Institutional Effectiveness Report

Name of Program/Department:	**Programs: Physics, Industrial Engineering Department: Physics and Engineering**
Year:	**2018-2019**
Name of Preparer:	**Larry Engelhardt**

Mission Statement

The Department of Physics and Engineering seeks to offer courses in astronomy, engineering, physical science, and physics that are taught by full-time faculty members with appropriate advanced degrees dedicated to science education at the University level. The faculty strive for excellence in instruction, research, and discipline-related service to the community. The courses offered in the department range in level from introductory courses that expose non-science majors to scientific thought to advanced courses that cover contemporary topics in physics and engineering. The laboratory experience is required in appropriate courses to illustrate the importance of experimentation to the scientific endeavor and engineering profession. For the majors in the department, the opportunity to undertake undergraduate research is offered and professional internships are encouraged. Majors graduating from programs in the department are expected to be proficient in oral and written communication, familiar with the scientific and engineering literature, and aware of the importance and usage of technology in science and engineering. Students completing the majors offered by the department will be prepared for careers in industry and scientific research or for graduate school.

Computational Physics and Health Physics

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, we will be developing new assessment tools that will be well-aligned with the teaching practices of the instructors teaching PHYS 201 and 202. In PHYS 201, there were two new instructors this year who will be developing the new PHYS 201 assessment for next year. In PHYS 202, the assessment that has been used in recent years consists of questions taken from the BEMA ("Brief Electricity and Magnetism Assessment") which was externally developed more than 20 years ago, and we suspect that our students are confused by the *language* used in the BEMA as opposed to the physics concepts. PHYS 202 will have a new instructor next year who will be developing that new assessment.

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. A new assessment was developed for the Health Physics majors, and we are in the process of rearranging how the upper-level assessments are delivered for the Computational Physics majors.

Concerning the Industrial Engineering program, assessment activities follow the ABET guidelines. The program recently received ABET accreditation and will continue to be evaluated by ABET. Of the 11 criteria (labeled a – k), student performance met all of them. We note that ABET recently replaced their 11 criteria (a – k) with Outcomes 1 – 7 which will be assessed next year.

This year, we also had two students graduate with a Physics major from FMU upon completion of our dual-degree engineering program with Clemson University. Since we did not actually teach these two students in upper-level courses, it would not be appropriate for us to use the same upper-level assessment, but we are developing an assessment of how well we have prepared students to complete the Clemson part of this program.

For the General Education courses, the students' experimental skills and their interpretation of experimental results was assessed. In each category, the students did reach the benchmark of 70%, but had the most difficulty "drawing conclusions based on experimental results". This summer, the faculty are rewriting some of the Physical Science lab experiments, and these redesigned labs will include more emphasis on drawing conclusions based on experimental results, which is what is being assessed in Item #6, where we saw the weakest student performance.

Student Learning Outcomes (Physics)

SLO#1.0: Students will demonstrate knowledge of introductory physics concepts.
Benchmark 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.
Benchmark 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.
Benchmark 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.
Benchmark 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.
Benchmark 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.
Benchmark 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.
Benchmark 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.

In PHYS 202, a 5-question pre/post instruction survey was administered. On all 5 questions, the N=27 students who took this assessment had very large pre-to-post gains, and also scored better than last year's group, but were still short of the 70% benchmark on 4 of the 5 questions (post-test averages: 48%, 22%, 81%, 56%, 63%; compared with pre-test averages: 7%, 7%, 41%, 30%, 41%).

In PHYS 201, this SLO was not accurately measured this year as a result of poor communication between the new departmental coordinator of Institutional Effectiveness and the new PHYS 201 instructors. Those instructors did not realize that a pre-instruction assessment should have been administered, and the post-instruction assessment that was administered was the same assessment that was given last year, which was not well aligned with the instruction that had taken place in PHYS 201. The percentage of correct responses for this three-question assessment were 22%, 24%, and 74%. Our benchmark is 70% for each of the three questions, so the benchmark was not met for the first two questions, but it was met for the third question.

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

This year, we developed an assessment tool which was administered in PHYS 418. The two Health Physics (HP) students in PHYS 418 took this assessment and achieved an average score of 65%. We don't find a great deal of significance to this result due to the small sample size, but this is the first step toward validating this new assessment tool in preparation for more significant pre and post testing in the future. For our assessment of upper-level Computational Physics (CP), our stated plan was to assess in PHYS 306 (Fall) and 406 (Spring), but PHYS 306 has been removed from the curriculum, and PHYS 406 has been moved to the fall. We are in the process of deciding on how to do this assessment in the future.

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

The ability of students to connect an 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, and 12 of the 29 students (41%) correctly accomplished this task.

On an exit survey, all six of the graduating physics majors indicated that they felt either very competent or fairly competent in their acquired laboratory skills. The department is also building 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.

Faculty assessments of Physics 419 presentations were not conducted this year.
In an exit survey, all six of the graduating physics majors indicated that they felt either very confident or fairly competent in giving presentations of scientific/technical work, and five of the six graduates (83%) indicated that they felt very confident or fairly confident in technical writing. This fell short of our benchmark (of 90% of students), although the sample size is small.

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

Three Physics majors graduated with a concentration in Computational Physics in Spring 2019, and they 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 three students averaged 47% on the measured criteria (with one of the students scoring very well and the other two scoring poorly) but we suspect that the means of delivery – asking them to complete this project right after their final semester had ended – likely resulted in an artificially low success rate. We will be discussing alternative ways to administer this assessment that might be more effective. On the exit survey, five of the six graduating physics majors (83%) indicated that they felt either very confident or fairly competent concerning their computational skills. This fell short of our benchmark (of 90% of students), although the sample size is small.

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 the six graduating physics majors. The percentage of 'expert-like' responses for these graduating seniors was 78%. The benchmark for this assessment is 70%, and for reference, this assessment was also administered in Physics 200 (to N=49 underclass students) who only had 28% 'expert-like' responses.

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

All six of the graduates (100%) indicated that they felt either very competent or fairly competent in their preparation for future studies or for employment (benchmark: 90%).

Industrial Engineering Program

Program Learning Outcomes (PLOs)

The Program Learning Outcomes for the Industrial Engineering (IE) 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 are measured at least twice throughout the academic year in more than one course. In addition, all specific outcomes for each course are measured twice during the same semester (Start of Semester 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											
			a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	***Total***
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 2018-2019 is shown in Figure 1 (below). As the figure depicts, none of the outcomes were below the target measure of 70%. This is an improvement of the outcomes for the academic year 2016-17, and consistent with the outcomes from the year 2017-2018. 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 shown in Table 2 (above).

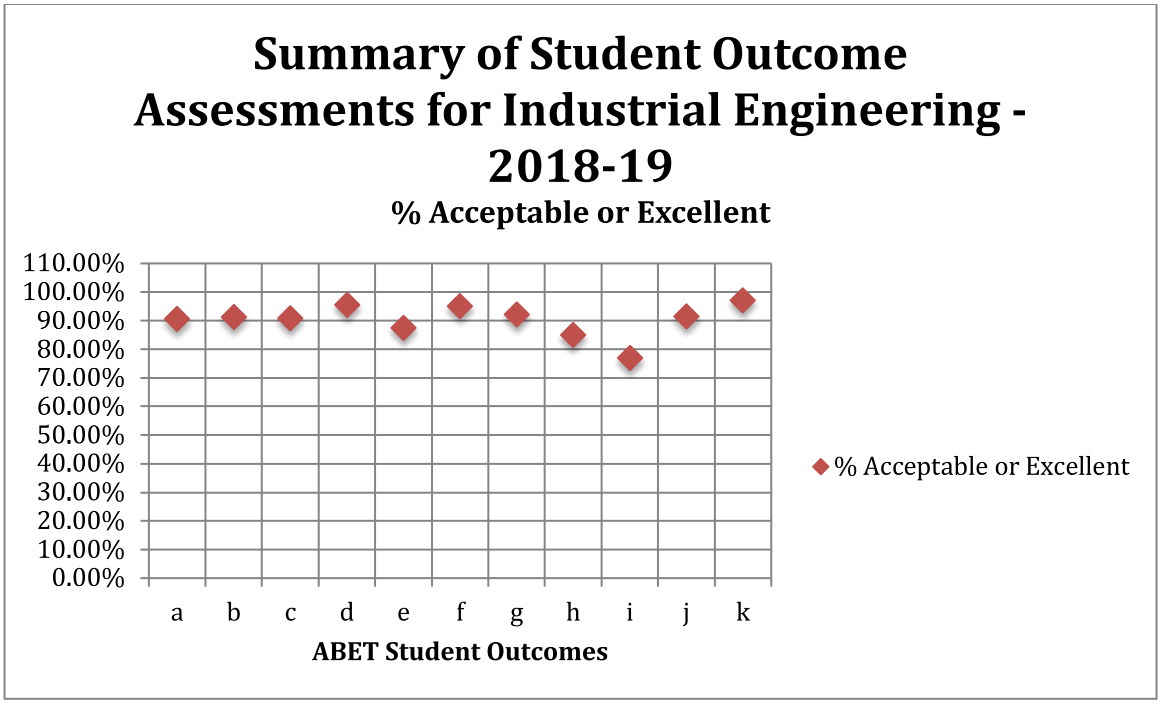

Figure 1. Summary of Student Outcomes Assessments

Table 3 (below) 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.

Table 3. Summary of Student Outcomes Assessment by Course for Academic Year 2018-2019

Semester	Course	Outcomes Measured	Excellent	Acceptable	Unacceptable	% >= Acceptable
Fall	ENGR301	a	5	6	0	**100.00%**
		e	7	4	0	**100.00%**
	ENGR320	b	1	7	2	**80.00%**
		g	2	7	1	**90.00%**
		d	3	7	0	**100.00%**
	ENGR350	a	5	4	0	**100.00%**
		i	5	3	1	**88.89%**
	ENGR420	c	8	4	1	**92.31%**
		k	10	2	1	**92.31%**
	ENGR467	a	3	6	3	**75.00%**
		b	9	2	0	**100.00%**
		h	8	2	1	**90.91%**
Spring	ENGR101	f	11	5	2	**88.89%**
		g	4	11	2	**88.24%**
		i	5	4	8	**52.94%**
	ENGR201	c	13	13	5	**83.87%**
		h	17	8	6	**80.65%**
	ENGR220	b	8	4	1	**92.31%**
		j	8	4	1	**92.31%**
	ENGR330	f	5	6	0	**100.00%**
		h	10	0	1	**90.91%**
	ENGR355	c	10	1	0	**100.00%**
		i	8	2	1	**90.91%**
		k	11	0	0	**100.00%**
	ENGR373	e	1	6	3	**70.00%**
		j	9	1	0	**100.00%**
	ENGR470	d	2	9	1	**91.67%**
		f	12	0	0	**100.00%**
		j	9	1	2	**83.33%**
	ENGR480	c	4	7	0	**100.00%**
		e	8	2	1	**90.91%**
		g	3	8	0	**100.00%**
		i	7	3	1	**90.91%**
		k	8	3	0	**100.00%**

Action Items

Actions from 2017-2018 assessments:

From last year's assessment, the IE faculty worked to make simple improvements to the course ENGR 101, so to improve student performance in outcomes *f* and *g*. These simple improvements included more emphasis of engineering ethics throughout the semester, and increased focus on developing communication skills by assigning multiple group presentations during the semester. These adjustments did seem to lead to a better performance for those outcomes. No further action will be taken.

Opportunities from 2018-2019 assessments:

Because none of the student 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, outcome i seems to have some room for improvement. As a reminder, outcome *i* targets student "*recognition of the need for, and an ability to engage in life-long learning*".

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 2019-20 the results are similar.

In addition, ABET has introduced new Student Outcomes for engineering programs. The known and previously stated outcomes a-k will transform into outcomes 1-7 (www.abet.org). The IE program will adopt these outcomes and develop assessment plans for the academic year 2019-2020.

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 assessed, such as the abilities to test scientific principles and draw conclusions supported by experimental data.

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=157)	Post-Test Results (N=180)
1. Identify all testable variables that might affect desired property (cart's acceleration, pendulum's time period) **Gen Ed goals: #3, #6**	7.0	7.5
2. Design experimental tests to eliminate (rule out) variables that do not affect the desired property. **Gen Ed goals: #5, #6**	5.5	7.8
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**	6.0	7.5
4. Demonstrate proficiency in the data collection and analysis process; accurate measurements and computations. **Gen Ed goals: #3, #5, #6**	6.0	7.8
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**	5.2	7.3
6. Demonstrate ability to draw valid conclusions based on experimental results; recognize strengths and limitations of experimental process. **Gen Ed goals: #3, #6**	5.8	7.0
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	7.6

Scoring follows a 1-10 scale, 10 being the highest score. Benchmark: 7/10 (70%).

Benchmark: Students will score at least 7/10 (70%) on each of the seven measurable outcomes being assessed.

Commentary/Actions

Students demonstrated measurable growth and improvement on each of the tested items, and the benchmarks were met for all seven of the items. Last year (2017-2018), there were two items for which the benchmarks were not met on the post-test assessment:

- Item #5 went up slightly from 68% last year to 73% this year.
- Item #7 went up significantly from 57% last year to 76% this year.

For Item #6, the benchmark was barely met, which was a slight decrease from 74% last year to 70% this year.

This summer, the faculty are rewriting some of the Physical Science lab experiments, and these redesigned labs will include more emphasis on drawing conclusions based on experimental results, which is what is being assessed in Item #6, where we saw the weakest student performance.