Institutional Effectiveness Report

Name of Program/Department:	**Physics, Industrial Engineering/Physics and Astronomy**
Year:	**2016-2017**
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.

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

Physics

In the introductory physics courses, students met the established target regarding their understanding of Newton's 3rd Law, but fell short in their understanding of Newton's 1st Law and of the vector nature of acceleration. An increased emphasis is planned in the lecture and laboratory to address these deficiencies.

Regarding experimental skills, students in the introductory course sequence fell short of expectations when asked to construct a relatively simple electric circuit that includes an ammeter to measure the current through a specified resistor. Since these students had hands-on experience in such matters in addition to the lecture coverage of the topic, these results are disappointing: only 36% could correctly accomplish the task. Since there are multiple ways in which the students might fail to accomplish the given task, an effort is planned to help identify all sources of difficulty, hopefully leading to an improved outcome. However, 100% of the graduating students responding to an exit survey indicated that they were at least fairly confident in their acquired experimental skills. Assessment of upper level competencies in physics could not be completed as planned due to the deletion from the program of one of the courses involved and low enrollments in others. A post-curriculum mini-project was used instead where students were asked to write a program to model a familiar physical phenomenon (interaction of two charged particles). The students did well on some aspects, but struggled with numerical assessment and code implementation. The mean score on the project was 61%, which fell short of which fell short of the 70% target. Plans have already been implemented to address these difficulties in an earlier course where the students will be presented with a similar project, and it is expected that the next group will benefit from these changes. Going forward, this criteria will need to be changed given the program change mentioned above, mainly the deletion of the PHYS 306 course.

In terms of indirect measures, the *Colorado Learning Attitudes About Science Survey* (*CLASS*) has been administered to sophomores and again to graduating seniors for the last two academic years. The student responses are then compared to those of experts in the field. The results showed that 78% (benchmark=70%) of our seniors displayed expert-like attitudes, approaches, and beliefs concerning the utility of physics in understanding the natural world. Additionally, exit surveys indicate that 100% of our graduates felt adequately prepared for further study or careers in the discipline, 100% were confident in their acquired skills. Surveys for department alumni are being developed to provide feedback from graduates 2-5 years removed.

Industrial Engineering

Assessment activities for the Industrial Engineering major have followed the requirements for the Accreditation Board for Engineering and Technology (ABET), whose accreditation is being sought. This program produced its first graduates in Spring 2017. Measures of 11 student learning outcomes have been undertaken multiple times across the entire curriculum and the results are displayed graphically in this report.

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. While the targets were met with regularity, certain shortcomings have been identified in both student performance, such as the ability to identify variables that might affect the performance of a physical system and in the techniques for minimizing experimental errors. Improvements to the approaches and techniques used include modifications to the experiments performed and at least one new experiment along with a more realistic pre-test where students are given less assistance from the instructor.

Student Learning Outcomes (Physics)

SLO#1.0: Students will demonstrate knowledge of introductory physics concepts.
Target performance: Students in Physics 201 will, on average, answer 70% of the post-test questions correctly in each category. [Benchmark = 75%]

SLO#2.0: Students will demonstrate knowledge in upper-level physics concepts.
Target 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. [Benchmark = 75%]

SLO#3.0: Students will be able to use modern laboratory techniques to measure and analyze experimental data.
Target 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. [Benchmark = 75%].

SLO#4.0 Students will be able to competently present technical information via both oral and written communication.
Target 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. [Benchmark = 90%].

SLO#5.0 Students will demonstrate competency in physics-relevant computer skills.
Target 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. [Benchmark =80%].

SLO#6.0: Students will have an appreciation for physics including its significance and practical relevance.
Target performance: Greater than 70% of the responses given by our graduates on the Colorado Learning Attitudes About Science Survey will be “expert-like”. [Benchmark = 75%].

SLO#7.0: Students will be prepared for a career or further study upon completion of the program.
Target 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. [Benchmark = 90%]

Assessment Methods/Results

Student Learning Outcome (SLO)	Course/ Component	Assessment Method/Benchmark	Assessment Results
#1.0: Students will demonstrate knowledge of introductory physics concepts. (knowledge outcome, direct measure)	PHYS 201 (Technical Physics II)	Newton's 3rd Law: Students were asked a question requiring a basic understanding of this law on three different occasions: pre-instruction, post-instruction, and final exam. Target*: 70% correct responses on post-test.*	Results improved from 57% to 91% to 100%, respectively. *The* target *of 70% was met for this item.*
		Newton's 1st Law: Students were asked a question concerning the net force acting on an object moving with a constant velocity, both pre-instruction and again on the final exam. Target*: 70% correct responses on post-test.*	Results improved from 15% correct responses pre-instruction to 44% on the final exam. *The* target *of 70% was not met for this item.*
		Definition of acceleration: Students were asked to identify accelerated motions from a list of several commonly observed motions, both pre-instruction and again on the final exam. Target*: 70% correct responses on post-test.*	On three of the four questions, the students scored 93%, 84%, and 91%, but on the fourth, there were only 58% correct responses. *The* target *was met overall for this item, but some shortcomings were observed that will be addressed.*

Student Learning Outcome (SLO)	Course/ Component	Assessment Method/Benchmark	Assessment Results
#2.0: Students will demonstrate knowledge in upper-level physics concepts. **(knowledge outcome, skills outcome, direct measure)**	PHYS 306, 318, 406, 418 Post-curriculum mini-project	Students are asked to write computer code to describe/predict the position, velocity, potential energy and kinetic energy of two charged particles initially separated by a known distance. They identify the relevant physical equations, develop the equivalent computer code, produce graphs of each quantity as a function of time, and evaluate the accuracy of their predictions. *Target: No target has yet been established due to the recent addition of this item.*	Student (N=3) projects were evaluated by two faculty members directly involved with the computational physics program. The projects were scored with respect to physical equations, code implementation, visualization and plots, numerical assessment, and physical assessment. The average score on the project was 61%. Students seemed to struggle most with the topics of numerical assessment and code implementation.
#3.0: Students will be able to use modern laboratory techniques to measure and analyze experimental data. **(skills outcome, indirect measure)**	Exit Survey	Senior Physics majors were given an exit survey question designed to assess their perceived competency regarding their acquired laboratory/experi-mental skills upon completion of their program. Target*: 90% of our graduates will indicate on an exit survey that they feel very competent or fairly competent with regard to their laboratory skills.*	Of the 5 students responses, 2 indicated they felt very confident in their laboratory skills and 3 indicated that they were fairly confident in these acquired skills. Thus, 100% of the students felt that they were at least fairly competent in their laboratory skills. *The target was met for this item.*

Student Learning Outcome (SLO)	Course/ Component	Assessment Method/Benchmark	Assessment Results
#3.0.1: Students will be able to use modern laboratory techniques to measure and analyze experimental data. **(skills outcome, direct measure)**	PHYS 202 Laboratory (Technical Physics III)	On an individual basis, students were asked to construct an electric circuit that contained resistances in parallel, including a multimeter, and to correctly measure the current through a specified resistor.	Of the 25 students that took part in the assessment, 9 students (36%) were able to correctly complete the task, which includes circuit connections, proper meter placement and meter settings.
#4.0 Students will be able to competently present technical information via both oral and written communica-tion. (direct assessment)	PHYS 419 (Senior Seminar in Physics)	Students in this course prepare a formal scientific review article on a selected physics topic, which culminates in both a written report and an oral presentation to faculty and fellow students. *Target: 90% of the students in Physics 419 will receive a score greater than 80/100 based on a faculty assessment of their oral presentations.*	Due to an error, the student presentations were not graded by the department's faculty this year.
#5.0 Students will demonstrate competency in physics-relevant computer skills. **(skills outcome, indirect measure)**	Exit Survey	Senior Physics majors were given an exit survey question designed to assess their perceived competency regarding their acquired computational skills. *Target: 90% of our graduates will indicate on an exit survey that they feel very competent or fairly competent with regard to their computational skills.*	Of the 5 student responses, 2 indicated they felt very confident in their computational skills and 3 indicated that they were fairly confident in these acquired skills. Thus, 100% of the students felt that they were at least fairly competent in their computational skills. *The target was met for this item.*

Student Learning Outcome (SLO)	Course/ Component	Assessment Method/Benchmark	Assessment Results
#5.0.1 Students will demonstrate competency in physics-relevant computer skills. (knowledge outcome, skills outcome, direct measure)	Post-curriculum mini-project	Students in the PHYS 406 (Advanced Computational Physics) course are asked to write computer code to describe/predict the position, velocity, potential energy and kinetic energy of two charged particles initially separated by a known distance. They identify the relevant physical equations, develop the equivalent computer code, produce graphs of each quantity as a function of time, and evaluate the accuracy of their predictions. *Target: No target has yet been established due to the recent addition of this item.*	Student (N=3) projects were evaluated by two faculty members directly involved with the computational physics program. The projects were scored with respect to physical equations, code implementation, visualization and plots, numerical assessment, and physical assessment. The average score on the project was 61%. Students seemed to struggle most with the topics of numerical assessment and code implementation.
#6.0: Students will have an appreciation for physics including its significance and practical relevance. (Skills outcome, Attitude outcome, indirect measure)	PHYS200 (pre-test group) Graduating Seniors (post-test group) Colorado Learning Attitudes About Science Survey (CLASS)	This survey measures students' self-reported beliefs about physics and their physics courses and how closely these beliefs about physics align with experts' beliefs. *Target: Greater than 70% of the responses given by our graduates on the Colorado Learning Attitudes About Science Survey will be "expert-like".*	Four graduating seniors' responses were compared to those of the introductory PHYS 200 group. Results: Group — %Expert-Like Responses PHYS 200 (N=64) — 61.5 Seniors (N=4) — 77.8 *The target was met for this item.*

Student Learning Outcome (SLO)	**Course/ Component**	**Assessment Method/Benchmark**	**Assessment Results**
#7.0: Students will be prepared for a career or further study upon completion of the program. (Skills outcome, Attitude outcome, indirect measure)	Exit Survey Alumni Survey	Students are asked how well they feel their major prepared them for graduate school and/or employment. *Target: 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.*	With 5 graduating students responding, 3 felt that they were very well prepared and 2 indicated they felt fairly well prepared, yielding a 100% score. *The target was met for this item.*

Action Items

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

As a group, the students showed considerable improvement in their understanding of Newton's 1st Law, but fell short of the established benchmark. The issue seems to be a failure to realize that a net force of zero can explain why an object may move with constant (and non-zero) velocity. This reflects a common misunderstanding among students, but should have been corrected during the course. The instructors for the course are planning to provide a greater emphasis on this point, which should be fairly easy to correct. (For a more detailed accounting of these items, see Appendix.

Regarding the definition of acceleration, a fundamental concept in physics, the students did well concerning the *scalar* (speed change) component of acceleration, but struggled with the *vector* (directional) aspect. In other words, a change in an object's direction of motion is also a type of acceleration, an example being *centripetal acceleration*. An increased emphasis on this topic, both in the lecture and in the laboratory is planned.

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. We plan to scrutinize this particular topic further in order to better identify the source(s) of the students' shortcomings.

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 this 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 this year's group contained a small sample size of 3 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.

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. We plan to scrutinize this particular topic further in order to better identify the source(s) of the students' shortcomings.

On an exit survey, all of the graduating seniors indicated that they felt at least fairly 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 Students will be able to competently present technical information via both oral and written communication.

Due to a misunderstanding/miscommunication issue, these presentations were not scored in the usual way. Though the presentations were of sufficient quality overall to meet the target, no supporting evidence was gathered. We do plan to resume our previous assessment techniques for the upcoming fall semester.

SLO#5 Students will demonstrate competency in physics-relevant computer skills.

The computer-based mini-project given in PHYS 406 (Advanced Computational Physics) had to serve double duty for assessment this academic year, and the results including an action plan were previously discussed under SLO#2.

Though an exit survey shows that all our graduates indicated that they felt they were at least fairly competent in regard to their computer skills, thus meeting the target, a similar question will be asked on a future survey sent out to our graduates 2 to 5 years later. At that time, our former graduates may have specific recommendations for improvements to the program based upon their experiences in graduate school and/or career paths.

SLO#6 Students will have an appreciation for physics including its significance and practical relevance.

For the last two academic years, the *Colorado Learning Attitudes About Science Survey (CLASS)* was administered to both introductory level students in the PHYS 200 (Technical Physics I) class and again as seniors. The survey measures students' self-reported attitudes, beliefs, study habits, perceived relevance of physics, etc. The results have been fairly consistent and stable, with an improvement in ‘expert-like’ responses of approximately 16% overall between the sophomore and senior years. (See Appendix for a more detailed accounting of the results.) The target for this item has been met, though with N=5-9 students for the senior group, like to continue with this survey for several years before drawing firm conclusions.

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

In an exit survey of graduating seniors (N=5), three have plans to enter the workforce, one plans to go to graduate school, and one is currently undecided. All have indicated that they feel at least fairly well prepared for a career or for further study. Alumni surveys are being constructed that will aid in our assessment of these items post-graduation. Given the low number of graduates from our program in any given year, a high response rate will be critical for this endeavor.

Industrial Engineering
Assessment Activities/Results
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 1 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 1. Map of Student Outcomes Measured For Industrial Engineering Courses

			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***

ABET Student Outcomes (SLO):

(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.

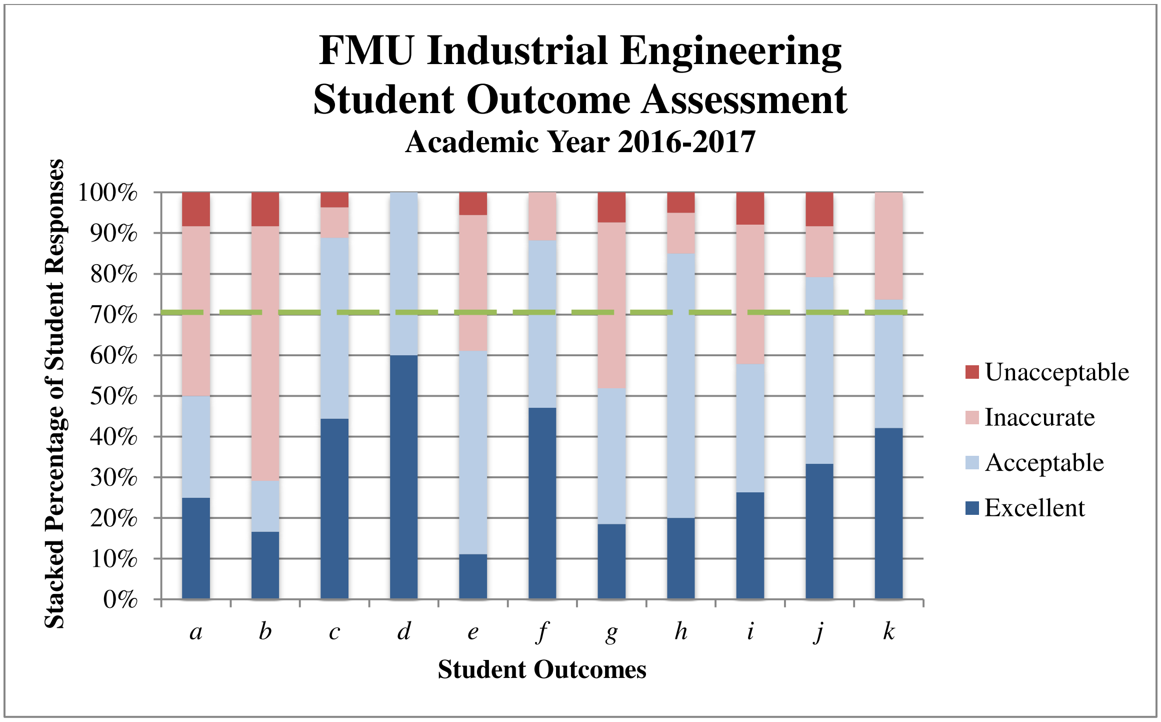
Instructors can evaluate students by either assigning specific work for accreditation or by selecting work or portions of work that are required for course credit(s). Each work evaluation is graded using a qualitative scale of: *excellent, good, average or poor*. The measure used to evaluate student performance is the *percentage of students who perform equal or better than "good"*. The summary of the data gathered for the academic year 2016-17 is shown in figures 1-. Each figure presents the said measure at the three stages in the detailed academic term.

Evaluation of Student Outcome Performance

The faculty of the program has determined a target for the student outcomes for each semester to ensure that graduates of the program will ultimately achieve the stated PEOs after graduating from the program.

- ***At least 70% of students perform at acceptable or excellent level.***

For each assessment of a student outcome at the three different evaluation periods of a semester, the number of responses in each category is counted. Responses in the "Excellent" and "Acceptable" categories are combined and compared to the total number of responses. If the percentage of this combination is at or above 70% after the end-of-semester evaluation, it is considered that the outcome has been obtained. However, if this combination fails to meet the target, a mandatory review is in place where, at the end of the semester, faculty meets to discuss possible root causes and appropriate course of actions for attainment of the outcome(s) in subsequent semesters.



Student Outcome Assessment Results – Academic Year 2016-2017

For the Academic year 2016-2017, the faculty of the program conducted assessment of all student outcomes, as described previously. This year was the first in which all engineering courses were offered, as the first graduating class entered their senior year.

Figure 9 presents the results of all outcomes for the entire academic year. This graph displays the results from all assessments obtained at the end of the Fall 2016 and Spring 2017 courses. It is clear from the figure that the target performance level (70%) was achieved for outcomes c, d, f, h, j, and k (in graph, this is seen in the addition of the blue portion of each bar).

The faculty of the Industrial Engineering program met after the Fall Semester of 2016 to discuss the Student Outcomes measures obtained for that semester in each course. As a result of this meeting, the following concerns were identified in each ENGR course offered during that semester, with corrective actions as indicated:

- **ENGR 320:** Faculty identified that students had a poor background in probability and statistics when they reached this course, therefore affecting the students' performance related to outcomes *b*, *d*, and *g*.
    - *Corrective action:* With no dedicated course on probability and statistics, the faculty saw an opportunity of including introductory topics in probability and statistics in the Introduction to Industrial Engineering course (ENGR 101). This was already implemented in the spring semester of 2016, but will be emphasized more in the spring semester of 2017.

The faculty will meet to discuss the results from the spring 2017 semester by course and outcome, and for the entire academic year by outcome. At this meeting faculty will discuss outcomes a, b, e, g, and i, which fall below the 70% goal. Faculty will review individual course assessments with measures from beginning, midterm, and end of semester results. This will help identify possible root causes for low performance levels, identify opportunity for the outcomes that missed the target, develop a plan for improvement of assessment or delivery methods, and implement changes for the upcoming academic year 2017-2018.

Assessment of General Education courses

As an assessment of the department's general education offerings, the Physical Science 101 Laboratory was used to measure students' abilities to conduct experiments, identify trends in the data and draw conclusions supported by the evidence they gathered. Early in the semester a pre-test is to be given followed by a post-test at the end of the semester. Students are given questions to answer by experimentation as outlined below. Specifically, the pre-test involves identifying factors affecting the acceleration of a cart rolling down an inclined plane and the post-test uses a simple pendulum and its time period in much the same way. Each item is scored by the lab instructor on 1-10 scale, 10 being the highest score.

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	Applicable General Education goal	Post-Test Results from 2015-2016 (N=65)	Post-Test Results from 2016-2017 (N=124)
Identify all testable variables that might affect a specified property (cart's acceleration, pendulum time period)	#3, #6	7	9
Design experimental tests to eliminate (rule out) variables that do not affect the desired property.	#5, #6	7	8

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.	#5, #6	8	8
Demonstrate proficiency in the data collection and analysis process, including accurate measurements and computations.	#3, #5, #6	7	8
Identification and minimization of sources of experimental errors, both random and systematic; computation of *percent difference* or *percent error* where appropriate.	#3, #5, #6	7	8
Demonstrate ability to draw valid conclusions based on experimental results; recognize strengths and limitations of the experimental process.	#3, #6	7	8

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*).	#3, #6	6	8

Commentary/Action Plan

Due to an error/misunderstanding, a pre-test was not administered during the past academic year. As a remedy, it was decided that we would compare this year's post-test results with those of the previous year. This approach does allow us to identify any gains from the previous year as well as any recurring deficiencies. The results indicate noticeable, though modest, gains in the students' abilities to identify variables that potentially affect the time period of a simple pendulum (Gen. Ed. Goals #3, #6). Also shown is an improvement in the ability to use a curve-fit to match their data with a mathematical expression (Gen. Ed. Goals #3, #6). The students' demonstrated abilities overall seem consistent compared to the previous year.

Going forward, we intend to resume administering the pre-test experiment with some changes that will allow us to better measure the students' gains in the measured parameters during the semester. The pre-test experiment can be modified such that the students will receive less instruction and guidance from the lab instructor. We feel that this change will more accurately reflect the students' initial state, making the observed gains a more meaningful quantity. It may also serve as a 'rude awakening' for the students early in the semester such that they may come to realize just how much improvement they will need to make. In addition, modifications to the lab manual itself are planned which include changes to experiments designed to illustrate mathematical relationships between variables.

Appendix

SLO#1 PHYS 201 Assessment Questions

Students were asked a question on Newton's Third Law on three occasions. The first, at the beginning of a prelecture online before class, once more after completing the online portion, and a final time as part of the final exam.

Time of question	Beginning of online pre-lecture	After completing online instruction	Final exam
% answering correctly	57%	91%	100%

Students in the class have clearly demonstrated mastery of this concept, as shown by the pre/post gains and the absolute score on the question during the final exam.

Students were also asked a question on Newton's First Law. This question asked students about the net force given an object moving at constant velocity.

Time of question	Prior to class on subject	Final exam
% answering correctly	15%	44%

The class demonstrated significant gains, and this question/concept is one that addresses preconceived misconceptions that students bring to the class and are difficult to change. While pleased with the gains demonstrated this semester, we also plan to place additional emphasis on this concept next year.

Finally, students were asked a question about the definition of acceleration. This multiple answer question asked students to identify all situations in which an object was accelerating.

	% Correct	
Motion (accelerating yes/no)	Prior to class on subject	Final exam
Increasing speed (yes)	89%	93%
Decreasing speed (yes)	76%	84%
Constant straight line speed (no)	96%	91%
Constant speed, circular (yes)	46%	58%

Students have demonstrated mastery of acceleration when the magnitude of velocity is changing. They struggle, however, with the concept of acceleration resulting from the direction of velocity changing (an object moving in a circular path.) While gains were observed in this concept, additional emphasis will be placed on this concept next year in an effort to improve student understanding.

SLO#3 Physics 202 - Individual Assessment of Experimental Skills (Fall 2016)

Logistics:

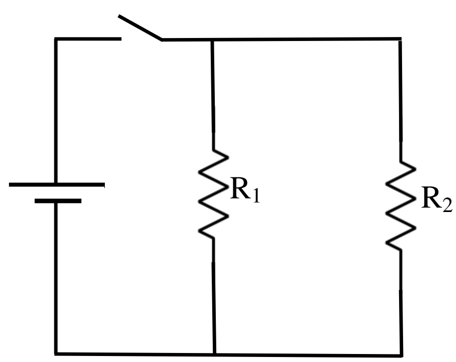
During the lab on measuring and mapping magnetic fields, the students were given this individual assessment of their experimental skills. Two identical setups were provided, each in a different part of the room, and the lab groups cycled through the assessment. When it was their turn, each group of two students split up, with each student working independently on one of the setups. Each student was provided a maximum of 5 minutes to complete the assessment. The students were asked not to talk with their classmates about the assessment after they complete it.

Equipment:

- 1 Battery
- 1 tap switch
- 1 DMM with two leads (banana to U-shaped)
- Resistor board with 2 resistors labeled "R_1" and "R_2")
    - Resistor R_1 = 220 Ohm
    - Resistor R_2 = 100 Ohm
- At least 4 wires (U-shaped to U-shaped) – I provided 6

Task:

Construct the following circuit, including a DMM to measure the current flowing through resistor R_2:



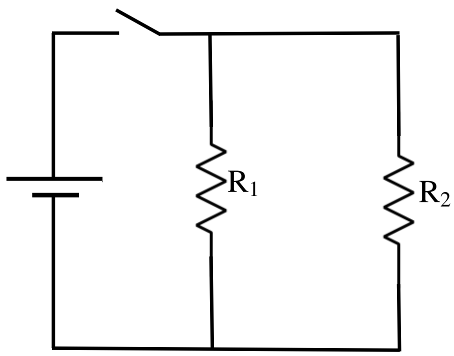
Additional Details:

- The students are provided with a picture showing how the equipment appears before they begin the assessment.
- The student is instructed to tell the instructor when they have completed the task (if completed within 5 minutes). The instructor will check their work.
- After being checked, the student is asked to return the equipment to its original state, as shown in the picture.

The next page is what was given to the students.

Physics 202 - Assessment of Experimental Skills

Construct the following circuit, including a DMM to measure the current that flows through resistor R_2 (when the switch is closed). The equipment provided to you is shown in the picture on the right. You may take up to five minutes to complete this task. Please start the timer now.



When you have completed your circuit, and tested that the DMM is indeed measuring a plausible value for the current, let your instructor know that you are done.

After your instructor has checked your circuit, please disassemble your circuit and leave the equipment as shown in the picture above.