spearhead/lead a major corporate initiative (these two PEOs require proficiency and skill in math, science and engineering). This same student, however, would certainly be able to organize community activities and acquire certifications (many non-technical certification opportunities exist for motivated individuals to pursue). In this way, the PEOs are intrinsically supported by those indicated student outcomes, which are deemed essential to PEO attainment.

Table 1. Mapping of Relationship Between Student Outcomes and Program Educational Objectives

			Student Outcomes											
			a	b	c	d	e	f	g	h	i	j	k	Total
Program Educational Objectives (PEOs)	Obtain Advanced Degree from Accredited Institution	a	X	X			X				X			4
	Lead Corporate Project/ Research	b		X	X	X	X	X	X	X		X	X	9
	Organize or Engage in Community Outreach Efforts	c			X	X		X	X	X				5
	Acquire skills/knowledge through certification in areas not in the IE curriculum	d		X					X		X	X		4

Assessment Methods

The industrial engineering program evaluates student performance using the eleven outcomes required by the Accreditation Board for Engineering and Technology (ABET). These outcomes, listed below, are measured at least twice throughout the academic year in more than one course. In addition, all specific outcomes for each course are measured at three times during the same semester (Start of the semester, Midterm, and End of Semester). Table 2 illustrates the framework used for evaluating student performance, including the mapping of all Student Outcomes to engineering courses (ENGR) and the illustration of measurement through the four-year curriculum of the program.

Table 2. Map of Student Outcomes Assessment for Industrial Engineering Curriculum

			ABET Outcomes											Total
			a	b	c	d	e	f	g	h	i	j	k	
Sp1	101	Intro to IE						x	x		x			3
Sp1	201	Eng Graphics			x					x				2
Sp2	220	Materials		x								x		2
Fa2	301	Mechanics	x				x							2
Fa3	310	Electronics												0
Fa3	320	Data Analytics		x		x			x					3
Sp3	330	Eng Econ						x		x				2
Fa3	350	Manuf Processes	x								x			2
Sp2	355	Prod + Ops Mgmt			x						x		x	3
Sp4	356	Quality Control												0
Sp3	373	OR					x					x		2
Fa4	420	HF			x								x	2
Fa4	467	Supply Chain	x	x						x				3
Fa4	468	Prod Planning												0
Sp4	470	Facility Design				x		x				x		3
Sp4	480	Capstone			x		x		x		x		x	5
		Fa1	0	0	0	0	0	0	0	0	0	0	0	0
		Sp1	0	0	1	0	0	1	1	1	1	0	0	5
		Fa2	1	0	0	0	1	0	0	0	0	0	0	2
		Sp2	0	1	1	0	0	0	0	0	1	1	1	5
		Fa3	1	1	0	1	0	0	1	0	1	0	0	5
		Sp3	0	0	0	0	1	1	0	1	0	1	0	4
		Fa4	1	1	1	0	0	0	0	1	0	0	1	5
		Sp4	0	0	1	1	1	1	1	0	1	1	1	8
		Total	**3**	**3**	**4**	**2**	**3**	**3**	**3**	**3**	**4**	**3**	**3**	***34***

Instructors can evaluate students by either assigning specific work for accreditation or by selecting work or portions of work that are required for course credit(s). Each work evaluation is graded using a qualitative scale of: *excellent, acceptable, or unacceptable.* The measure used to evaluate student performance is the *percentage of students who perform equal or better than "acceptable" by the end of each course*. The target for this measure is 70%.

Assessment Results

The summary of the data gathered for the academic year 2017-18 is shown in figure 1 below. As the figure depicts, none of the outcomes reflected to be below the target measure of 70%. This is an improvement of the outcomes for the academic year 2016-17, where five outcomes were below the target. Based on these results, no immediate action will be taken to improve instruction in the courses where the outcomes were measured. However, as a continuous improvement method, the faculty of the program will evaluate the student outcomes and where they are currently being measured and make changes as needed to the map previously shown in Table 2.

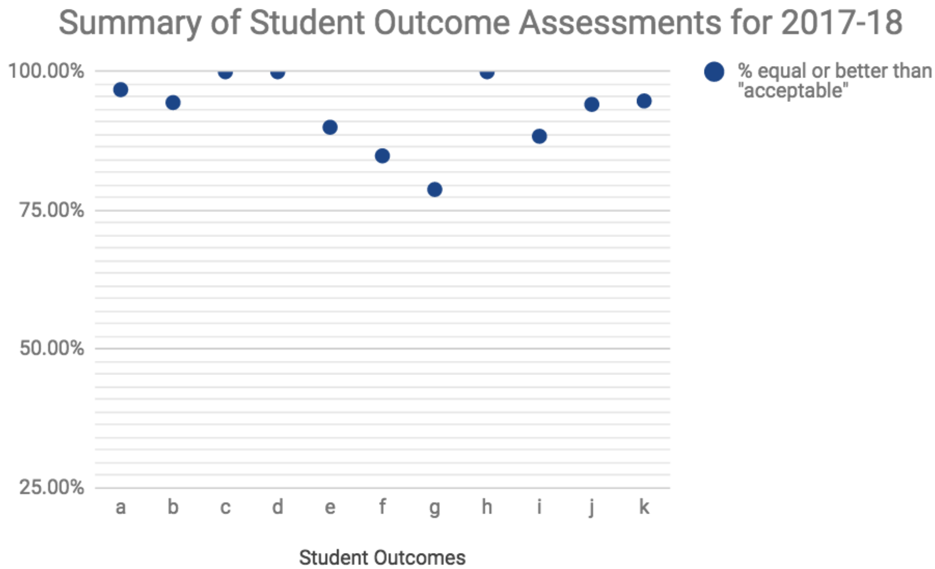

Figure 1. Summary of Student Outcomes Assessments

Table 3 provides a detailed view of the results by outcome, specifying the courses in which they were measured. This table will allow faculty members to act on those courses in which the number of students performing at the “unacceptable” level seems to be significant. For example, in the course ENGR 101, Introduction to Industrial Engineering, outcomes f and g barely meet the target. Therefore, some improvements can still take place to reflect even better results in the coming academic year. These are discussed in the following section.

Table 3. Summary of Student Outcomes Assessment by Course for Academic Year 2017-18

Outcome	Course	Excellent	Acceptable	Unacceptable	Total
a	301	7	5	0	12
	350	6	5	1	12
	467	4	3	0	7
b	320	4	8	0	12
	467	3	2	1	6
c	201	10	5	0	15
	355	4	6	0	10
	420	3	1	0	4
	480	3	2	0	5
d	320	6	6	0	12
	470	5	0	0	5
e	301	5	6	2	13
	373	6	5	1	12
	480	2	3	0	5
f	101	12	0	4	16
	330	9	2	1	12
	470	3	2	0	5
g	101	9	3	4	16
	320	4	7	1	12
	480	2	1	2	5
h	201	7	8	0	15
	330	7	5	0	12
	467	4	2	0	6
i	101	9	6	1	16
	350	7	3	2	12
	355	3	6	1	10
	480	2	2	1	5
j	373	8	3	1	12
	470	4	1	0	5
k	355	4	6	0	10

	420	4	0	0	4
	480	2	2	1	5

Action Items

As stated before, because none of the outcomes measures resulted in failure to meet the target of 70% students performing at least at the acceptable level, no immediate action will be taken to improve instruction in the courses where the outcomes were measured.

However, in the course ENGR 101, Introduction to Industrial Engineering, outcomes f and g seem to have some room for improvement. As a reminder, these outcomes are:

(f) an understanding of professional and ethical responsibility

(g) an ability to communicate effectively

The Industrial Engineering faculty agrees that the cause of this performance from the students may be a lack of experience in the field and the fact that most students take this engineering course in their first year, in which they are still developing the skills required by said outcomes. The instructor for the course will not make changes to the content of the course for the upcoming academic year. Nonetheless, actions might be taken if after academic year 2018-19 the results are similar.

General Education

The department assesses its general education offerings in the PSCI 101 (Physical Science I) course, specifically its laboratory component. Relevant goals of the university's general education program are identified and tested, such as the ability to test scientific principles and the ability to draw conclusions supported by experimental data. Benchmark: Students will score at least 7/10 (70%) on each of the measurable outcomes tested.

Applicable General Education program goals include:

#3: The ability to use technology to locate, organize, document, present, and analyze information and ideas.

#5: The ability to use fundamental mathematical skills and principles in various applications.

#6: the ability to demonstrate an understanding of the natural world and apply scientific principles to reach conclusions.

Measureable Outcome	Pre-Test Results (N=95)*	Post-Test Results (N=122)
1. Identify all testable variables that might affect desired property (cart's acceleration, pendulum's time period) **Gen Ed goals: #3, #6**	5.2	7.3
2. Design experimental tests to eliminate (rule out) variables that do not affect the desired property. **Gen Ed goals: #5, #6**	4.8	7.3
3. From experimental results, identify trends in the data related to variables that do have a significant effect on the desired property, such as direct or inverse relationships. **Gen Ed goals: #5, #6**	4.8	7.4
4. Demonstrate proficiency in the data collection and analysis process; accurate measurements and computations. **Gen Ed goals: #3, #5, #6**	5.8	7.9
5. Identification and minimization of sources of experimental errors, both random and systematic; computation of *percent difference* or *percent error* where appropriate. **Gen Ed goals: #3, #5, #6**	4.5	6.8
6. Demonstrate ability to draw valid conclusions based on experimental results; recognize strengths and limitations of experimental process. **Gen Ed goals: #3, #6**	5.3	7.4
7. Where appropriate, develop an empirical equation that describes a particular relationship (such as that between the pendulum's length l and its time period T). **Gen Ed goals: #3, #6**	N/A	5.7

Scoring should follow a 1-10 scale, 10 being the highest score.

* One lab section did not meet during the scheduled Pre-Test week due to inclement weather. This resulted in a small N compared to the Post-Test group.

Commentary/Actions

While the students demonstrated measurable growth and improvement on each of the tested items, benchmarks were still not met on two of the items. The ability to identify and minimize sources of experimental error needs to be addressed, along with the development of an empirical equation based on the experimental results. Curiously, several students elected not to attempt to write an equation that can be used to predict the time period for any simple pendulum. As a result, they received a score of 0 on this measure, lowering the overall average.

The development of new experiments and modification of others is being planned in an attempt to address these shortcomings. The concept of experimental errors, including systematic and random error types will be emphasized, along with techniques for minimizing these errors where appropriate.