Physics and Engineering
General Education 1E: Quantitative Reasoning

GELO 1E. Quantitative Reasoning: Students will be able to solve problems that are quantitative in nature.

Measure: Final exam questions embedded in the following general education courses: University Physics (PHY241), General Physics (PHY141), and Cosmos (PSC105). Select questions through through the semester in tests, quizzes, and homework were compiled for use in Earth Science (PSC103).

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.

Longitudinal Data:
Listed below are the data from the General Education courses using measures of the following aspects of solving quantitative problems in the context of a physical scientist:

Aspect 1: translating graphs and words into equations and conclusions

Aspect 2: calculation and mathematical reasoning

Aspect 3: hold a reasonable view of nature (such as sense of scale, etc.)

PHY141: General Physics

	2016Su	2015Su	2014Su
N of Students	40	30	24
Aspect 1 Above 2.5	98%	100%	100%
Aspect 2 Above 2.5	90%	100%	100%
Aspect 3 Above 2.5	88%	83%	67%
Achieved Criteria	yes	yes	no

PSC105: Cosmos*

	2016S	2015F
N of Students	42	24
Aspect 1 Above 2.5	57%	96%
Aspect 2 Above 2.5	85%	92%
Aspect 3 Above 2.5	86%	100%
Achieved Criteria	no	yes

PHY241: University Physics

	2016S	2015S
N of Students	-	23
Aspect 1 Above 2.5	-	100%
Aspect 2 Above 2.5	-	96%
Aspect 3 Above 2.5	-	100%
Achieved Criteria	-	yes

PSC103: Earth Science

	2015F	2014F
N of Students	37	36
Aspect 1 Above 2.5	79%	87%
Aspect 2 Above 2.5	77%	87%
Aspect 3 Above 2.5	87%	77%
Achieved Criteria	yes	yes

* Data from F15 PHY105 was not a random sample

Additional Data for PHY141:

PHY141: General Physics

	2013F	2012F	2010F	2009F
N of Students	43	51	47	50
Aspect 1 Above 2.5	98%	98%	93%	100%
Aspect 2 Above 2.5	100%	100%	96%	100%
Aspect 3 Above 2.5	75%	82%	72%	86%
Achieved Criteria	yes	yes	yes	yes

Conclusions Drawn from Data:
Overall PSC classes (Earth Science and Cosmos) tend to have a lower level of success on calculation and mathematical reasoning within a scientific context then the introductory physics classes. This is not surprising in that PHY141 and PHY241 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 was observed in the measures used.

PSC105 demonstrated high success the first semester and lower level of success the second semester. The measurement tool on the final exam was slightly adjusted between semesters, and may still need some modifications. The spring semester translation aspect did emphasize a particular skill (using HR diagrams) and in the future a wider range of questions might be useful to analyze. This year was the first year quantitative reasoning was emphasized in this course. Additionally this sample was not random in Fall of 2015 (as several exams were returned before analysis) and data in the future probably should not be compared to these numbers.

PHY141 and PHY241 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. This being said, PHY141 consistently shows low success in a reasonable view of nature. The measures used in the this course in this category tend to focus on the correction of misconceptions that students may hold coming into class, and some of these misconceptions tend to be held even after completing the class.

Changes to be Made Based on Data: Prior to 2014-15, PSC103 did not incorporate significant aspects of calculation (the second criteria). This was increased in the last two years.

Prior to 2015-16, PSC105 did not incorporate significant use of quantitative reasoning. These skills were integrated and measured beginning this year.

Rubric Used: Physics and Engineering Quantitative Reasoning Rubric

	Outstanding (4)	High satisfactory (3)	Low Satisfactory (2)	Unsatisfactory (1)
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