Learning Outcome: 1e. Quantitative Reasoning: Students will be able to solve problems that are quantitative in nature.

Components of this outcome as defined by the department:
- Translation of words into equations and conclusions
- Calculations and mathematical reasoning
- Reasonable and realistic view of nature

Outcome Measure: Questions embedded in the final exam are the basis for assessment in all GE Physics and Physical Science classes.
PHY1034 The Physics of Sound and Music (formerly PHY113)
PHY1044 General Physics I (formerly PHY141)
PHY1054 General Physics II (formerly PHY142)
PHY2044 University Physics (formerly PHY241)
PSC1004 The Cosmos (formerly PSC105)
PSC1014 Physical Science for Teachers (formerly PSC110)

Criteria for Success: At least 70% of students will have an average above 2.5 on each area of the Physics and Engineering Quantitative Reasoning Rubric. These aspects of quantitative reasoning in a scientific context are as follows: (1) translating graphs and words into equations and conclusions (2) calculation and mathematical reasoning (3) reasonable view of nature.

Scale Used:
0   Unsatisfactory - Completely Incorrect
1   Low Satisfactory - Missed more than one key concept or step
2   Satisfactory - Missed one key concept or step
3   High Satisfactory - Made a minor error
4   Outstanding - Completely correct

Longitudinal Data:

		Translate words or graphis into equations and conclusions	Calculations and mathematical reasoning	Reasonable and realistic view of nature
PHY141	Summer 2014	100%	100%	67%
PHY141	Summer 2015	100%	100%	83%
PHY141	Summer 2016	98%	90%	88%
PHY141	Summer 2017	100%	100%	100%
PHY141	Fall 2017	95%	85%	90%
PHY141	Summer 2018	100%	95%	95%
PHY141	Fall 2018	89%	84%	74%
PHY141	Summer 2019	80%	100%	85%
PHY1044	Fall 2019	68%	100%	79%
PHY1044	*Summer 2020*	*100%*	*100%*	*100%*
PHY1044	*Spring 2021*	*90%*	*100%*	*95%*
PHY1044	*Fall 2021*	*94%*	*100%*	*89%*
PHY1044	Fall 2022	85%	100%	95%
PHY142	Spring 2017	70%	90%	75%
PHY142	Summer 2017	84%	100%	68%
PHY142	Spring 2018	90%	95%	85%
PHY142	Summer 2018	100%	100%	100%
PHY142	Spring 2019	95%	95%	89%
PHY142	Summer 2019	85%	85%	90%
PHY1054	*Spring 2020*	*100%*	*100%*	*100%*
PHY1054	*Fall 2020*	*69%*	*85%*	*77%*
PHY1054	*Spring 2021*	*85%*	*100%*	*100%*
PHY1054	Spring 2022	95%	85%	50%
PHY1054	Spring 2023	75%	75%	80%
PHY241	Spring 2015	100%	96%	100%
PHY241	Spring 2017	100%	100%	95%
PHY241	Spring 2018	84%	100%	89%
PHY241	Fall 2018	90%	90%	80%
PHY2044	Fall 2019	90%	100%	95%
PHY2044	*Fall 2020*	*100%*	*100%*	*100%*
PHY2044	*Fall 2021*	*85%*	*90%*	*85%*
PHY2044	Fall 2022	90%	85%	90%
PSC105	Spring 2016	57%	85%	86%
PSC105	Fall 2016	100%	65%	88%
PSC105	Spring 2017	90%	100%	95%
PSC105	Fall 2017	95%	95%	90%
PSC105	Spring 2018	85%	90%	90%
PSC105	Summer 2018	100%	100%	94%
PSC105	Fall 2018	94%	94%	89%
PSC105	Spring 2019	95%	95%	100%
PSC1004	Fall 2019	90%	95%	80%
PSC1004	*Spring 2020*	*100%*	*95%*	*63%*
PSC1004	*Summer 2020*	*89%*	*83%*	*89%*
PSC1004	*Spring 2021*	*94%*	*79%*	*100%*
PSC1004	*Fall 2021*	*95%*	*89%*	*95%*
PSC1004	*Spring 2022*	*85%*	*80%*	*65%*
PSC1004	Fall 2022	100%	90%	100%
PSC111	Fall 2017	90%	95%	95%
PSC111	Fall 2018	75%	90%	85%
PSC1014	Fall 2019	85%	85%	85%
PSC1014	*Fall 2020*	*85%*	*90%*	*95%*
PSC1014	*Spring 2021*	*100%*	*100%*	*100%*
PSC1014	*Fall 2021*	*81%*	*81%*	*94%*
PSC1014	Fall 2022	80%	80%	100%
PHY113	Fall 2018	84%	89%	89%
PHY1013	Fall 2019	89%	95%	100%
PHY1034	Fall 2019	89%	95%	100%
PHY1034	*Spring 2021*	*92%*	*100%*	*100%*
PHY1034	*Fall 2021*	*91%*	*91%*	*91%*
PHY1034	Fall 2022	100%	100%	100%

Italics represent the terms during the COVID pandemic.

PSC1004 and PHY1044 were not assessed in Fall 2020. This was due to the complexity of conducting the assessment in an all remote pandemic semester.

Note that the following changes have been made in the GE course offerings:
- PSC103 Earth Science has been eliminated as a GE class (data removed from data set)
- PSC110 Physical Science has been eliminated as a GE class (data removed from data set)
- PSC1014 Physical Science for Teachers has been added as a GE offering focused specifically on the preparation of elementary school teachers (this replaced PHY111)
- PHY1013 The Physics of Sound and Music is a new GE class and was subsequently renumbered PHY1034.

Conclusions Drawn from Data: Overall general education classes created for students who are not in scientific majors (PSC1004, PSC1014 and PHY1034) tend to have a slightly lower level of success on calculation and mathematical reasoning within a scientific context than the introductory physics classes. This is not surprising in that PHY1044, PHY1054 and PHY2044 have significant mathematical pre-requisites, and it is observed that these students are succeeding at applying these skills in a scientific context.

The PSC courses tend to emphasize the reasonable view of nature category, and the corresponding student understanding can be observed in the measures used. PHY1044, PHY1054 and PHY2044 include a considerable amount of quantitative reasoning. The measures used in these courses are not calibrated to the PSC courses, but are instead designed to identify areas of potential improvement within the context of the expected level of these courses. The measures used tended to be of a more sophisticated nature.

Changes to be Made Based on Data:
Prior to 2015-16, PSC1004 did not incorporate significant use of quantitative reasoning. These skills were integrated and measured starting in 2017-18. In addition, in 2017-18, the Physical Science GE course (PSC111/PSC1014) was reshaped to include an increased emphasis on quantitative reasoning.

Overall the students are meeting our criteria for success and did reasonably well during the COVID pandemic.

Physics and Engineering GE Quantitative Reasoning Rubric
(PHY1034, PHY1044, PHY1054, PHY2044, PSC1004, PSC1014)

Criteria	Outstanding	High Satisfactory	Low Satisfactory	Unsatisfactory
Translating words or graphs into equations or conclusions	☐ No mistakes	☐ Few mistakes, mostly correct	☐ Several mistakes, some understanding	☐ Many mistakes, not interpreting information
Calculation and Math reasoning	☐ No mistakes	☐ Few mistakes	☐ Several mistakes	☐ Many mistakes (incorrect use of data and equations)
Reasonable and realistic view of nature (sense of scale, etc.)	☐ Good understanding	☐ Minor misunderstandings	☐ Some clear understandings mixed with some misunderstandings	☐ Significant misunderstandings