Physics and Engineering

Program Learning Outcome Assessment

2018-19

Program Learning Outcomes

Physics and Engineering

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

- Students will develop an understanding of the fundamental principles of physics
- Students will apply physical principles, mathematical reasoning, and computational techniques to solve real-world problems
- Students will design and conduct experiments as well as analyze and interpret data
- Students will effectively communicate complicated technical information in writing
- Students will effectively communicate complicated technical information orally
- Students will be able to identify, locate, evaluate, and effectively and responsibly use and cite information for the task at hand.
- Students will effectively collaborate in teams

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

- Students will develop an understanding of the fundamental principles of physics and of engineering
- Students will apply physical principles, mathematical reasoning, and computational techniques to solve real-world problems
- Students will design and conduct experiments or complete an engineering design project as well as analyze and interpret data.
- Students will effectively communicate complicated technical information in writing
- Students will effectively communicate complicated technical information orally
- Students will be able to identify, locate, evaluate, and effectively and responsibly use and cite information for the task at hand.
- Students will effectively collaborate in teams

Note: Because these program learning outcomes are very similar and the assessment points for them are the same, assessment date for physics majors and engineering physics majors has been combined into a single report.

Physics and Engineering

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

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

Criteria for Success (how do you judge if the students have met your standards):
At least 50% of students will score more than the 40th percentile on the MFAT in Physics.

Aligned with DQP Learning Areas (circle one or more but not all five):

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

Longitudinal Data:

	Percentage of Students at the 40th percentile							
	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Physics MFT	71%	57%	33%	50%	50%	37%	57%	21%

Conclusions Drawn from Data:
Generally students are just barely meeting the criteria established and in some years missing it (but the variability is partially the result of a relatively small sample size). 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 has been embedded into a required upper division class for seniors.

As part of the program review process, we will be discussing if the ETS is really an appropriate measure of learning for the majority of our seniors who are engineering-physics majors.

Rubric Used
No rubric used since the results are provided by ETS.

Physics and Engineering

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

Outcome Measure:
Embedded final exam questions given in upper division mastery class on a rotating basis (PHY361 and PHY431).

Criteria for Success (how do you judge if the students have met your standards):
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 (circle one or more but not all five):

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

Longitudinal Data:

	Percentage of Students scoring 2.5 or higher							
	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
	PHY361	PHY431	PHY361	PHY431	PHY361	PHY431	PHY361	PHY431
Application Rubric	71%	84%	88%	82%	80%	71%	96%	81%

Conclusions Drawn from Data:
Typically, our students are meeting the benchmark. 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.

The adjusted curriculum (starting Fall 2019) includes more labs and thus more opportunities for “hands on” work and computations.

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

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

Physics and Engineering

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

Outcome Measure:
PHY475: Senior Lab final project highlighting design.

Criteria for Success (how do you judge if the students have met your standards):
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 (circle one or more but not all five):

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

Longitudinal Data:

	Percentage of Students scoring 2.5 or higher						
	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Design Rubric	75%	N/A	88%	93%	89%	86%	100%

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

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).

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. To address this issue, our program review concluded that a curriculum that had more labs would be helpful with the junior and senior level labs involving a greater level of independence.

Rubric Used

Physics and Engineering
Experimental Rubric

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

Physics and Engineering

Learning Outcome:
Written Communication: Students will effectively communicate complicated technical information in writing.

Outcome Measure:
PHY475 Senior Lab Written Technical Report.

ETS Proficiency Profile Exam

Criteria for Success (how do you judge if the students have met your standards):
PHY475: At least 75% of students will achieve an average score of 2.5 or higher on criteria on the Written Report rubric.

ETS: 75% of the students will be marginal or proficient at Level 2 Writing.

Aligned with DQP Learning Areas (circle one or more but not all five):

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

Longitudinal Data:

PHY475:

	Percentage of Students at 2.5 or higher						
	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Written Report Rubric	75%	N/A	100%	100%	84%	64%	100%

ETS:

	Percentage of Students Marginal or Proficient						
	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
ETS Proficiency Profile Level 2 Writing	100%	100%	75%	62%	94%	73%	87%

Conclusions Drawn from Data:
The students are consistently hitting the benchmarks in both the written report and the ETS exam. The dip in the ETS exam in 2015-16 was due to small sample size (if one student had a slightly higher score the benchmark would have been met).

The reports that students are writing in the senior lab have been uneven. Examining the data from 2017-18 the main areas of weakness are:

- Information literacy (multiple references and the references cited)
- A well-written conclusion
- Uncertainties and error propagation discussed in the paper.

Changes to be Made Based on Data:
The department will be undergoing program review in the coming year and will look at the alignment between the ETS exam and the written report expectations. It is clear that the students are not fully understanding the expectations for the final lab report that is being used in this class.

Rubric Used
ETS: No rubric.

PHY457 Written Report Rubric:

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

Physic and Engineering

Learning Outcome:
Oral Communication: Students will effectively communicate complicated technical information orally.

Outcome Measure:
PHY475 Senior Lab project technical talk.

Criteria for Success (how do you judge if the students have met your standards):
At least 75% of students will achieve an average score of 2.5 or higher on criteria on the Oral Presentation rubric in a talk juried by department faculty.

Aligned with DQP Learning Areas (circle one or more but not all five):

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

Longitudinal Data:

	Percentage of Students at 2.5 or higher						
	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Oral Presentation Rubric Scores	88%	100%	100%	100%	100%	93%	75%

Conclusions Drawn from Data:
The students are achieving the benchmark.

Changes to be Made Based on Data:
In the future the department may want to analyze the data base on individual components of the Oral Presentation Rubric rather than using a single average score for each student.

Rubric Used

Physics and Engineering Oral Presentation Rubric

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

Physic and Engineering

Learning Outcome:
Information Literacy: Students will be able to identify, locate, evaluate, and effectively and responsibly use and cite information for the task at hand.

Outcome Measure:
PHY475 Senior Lab Written Technical Report.

Criteria for Success (how do you judge if the students have met your standards):
PHY475: At least 75% of students will achieve an average score of 2.5 or higher on criteria on the information literacy portion of the Written Report rubric.

Aligned with DQP Learning Areas (circle one or more but not all five):

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

Longitudinal Data:

	Percentage of Students at 2.5 or higher						
	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Written Report Rubric IL	25%	N/A	63%	86%	53%	43%	44%

Conclusions Drawn from Data:
The students are not achieving the benchmark. It is clear from looking at the individual scores in the writing rubrics, that this is the weakest category for students. For example in 2018-19 100% of the students hit the overall benchmark for writing, but when information literacy is considered separately, only 44% of the students have achieved the target.

Changes to be Made Based on Data:
The department needs to work with students to clarify expectations for the use and citation of material in technical write-ups. This will be part of the curricular adjustments made as the result of program review.

Rubric Used

PHY457 Written Report Rubric:

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

Physics and Engineering

Learning Outcome:
Students will effectively collaborate in teams.

Outcome Measure:
Teamwork survey used for students to rate their teammates. This survey and evaluation is done in PHY304L.

Criteria for Success (how do you judge if the students have met your standards):
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 (circle one or more but not all five):

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

Longitudinal Data:

	Percentage scoring 2.5 or higher					
	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Teamwork Rubric (teams)	86%	95%	94%	94%	91%	86%
Teamwork Rubric (professor)	100%	88%	89%	94%	N/A	N/A

Conclusions Drawn from Data:
Overall students tend to rate each other very highly. This motivated the addition of observations from the professor. However the professor observations aligned well with the student assessment, so the professor rating was discontinued after 2016-17.

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

Physic and Engineering

Learning Outcome:
Critical Thinking: Students will be able to examine, critique and synthesize information in order to arrive at reasoned conclusions.

Outcome Measure:
ETS Proficiency Profile Exam

Criteria for Success (how do you judge if the students have met your standards):
75% of the students will be marginal or proficient at Level 2 Reading/Critical Thinking.

Aligned with DQP Learning Areas (circle one or more but not all five):

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

Longitudinal Data:

	Percentage of Students Marginal or Proficient						
	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
ETS Proficiency Profile Level 2 Critical Thinking	100%	100%	75%	77%	89%	73%	73%

Conclusions Drawn from Data:
The students are in general achieving the benchmark.

Changes to be Made Based on Data:
The variability in the data appears to be the result of relatively small sample sizes.

Rubric Used
No rubric. We use the ETS Proficiency Profile test results.

Physics and Engineering

Learning Outcome:
Quantitative Reasoning: Students will be able to solve problems that are quantitative in nature.

Outcome Measure:
ETS Proficiency Profile Exam

Outcome Measure:
ETS Proficiency Profile Exam

Criteria for Success (how do you judge if the students have met your standards):
95% of the students will be marginal or proficient at Level 2 Math.

Aligned with DQP Learning Areas (circle one or more but not all five):

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

Longitudinal Data:

	Percentage of Students Marginal or Proficient						
	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
ETS Proficiency Profile Level 2 Math	100%	100%	100%	100%	100%	91%	100%

Conclusions Drawn from Data:
The students are consistently hitting the benchmark.

Changes to be Made Based on Data:
None at this time.

Rubric Used
No rubric. We use the ETS Proficiency Profile test results.