Program Assessment Data

Physics and Engineering Physics
Spring 2016

Assessment data for the the combined programs of physics and engineering physics are presented together. The learning outcomes for each program is listed below.

Graduates from the Physics B.S. and B.A. programs will demonstrate the following learning outcomes:

1. Students will develop an understanding of the fundamental principles of physics
2. Students will apply physical principles, mathematical reasoning, and computational techniques to solve real-world problems
3. Students will design and conduct experiments as well as analyze and interpret data
4. Students will effectively communicate complicated technical information
5. Students will effectively collaborate in teams

Graduates from the Engineering Physics program will demonstrate the following learning outcomes:

1. Students will develop an understanding of the fundamental principles of physics and of engineering
2. Students will apply physical principles, mathematical reasoning, and computational techniques to solve real-world problems
3. Students will design and conduct experiments or complete an engineering design project as well as analyze and interpret data.
4. Students will effectively communicate complicated technical information
5. Students will effectively collaborate in teams

Physics and Engineering
PLO 1: Fundamental Principles

Program Learning Outcome: Students will develop an understanding of the fundamental principles of physics.

Measure: Major Field Achievement Test in Physics taken by seniors in the capstone course PHY475.

Criteria for success: At least 50% of students will score more than the 40th percentile on the MFAT in Physics.

Aligned with DQP Learning Areas:

1. Specialized Knowledge
2. Broad Integrative Knowledge
3. Intellectual Skill/Core Competencies
4. Applied and Collaborative Learning
5. Civic and Global Learning

Longitudinal Data:

	2007	2008	2009*	2012	2013	2014	2015	2016
N of Students	5	6	9	7	7	6	8	14
Above 40th	80%	57%	56%	71%	57%	33%	50%	50%
Score Average	160±25	147±10	141±9	148±13	148±15	139±9	144±6	145±12
Lower Division	58±26	48±13	41±11	50±15	48±16	43±11	46±8	49±13
Upper Division	60±20	46±13	42±10	44±10	46±12	36±13	43±9	42±13
Achieved Criteria	yes	yes	yes	yes	yes	no	yes	yes

*Data was not collected during the 2009-10 or 2010-11 academic years.

Additional Data: In our survey of graduating seniors, students all in 2015 (8/8) and 13/14 rated themselves as either high satisfactory or outstanding in having achieved this learning outcome. (Though this may be more a measure of self-confidence.)

Conclusions Drawn from Data:
Generally students are just barely meeting the criteria established. Students are typically measured at the end of their senior year. This data suggests that the "typical student" is unable to recall ideas at the time they are taking the exam that we hope they would have.

There is a tendency for averages to be changed significantly by a few individuals, so these averages should be perhaps viewed cautiously. Often students who have reviewed material before the MFAT exam do significantly better. This occurs primarily from students who take the physics GRE, and to a lesser degree individuals who severed as TAs. However, the population doing these activities might naturally score higher on the MFAT.

We are in process of evaluating whether the criteria of success is appropriate (perhaps setting different criteria for the two programs, or including additional data such as the breakdown of material provided by the MFAT, or the department average as a whole.)

Brief interviews with students indicated that we may not be preparing the students to take this kind of exam very well (i.e. they almost never see multiple choice, and rarely problems that they are not completely working out.)

Changes to be Made Based on Data:

The MFAT exam itself has more of a focus on material typically through the first 2-3 years in the curriculum. In 2015 there were changes made to the content of the Senior Lab course. In particular, the two advanced lab rotations more intentionally started with fundamental principles and then built on this material. Additionally, one class session of "big ideas" was added. To a small extent this exposes all students to some level of review.

We also have not had a system in place to guarantee that all our majors have taken the MFAT. Beginning 2014-15 the exam will be embedded into a required upper division class for seniors.

Rubric Used: None

Physics and Engineering
PLO 2: Application

Program Learning Outcome: Students will apply physical principles, mathematical reasoning, and computational techniques to solve real-world problems.

Measure: Embedded final exam question given in upper division mastery class on a rotating basis.

Criteria for success: At least 75% of students will achieve an average score of 2.5 or higher on criteria described in application rubric.

Aligned with DQP Learning Areas:

1. Specialized Knowledge
2. Broad Integrative Knowledge
3. Intellectual Skill/Core Competencies
4. Applied and Collaborative Learning
5. Civic and Global Learning

Longitudinal Data:

	2011-12	2012-13	2013-14	2014-15	2015-16
N of Students	22	15	17	11	35
Class	E&M	Nuclear	E&M	Nuclear	E&M
% above 2.5	71 %	84 %	88%	82%	80%
met criteria	no	yes	yes	yes	yes

Note that some raw student work was missing and a mapping method was used to approximate application of the rubric to appropriate questions on the final exam. This method probably gives a reasonable estimate of data though direct use of the rubric is preferable.

Additional Data: In the survey of graduating seniors, students typically (7/8 in 2015 and 13/14 in 2016) rated themselves as either high satisfactory or outstanding in this category. One student, who rated themselves as low satisfactory, suggested adding a seminar in applications, while another indicated that little focus is placed on this for the mechanical emphasis.

Conclusions Drawn from Data: Typically our students are doing well. Though not directly measured, we have noticed occasionally students struggle knowing when computational tools are most appropriate if not prompted in some way.

In establishing this learning outcome, review of the curriculum tended to show that we had previously not focused as much on applications within courses. The computational piece has been strengthened by utilizing tools such as MATLAB through several courses from freshman through senior level.

Changes to be Made Based on Data: Increased use of computational techniques including introductory physics lab, modern physics, and various upper division classes.

The degree to which students evaluate their solution is also varied. Typically this has not explicitly been a required part of problems being solved. It is recommended that at least periodically an evaluation of their solutions be an explicit part of problems rather than the hope that students have learned the good habit of evaluating their solution when they have finished it, and assume that this is taking place.

Rubric Used: Physics and Engineering Application Rubric

Physics and Engineering Application Rubric

	Outstanding	High satisfactory	Low Satisfactory	Unsatisfactory
Demonstrates knowledge of relevant physical principles	☐ Identifies all the appropriate physical principles necessary to solve the problem, and can provide clear reasoning why these principles are applicable and useful	☐ Identifies all physical principles necessary to solve the problem, but cannot clearly articulate why each principle is applicable and helpful in arriving at a solution	☐ Identifies most of the relevant physics	☐ Cannot identify relevant physics
Correctly applies physical principles	☐ Efficiently uses identified physical principles to move toward solution	☐ Uses identified physical principles to move toward solution	☐ Application of physical principles contains few errors	☐ Application of physical principles contains many errors
Applies mathematical techniques, concepts and processes	☐ Mathematics are used correctly and efficiently to move toward a solution	☐ Mathematical techniques are used correctly with few or no errors	☐ Mathematical techniques are used correctly with several errors	☐ Mathematical techniques contain many errors
Demonstrates knowledge of computational techniques	☐ Can articulate why a particular computational technique or tool is useful	☐ Can identify relevant tools and techniques	☐ Identifies some tools or techniques which may work	☐ Cannot identify computational techniques applicable to the problem
Application of computational techniques	☐ Uses appropriate tools to formulate a complete solution efficiently and correctly	☐ Arrives at a solution which is correct	☐ Arrives at a solution which may contain some minor errors	☐ Does not arrive at a solution
Evaluation of solution	☐ Can evaluate solution for correctness either using alternate methods or reasonableness using physical principles	☐ Can evaluate the solution generally based on physical principles	☐ Rough evaluation of solution without clear reasoning	☐ Cannot provide any evaluation of correctness of solution

Physics and Engineering
PLO 3: Experimental

Program Learning Outcome: Students will design and conduct experiments or complete engineering design projects as well as analyze and interpret data.

Measure: Two assignments from PHY475: lab rotation one highlighting analysis and Senior Lab final project highlighting design.

Criteria for success: At least 75% of students will achieve an average score of 2.5 or higher on criteria described in experimental rubric.

Aligned with DQP Learning Areas:

1. Specialized Knowledge
2. Broad Integrative Knowledge
3. Intellectual Skill/Core Competencies
4. Applied and Collaborative Learning
5. Civic and Global Learning

Longitudinal Data:

	2012-13	2013-14	2014-15	2015-16
N of Students	8	8	8	14
% above 2.5	75%	-	88%	93%
met criteria	yes	no	yes	yes

In 2013-14 students did not complete an individual project, but rather reported on a particular topic, but did participate in lab rotations.

Additional Data: In a 2015 survey of graduating seniors, students generally (7/8) rated themselves as either high satisfactory or outstanding in having achieved this learning outcome. Several comments indicated that more upper-division experience in this would be helpful.
In a 2016 survey of graduating seniors, 10/14 students rated themselves as either high satisfactory or outstanding in having achieved this learning outcome. This learning outcome was the lowest scored learning outcome from this self-response survey. Students with a mechanics emphasis particularly indicated they would like to have more opportunities to develop their ability to complete an engineering project.

Conclusions Drawn from Data: Students are observed to be strong at certain features on the rubric (error analysis, reach appropriate conclusions) while typically weaker in others (developing procedures independently). Perhaps not surprisingly, students are strongest in aspects that they have practiced the most.

Changes to be Made Based on Data: Upon establishing this learning outcome and developing the rubric the department recognized that we did not provide many opportunities for students to develop their own procedures (many procedures were described for them.) Creating an advanced lab was an important step in accomplishing this. Additionally this year a project was added to analytical mechanics in the 2015-16 year.

PHY475 has improved students abilities, but a stronger thread through the curriculum appears necessary. Building a more scaffolded approach, where they practice an increasing amount of independence would be helpful. In viewing our curriculum in program review, this will be one area that will be considered.

Rubric Used: Physics and Engineering Experimental Rubric

Physics and Engineering
Experimental Rubric

	Outstanding	High satisfactory	Low Satisfactory	Unsatisfactory
Develop adequate physics/engineering background to carry out novel experiments	☐	☐	☐	☐
Establish and communicate the purpose of an experiment or project	☐	☐	☐	☐
Operate and troubleshoot complex physical apparatus	☐	☐	☐	☐
Devise a procedure for achieving the goals of the experiment or project	☐	☐	☐	☐
Carry through error analysis	☐	☐	☐	☐
Reach appropriate conclusions from data	☐	☐	☐	☐
Explain, follow and ensure lab safety	☐	☐	☐	☐

Physics and Engineering
PLO 4: Communication

Program Learning Outcome: Students will effectively communicate complicated technical information.

Measure: PHY475: Senior Lab final written project and technical talk. Juried as a department; Secondary Measure Oral Examination in Electricity and Magnetism.

Criteria for success: At least 75% of students will achieve an average score of 2.5 or higher on criteria on the Oral and Written Presentation rubrics; At least 75% of students will achieve an average score of no less than one grade lower on their PHY361 final oral exam than their written exam.

Second Measure:

Aligned with DQP Learning Areas:

1. Specialized Knowledge
2. Broad Integrative Knowledge
3. Intellectual Skill/Core Competencies
4. Applied and Collaborative Learning
5. Civic and Global Learning

Longitudinal Data:
Data from Senior Project Talks:

	2012-13	2013-14	2014-15	2015-16
N of Students	8	7	8	14
% above 2.5	88%	100%	100%	100%
average score	-	3.2	3.4	3.6
met criteria	yes	yes	yes	yes

Data from papers written on senior projects. Note that seniors did not create a write-up in the 2013-14 academic year.

	2012-13	2013-14	2014-15	2015-16
N of Students	8	7	8	14
% above 2.5	75%	-	100%	93%
met criteria	yes	no	yes	yes

Additional Data:
Data from E&M oral exams showing the number of students that scored no more than a grade lower (9 percent less) on their oral portion of their final compared to the written final.

	2009-10	2011-12	2013-14	2015-16
N of Students	11	22	18	35
met requirement	82%	95%	83%	100%
met criteria	yes	yes	yes	yes

In a survey of graduating seniors, all students (8/8 in 2015 and 14/14 in 2016) rated themselves as either high satisfactory or outstanding in having achieved this learning outcome. (This may be more a measure of self-confidence.)

Conclusions Drawn from Data: Students have often demonstrated stronger speaking skills than writing skills. Though students are frequently meeting our criteria, their overall scores are closer to the 2.5 range.
The criteria for the secondary data taken from the oral exams might need to be revisited. On the data from the 2015-16 year, 3 of the students did not do well on the oral exam, but did much worse on the written exam. Perhaps an additional minimum criteria for the oral exam score would be more indicate of a students ability to communicate technical information.

Changes to be Made Based on Data: Both writing and speaking have been incorporated into more courses. Increased opportunities to develop these skills is important. In 2015 the writing rubric was applied to students starting in their sophomore year. This led to more rigorous attention to the presentation of data and communication. It would be helpful to build in some additional practice with speaking about technical concepts earlier in their academic career.

In 2016 the PHY495 class seminar focused on technical writing and presenting skills. In program review this might allow for a more of an emphasis on the student projects in PHY475.

Rubric Used:

Physics and Engineering
Oral Presentation Rubric

	Outstanding	High satisfactory	Low Satisfactory	Unsatisfactory
Command of Material	☐ clearly knows material ☐ expands on PPT slides ☐ content appropriate for audience	☐ knows most key facts ☐ some expansion on slides ☐ partial adaption for audience	☐ reads some, knows some ☐ no expansion on slides ☐ little adaption of content for audience	☐ reads many sentences from slides ☐ dependent on notes ☐ lacks adaption of content to audience
Organization	☐ clear and concise outline ☐ relevant graphics and key text on slides ☐ ±30 s of time limit	☐ clear outline ☐ too much information on slides ☐ ±60 s of time limit	☐ some sense of outline ☐ too much information and detail ☐ ±1.5 m of time limit	☐ no clear sense of outline ☐ slides are paragraphed; too much detail on one slide ☐ ±2 m of time limit
Presentation Skills	☐ clearly practice several times; smooth transitions ☐ free of uhms and the like ☐ clearly heard and used inflection for emphasis ☐ engages audience with eye contact ☐ engages audience with gestures	☐ Practiced, but transitions not smooth ☐ few uhms ☐ understood much of the time and some inflection ☐ some engagement with eye contact ☐ some engagement with gestures	☐ practiced, but no transitions between slides ☐ many uhms ☐ some difficulty hearing and little inflection ☐ infrequent eye contact ☐ some distracting gestures	☐ not practiced, doesn't anticipate content of next slide ☐ uhms and the like detract from the presentation ☐ cannot be heard and/or speaks in a monotone ☐ no eye contact ☐ frequent distracting gestures
Presentation Tools	☐ PPT background matched to content, legible font, graphics, seamless transitions ☐ Appropriate graphics used.	☐ appropriate background, font, transitions ☐ Some graphics used to enhance presentation.	☐ distracting backgrounds, transitions, fonts hard to read ☐ graphics do not enhance presentation	☐ no attention to backgrounds, transitions, fonts very hard to read ☐ distracting use of graphics

Physics and Engineering
Write-up Rubric

	Outstanding	High satisfactory	Low Satisfactory	Unsatisfactory
Structural pieces	☐ abstract is a clear and concise summary of all relevant results and descriptions in the order emphasized in the paper.	☐ abstract could be made clear and/or concise with minor changes.	☐ abstract is missing some information and/or contains unnecessary information.	☐ abstract does not contain necessary information
	☐ introduction indicates precise subject, scope, and purpose	☐ introduction is missing one of the following: precise subject, scope, and purpose.	☐ introduction is missing two of the following: precise subject, scope, and purpose.	☐ introduction does not give precise subject, scope and purpose.
	☐ main body is a well organized, logical and contains all necessary information without extra information.	☐ main body lacks some organization	☐ main body is missing some important pieces and/or is not well organized	☐ main body is not well organized, lacks logical arguments and relevant data
	☐ conclusion appropriately sums up, gives conclusions, and recommendations	☐ conclusion does two of the following: sums up, gives conclusions, and recommendations	☐ conclusion does one of the following: sums up, gives conclusions, and recommendations	☐ conclusion does provide any summation, conclusions, or recommendations
	☐ multiple references from reputable sources.	☐ most references from distinct reputable sources	☐ some references from reputable sources	☐ no bibliography, or all references from untrusted sources
	☐ references cited in the body of the document	☐ some citation of reference in body	☐ limited citation of references	☐ no citation of references
Data	☐ data is clearly presented in properly formatted tables, figures and graphs where appropriate.	☐ some data could be presented more clearly	☐ data is poorly presented and some key data is missing.	☐ several pieces of key data are missing
	☐ all uncertainties are shown and error propagation are carried out where appropriate.	☐ most uncertainties are shown and propagation of error carried out.	☐ many uncertainties are missing and/or propagation or error not carried out correctly	☐ no uncertainties of measurements are show
Grammer, Spelling, and Style	☐ no grammatical or spelling errors	☐ few grammatical and spelling errors	☐ some grammatical and spelling errors	☐ many grammatical and spelling errors
	☐ equations well formatted, and variables introduced as needed.	☐ a few errors in formatting equations	☐ poorly formatted equations	☐ incorrect equations
	☐ appropriate style (no first person, past tense when reporting what was done)	☐ a few informal statements and/or tense	☐ several areas with are too informal and tense errors	☐ very informal and/or use of future tense where not appropriate
	☐ clear sentences and ideas are presented in a way that won't be misunderstood	☐ a few unclear sentences	☐ many complex and unclear sentences	☐ many sentences are unclear and have overly complex construction
	☐ concise and quantitative as subject matter permits	☐ a few unnecessary words and ideas	☐ frequent extra and inexact words	☐ many vague, inexact, many idle words
	☐ arguments are complete and logical	☐ most arguments are complete	☐ several arguments are difficult to follow	☐ arguments are incomplete, illogical, and may contain unnecessary information and specialized jargon

Physics and Engineering
PLO 5: Teamwork

Program Learning Outcome: Students will effectively collaborate in teams.

Measure: Teamwork survey taken, and faculty evaluation of the teams. This survey and evaluation is done in PHY304L.

Criteria for success: At least 75% of students will achieve an average score of 2.5 or higher on criteria described in teamwork rubric.

Aligned with DQP Learning Areas:

1. Specialized Knowledge
2. Broad Integrative Knowledge
3. Intellectual Skill/Core Competencies
4. Applied and Collaborative Learning
5. Civic and Global Learning

Longitudinal Data:
Peer team evaluation:

	2013-14	2014-15	2015-16
N of Students	13	24	18
% above 2.5	86%	95%	94%
average score	3.5	3.5	3.6
met criteria	yes	yes	yes

Additional Data:
Faculty evaluation of teams. The team as a whole was evaluated on the first, second and sixth row on the rubric (focus, working together, and accomplishing goal):

	2013-14	2014-15	2015-16
N of teams	4	8	9
% above 2.5	100%	88%	89%
average score	3.0	3.3	3.3
met criteria	yes	yes	yes

Conclusions Drawn from Data: Overall students tend to rate each other very highly. This motivated the addition of observations from the professor.

Changes to be Made Based on Data: The measurement instrument was changed after the first year. The second year a more detailed instrument was used in addition to data gathered from the professor. Further modifications may be helpful in the rubric (adding more specifics) to help guide students toward being more effective team members.

Rubric Used:

Evaluator: _____ Person Evaluated: _____

	Outstanding	High satisfactory	Low Satisfactory	Unsatisfactory
Focus on Task	☐ Stays on task all of the time	☐ Stays on task most of the time	☐ Stays on task some of the time with some reminders from group	☐ Hardly ever on task. Lets others do task
Extent to which works togther	☐ A very strong group member who works hard and helps other in the group	☐ A strong group member who works hard	☐ Sometimes active group member but needs to try harder	☐ Frequently choosing not to help out
Meeting Habits	☐ On time to meetings or any assigned tasks	☐ Usually on time, and completes any assigned task	☐ Sometimes late for meeting or not completing tasks	☐ Late or absent for many or all meetings
Attitude while listening and discussing	☐ Respectful listener, discusses, and helps direct the group in solving problems	☐ Respectful, listens and asks questions	☐ Has trouble listening with respect and takes over discussions without letting others have a turn	☐ Does not listen or consider other's ideas. Blocks group from reaching agreement
Problem Solving	☐ Actively seeks and suggests solutions to problems	☐ Improves on solutions and suggestions given by others	☐ Does not offer solutions, but is willing to try solutions offered by others	☐ Does not try to solve problems or help others solve problems
Goal Completion	☐ Works to complete group goals	☐ Usually helps to complete group goals	☐ Occasionally helps to complete group goals	☐ Does not help to complete group goals