

Physics and Engineering
Program Learning Outcome Assessment
2020-21

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 orally
- Students will effectively communicate complicated technical information in writing
- 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 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 orally
- Students will effectively communicate complicated technical information in writing
- 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 data for physics majors and engineering majors have 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 PHY4072.

Note that this measure is being updated as part of the revision of learning outcomes and measures to be commenced in the 2021-22 academic year.

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 40 th percentile									
	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Physics MFT	71%	57%	33%	50%	50%	37%	57%	21%	N/A	N/A

Conclusions Drawn from Data: Note that in 2019-20 the department decided to stop using the MFT in Physics. The department was not getting useful data from the expense involved in the exam because it is not well aligned with the learning outcomes of the programs. We are in the process of revising learning outcomes and the related measures.

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 served as TAs. However, the population doing these activities might naturally score higher on the MFT.

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 majority of the majors in our department are engineering majors so the MFT in Physics is not the best measure of their knowledge. We are discontinuing the use of the test and will be replacing it with other embedded assessments.

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 (EGR/PHY3063, EGR/PHY3043 and EGR/PHY4053).

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 Over 2.5								
	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
	PHY431	PHY361	PHY431	PHY361	PHY431	PHY361	PHY431	PHY3063	PHY/EGR3043
Application Rubric	84%	88%	82%	80%	71%	96%	81%	92%	100%

* Note the courses were renumbered in the 2019-20 academic year. PHY361 became PHY3063. At that time some courses were cross listed as both engineering and physics.

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.

Physics and Engineering Application Rubric
(PHY/EGR3063, PHY4053)

Criteria	Outstanding	High Satisfactory	Low Satisfactory	Unsatisfactory
Demonstrates relevant physical principles	<input type="checkbox"/> Identifies all the appropriate physical principals necessary to solve the problem and can provide clear reasoning why these principals are applicable and useful	<input type="checkbox"/> 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	<input type="checkbox"/> Identifies most of the relevant physics	<input type="checkbox"/> Cannot identify relevant physics
Correctly applies physical principals	<input type="checkbox"/> Efficiently uses identified physical principals to move toward solution	<input type="checkbox"/> Uses identified physical principles to move toward solution	<input type="checkbox"/> Application of physical principles contains few errors	<input type="checkbox"/> Application of physical principles contains many errors
Applies mathematical techniques, concepts and processes	<input type="checkbox"/> Mathematics are used correctly and efficiently to move toward a solution	<input type="checkbox"/> Mathematical techniques are used correctly with few or no errors	<input type="checkbox"/> Mathematical techniques are used correctly with several errors	<input type="checkbox"/> Mathematical techniques contain many errors
Demonstrates knowledge of computational techniques	<input type="checkbox"/> Can articulate why a particular computational technique or tool is useful	<input type="checkbox"/> Can identify relevant tools and techniques	<input type="checkbox"/> Identifies some tools or techniques which may work	<input type="checkbox"/> Cannot identify computational techniques applicable to the problem
Application of computational techniques	<input type="checkbox"/> Uses appropriate tools to formulate a complete solution efficiently and correctly	<input type="checkbox"/> Arrives at a solution which is correct	<input type="checkbox"/> Arrives at a solution which may contain some minor errors	<input type="checkbox"/> Does not arrive at a solution
Evaluation of solution	<input type="checkbox"/> Can evaluate solution for correctness either using alternate methods or reasonableness using physical principals	<input type="checkbox"/> Can evaluate the solution generally based on physical principals	<input type="checkbox"/> Rough evaluation of solution without clear reasoning	<input type="checkbox"/> 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: Assessment of design as part of EGR/PHY4072 Senior Project.

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	2019-20	2020-21
Design Rubric	75%	N/A	88%	93%	89%	86%	100%	69%	80%

*Note that 2019-20 and 2020-21 were COVID years.

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.

An analysis of the data for 2019-20 shows that the students who did not meet the basic benchmark of an average score of 2.5 across all areas of the rubric showed weakness in:

- Develop adequate physics/engineering background to carry out novel experiments
- Devise a procedure for achieving the goals of the experiment or project

In 2020-21 the scores improved and there were no notable areas of shortfall.

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).

EGR/PHY4072 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. These new labs are being added to the curriculum

but the students in the 2019-20 course were not the beneficiaries of that curricular change. The students who take the class in 2020-21 will be the first cohort to have an increased number of labs and based on data, there seems to possibly be some positive impact.

**Physics and Engineering Experimental Rubric
(PHY/EGR4072)**

Criteria	Outstanding	High Satisfactory	Low Satisfactory	Unsatisfactory
Develop adequate physics/engineering background to carry out novel experiments	Demonstrates the background for carrying out novel experiments.	Can carry out a novel experiments with a small amount of guidance.	Struggles with carrying out novel experiments.	Cannot carry out novel experiments.
Establish and communicate the purpose of an experiment or project	Clearly communicates the purpose of the experiment or project.	Communicates the purpose of the experiment or project with minor errors or missing details.	Communicates a vague sense of the purpose of the project or experiment.	Cannot communicate the purpose of the experiment or project.
Operate and troubleshoot complex physical apparatus	The student can operate and troubleshoot the equipment.	The student can operate and troubleshoot the equipment most of the time.	The student can do one of operating or troubleshooting the equipment.	The student cannot operate the equipment and cannot troubleshoot.
Devise a procedure for achieving the goals of the experiment or project	The procedure will achieve the goals.	The procedure will mostly address the goals of the project.	The procedure will partially address the goals of the project.	The procedure is not connected to the goals.
Reach appropriate conclusions from data	The conclusions are clearly connected to the data.	The conclusions are mostly connected to the data.	The conclusions are partially connected to the data.	The conclusions are not connected to the data.

Physics and Engineering

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

Outcome Measure: PHY4072 Senior 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	2019-20*	2020-21*
Oral Presentation Rubric Scores	88%	100%	100%	100%	100%	93%	75%	100%	88%

*COVID-19 Year

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

Changes to be Made Based on Data: In the future the department will analyze the data base on individual components of the Oral Presentation Rubric rather than using a single average score for each student. This should provide a deeper look at the areas where students are showing weaknesses.

PHY-ENG Oral Presentation Rubric Update

Criteria	Outstanding	High Satisfactory	Low Satisfactory	Unsatisfactory
Command of material	<input type="checkbox"/> Clearly knows material	<input type="checkbox"/> Knows most key facts	<input type="checkbox"/> Reads some, knows some	<input type="checkbox"/> Reads many sentences from slides
	<input type="checkbox"/> Expands on PowerPoint slides	<input type="checkbox"/> Some expansion on slides	<input type="checkbox"/> No expansion on slides	<input type="checkbox"/> Dependent on notes
	<input type="checkbox"/> Content appropriate for audience	<input type="checkbox"/> Partial adaptation for audience	<input type="checkbox"/> Little adaptation of content for audience	<input type="checkbox"/> Lacks adaptation of content to audience
Organization	<input type="checkbox"/> Clear and concise outline	<input type="checkbox"/> Clear outline	<input type="checkbox"/> Some sense of outline	<input type="checkbox"/> No clear sense of outline
	<input type="checkbox"/> Relevant graphics and key text items on slides	<input type="checkbox"/> Too much information on slides (not concise)	<input type="checkbox"/> Too much information and detail	<input type="checkbox"/> Slides are in paragraphs; too much detailed information on one slide
	<input type="checkbox"/> Plus/minus 30 seconds of time limit	<input type="checkbox"/> Plus/minus 60 seconds of time limit	<input type="checkbox"/> Plus/minus 1.5 minutes of time limit	<input type="checkbox"/> Plus/minus 2 minutes of time limit
Presentation skills	<input type="checkbox"/> Clearly has practiced several times; smooth transitions	<input type="checkbox"/> Practiced, but transitions are not smooth	<input type="checkbox"/> Practiced, but not transitions between slides	<input type="checkbox"/> Not practiced, doesn't anticipate content of next slide
	<input type="checkbox"/> Free of uhms and the like	<input type="checkbox"/> Few uhms and the like	<input type="checkbox"/> Many uhms and the like	<input type="checkbox"/> Uhms and the like detract from the presentation
	<input type="checkbox"/> Clearly heard and used inflection for emphasis	<input type="checkbox"/> Understood much of the time and some inflection	<input type="checkbox"/> Some difficulty hearing and little inflection	<input type="checkbox"/> Cannot be heard and/or speaks in a monotone
	<input type="checkbox"/> Engages audience with eye contact	<input type="checkbox"/> Some engagement with eye contact	<input type="checkbox"/> Infrequent eye contact	<input type="checkbox"/> No eye contact
	<input type="checkbox"/> Engages audience with gestures	<input type="checkbox"/> Some engagement with gestures	<input type="checkbox"/> Some distracting gestures	<input type="checkbox"/> Frequent distracting gestures
Presentation tools	<input type="checkbox"/> PPT background is matched to content, legible font, graphics, seamless transitions	<input type="checkbox"/> Appropriate background, font, transitions	<input type="checkbox"/> Distracting backgrounds, transitions, fonts hard to read	<input type="checkbox"/> No attention to backgrounds, transitions, fonts very hard to read
	<input type="checkbox"/> Appropriate graphics used	<input type="checkbox"/> Some graphics used to enhance presentation	<input type="checkbox"/> Graphics to not enhance presentation	<input type="checkbox"/> Distracting use of graphics

Physics and Engineering

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

Outcome Measure: PHY4072 and PHY4082 Senior Project Written Report.

ETS Proficiency Profile Exam

Criteria for Success (how do you judge if the students have met your standards):
PHY4072/PHY4082: 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:

PHY4072:

	Percentage of Students at 2.5 or higher								
	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20*	2020-21*
Written Report Rubric	75%	N/A	100%	100%	84%	64%	100%	No Data	80%

ETS:

	Percentage of Students Marginal or Proficient								
	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20*	2020-21*
ETS Proficiency Profile Level 2 Writing	100%	100%	75%	62%	94%	73%	87%	60%	86%

*COVID-19 Year

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). However in there was a significant drop in 2019-20 in the ETS score. This may be attributable to COVID or to the students not taking the exam particularly seriously because of not taking it in a classroom setting. However improvement was seen in 2020-21.

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

In 2018-19 the students met the benchmarks. In 2019-20, the year of the COVID-19 outbreak, spring writing data was not gathered. Data was again gathered in the 2020-21 year.

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.

Written Report Rubric: On the next page.

PHY-ENG Written Presentation Rubric

Criteria	Outstanding	High Satisfactory	Low Satisfactory	Unsatisfactory
Structural pieces	<input type="checkbox"/> Abstract is a clear and concise summary of all relevant results and descriptions in the order emphasized in the paper	<input type="checkbox"/> Abstract could be made clear and/or concise with minor changes	<input type="checkbox"/> Abstract is missing some information and/or contains unnecessary information	<input type="checkbox"/> Abstract does not contain necessary information
	<input type="checkbox"/> Introduction indicates precise subject, scope, and purpose	<input type="checkbox"/> Introduction is missing one of the following: precise subject, scope or purpose	<input type="checkbox"/> Introduction is missing two of the following: precise subject, scope or purpose	<input type="checkbox"/> Introduction does not give precise subject, scope and purpose
	<input type="checkbox"/> Main body is well organized, logical and contains all necessary information without extra information	<input type="checkbox"/> Main body lacks some organization	<input type="checkbox"/> Main body is missing some important pieces and/or is not well organized	<input type="checkbox"/> Main body is not well organized, lacks logical arguments and relevant data
	<input type="checkbox"/> Conclusion appropriately sums up, gives conclusions, and recommendations	<input type="checkbox"/> Conclusion does two of the following: sums up, gives conclusions, and recommendations	<input type="checkbox"/> Conclusion does one of the following: sums up, gives conclusions, and recommendations	<input type="checkbox"/> Conclusion does not provide any summation, conclusions, or recommendations
	<input type="checkbox"/> Multiple references from reputable sources	<input type="checkbox"/> Most references from distinct reputable sources	<input type="checkbox"/> Some references from reputable sources	<input type="checkbox"/> No bibliography or all references from untrusted sources
	<input type="checkbox"/> References cited in the body of the document	<input type="checkbox"/> Some citations of reference in the body	<input type="checkbox"/> Limited citation references	<input type="checkbox"/> No citation of references
Data	<input type="checkbox"/> Data is clearly presented in properly formatted tables, figures and graphs where appropriate	<input type="checkbox"/> Some data could be presented more clearly	<input type="checkbox"/> Data is poorly presented and some key data is missing	<input type="checkbox"/> Several pieces of key data are missing
	<input type="checkbox"/> All uncertainties are shown and error propagation is carried out where appropriate	<input type="checkbox"/> Most uncertainties are shown and propagation of error carried out	<input type="checkbox"/> Many uncertainties are missing and/or propagation or error not carried out correctly	<input type="checkbox"/> No uncertainties of measurements are shown
Grammar, spelling and style	<input type="checkbox"/> No grammatical or spelling errors	<input type="checkbox"/> Few grammatical and spelling errors	<input type="checkbox"/> Some grammatical and spelling errors	<input type="checkbox"/> Many grammatical and spelling errors
	<input type="checkbox"/> Equations well formatted and variables introduced as needed	<input type="checkbox"/> A few errors in formatting equations	<input type="checkbox"/> Poorly formatted equations	<input type="checkbox"/> Incorrect equations
	<input type="checkbox"/> Appropriate style (no first-person, past tense when reporting was done)	<input type="checkbox"/> A few informal statements and/or tense	<input type="checkbox"/> Several areas which are too informal and tense errors	<input type="checkbox"/> Very informal and/or use of future tense where not appropriate
	<input type="checkbox"/> Clear sentences and ideas are presented in a way that won't be misunderstood	<input type="checkbox"/> A few unclear sentences	<input type="checkbox"/> Many complex and unclear sentences	<input type="checkbox"/> Many sentences are unclear and have overly complex construction
	<input type="checkbox"/> Concise and quantitative as subject matter permits	<input type="checkbox"/> A few unnecessary words and ideas	<input type="checkbox"/> Frequent extra and inexact words	<input type="checkbox"/> Many vague, inexact, and/or idle words
	<input type="checkbox"/> Arguments are complete and logical	<input type="checkbox"/> Most arguments are complete	<input type="checkbox"/> Several arguments are difficult to follow	<input type="checkbox"/> Arguments are incomplete, illogical, and may contain unnecessary information and specialized jargon

Physics 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: PHY4072 Senior Lab Written Technical Report.

Criteria for Success (how do you judge if the students have met your standards):

PHY4072/PHY4082: 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	2019-20*	2020-21*
Written Report Rubric IL	25%	N/A	63%	86%	53%	43%	44%	No Data	80%

*COVID-19 Year

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. In 2019-20 due to COVID-19 writing data was not gathered. In 2020-21 the student scores bounced back. We are still analyzing the data, but I may simply be a matter of the variation created by a relatively small sample size.

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: PHE Written Report Rubric

PHY-ENG Written Presentation Rubric

Criteria	Outstanding	High Satisfactory	Low Satisfactory	Unsatisfactory
Structural pieces	<input type="checkbox"/> Abstract is a clear and concise summary of all relevant results and descriptions in the order emphasized in the paper	<input type="checkbox"/> Abstract could be made clear and/or concise with minor changes	<input type="checkbox"/> Abstract is missing some information and/or contains unnecessary information	<input type="checkbox"/> Abstract does not contain necessary information
	<input type="checkbox"/> Introduction indicates precise subject, scope, and purpose	<input type="checkbox"/> Introduction is missing one of the following: precise subject, scope or purpose	<input type="checkbox"/> Introduction is missing two of the following: precise subject, scope or purpose	<input type="checkbox"/> Introduction does not give precise subject, scope and purpose
	<input type="checkbox"/> Main body is well organized, logical and contains all necessary information without extra information	<input type="checkbox"/> Main body lacks some organization	<input type="checkbox"/> Main body is missing some important pieces and/or is not well organized	<input type="checkbox"/> Main body is not well organized, lacks logical arguments and relevant data
	<input type="checkbox"/> Conclusion appropriately sums up, gives conclusions, and recommendations	<input type="checkbox"/> Conclusion does two of the following: sums up, gives conclusions, and recommendations	<input type="checkbox"/> Conclusion does one of the following: sums up, gives conclusions, and recommendations	<input type="checkbox"/> Conclusion does not provide any summation, conclusions, or recommendations
	<input type="checkbox"/> Multiple references from reputable sources	<input type="checkbox"/> Most references from distinct reputable sources	<input type="checkbox"/> Some references from reputable sources	<input type="checkbox"/> No bibliography or all references from untrusted sources
	<input type="checkbox"/> References cited in the body of the document	<input type="checkbox"/> Some citations of reference in the body	<input type="checkbox"/> Limited citation references	<input type="checkbox"/> No citation of references
Data	<input type="checkbox"/> Data is clearly presented in properly formatted tables, figures and graphs where appropriate	<input type="checkbox"/> Some data could be presented more clearly	<input type="checkbox"/> Data is poorly presented and some key data is missing	<input type="checkbox"/> Several pieces of key data are missing
	<input type="checkbox"/> All uncertainties are shown and error propagation is carried out where appropriate	<input type="checkbox"/> Most uncertainties are shown and propagation of error carried out	<input type="checkbox"/> Many uncertainties are missing and/or propagation or error not carried out correctly	<input type="checkbox"/> No uncertainties of measurements are shown
Grammar, spelling and style	<input type="checkbox"/> No grammatical or spelling errors	<input type="checkbox"/> Few grammatical and spelling errors	<input type="checkbox"/> Some grammatical and spelling errors	<input type="checkbox"/> Many grammatical and spelling errors
	<input type="checkbox"/> Equations well formatted and variables introduced as needed	<input type="checkbox"/> A few errors in formatting equations	<input type="checkbox"/> Poorly formatted equations	<input type="checkbox"/> Incorrect equations
	<input type="checkbox"/> Appropriate style (no first-person, past tense when reporting was done)	<input type="checkbox"/> A few informal statements and/or tense	<input type="checkbox"/> Several areas which are too informal and tense errors	<input type="checkbox"/> Very informal and/or use of future tense where not appropriate
	<input type="checkbox"/> Clear sentences and ideas are presented in a way that won't be misunderstood	<input type="checkbox"/> A few unclear sentences	<input type="checkbox"/> Many complex and unclear sentences	<input type="checkbox"/> Many sentences are unclear and have overly complex construction
	<input type="checkbox"/> Concise and quantitative as subject matter permits	<input type="checkbox"/> A few unnecessary words and ideas	<input type="checkbox"/> Frequent extra and inexact words	<input type="checkbox"/> Many vague, inexact, and/or idle words
	<input type="checkbox"/> Arguments are complete and logical	<input type="checkbox"/> Most arguments are complete	<input type="checkbox"/> Several arguments are difficult to follow	<input type="checkbox"/> 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 PHY3004L.

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	2019-20	2020-21
Teamwork Rubric (teams)	86%	95%	94%	94%	91%	86%	100%	100%

Conclusions Drawn from Data: This is a highly cooperative class and the students ratings are consistent with observed behavior. Overall students tend to rate each other very highly.

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 to help shape their ratings of each other.

**Physics and Engineering Teamwork Rubric
(PHY3004L)**

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