GE Standard VIII: Quantitative Standard

Courses seeking to meet the Quantitative Standard must:

(i) Require students to engage in particular activities, and
(ii) Use direct assessment to demonstrate improvement of student skills in particular areas

To meet the Standard, courses must address *each* of the following four areas, and direct assessment must be used in *each* of the four areas.

The specific requirements for addressing and assessing each Area follow, and are listed under the Area headings themselves. One page is devoted to each of the four Areas.

Physics 161: Physics I

Area 1: Comprehension of Quantitative Language

Briefly describe contexts in which your course will require students to do one or more of the things listed in the following bullet point:

- Interpret and explain information presented in standard quantitative formats such as graphs, mathematical expressions, equations, diagrams, tables, and English text.

These activities pervade Physics I. The data gathered in laboratories is often presented in graphical and/or tabular form. The near entirety of the course content is captured in a single mathematical equation, and students are tasked with using this equation to predict behavior in myriad situations. Students must commonly move back and forth between textual and mathematical expressions of ideas.

Your course is asked to demonstrate improvement in one or more of the following student skills:

- The ability to extract basic information from graphs, diagrams, or tables
- The ability to identify trends appearing in graphs, diagrams, or tables, and the ability to extrapolate from them
- The ability to extract quantitative information from English text, mathematical expressions, or mathematical equations

Describe what direct assessments you will use in order to demonstrate improvement of such skills among your students.

Bullet 1: Five of the laboratory activities in the course have sections tagged as "QG" sections, in which students must extract information from non-trivial graphical or tabular data. Class average score on these sections is reported. Class improvement by lab activity is progressively tracked.
Bullet 3: Ten of the Quiz questions (Weeks 4-14) are tagged as "QE" questions, in which quantitative data must be extracted purely from text. First Quiz performance vs. average quiz performance is recorded for each student, and class percentage improving is reported.
Bullet 3: A subset of 15 mathematically intensive Quiz questions are tagged as "QM" questions. First Quiz performance vs. average quiz performance is recorded for each student, and class percentage improving is reported.

Area 2: Expression through Quantitative Language

Briefly describe contexts in which your course will require students to do one or more of the things listed in the following bullet point:

- Communicate ideas through the appropriate use of standard quantitative formats such as graphs, equations, diagrams, tables, and English text.

Communication as described above is an extremely common task in Physics 161. Students are asked to do so on several quizzes and during several laboratory activities.

Your course is asked to demonstrate improvement in one or more of the following student skills:

- The ability to communicate information through the use of graphs, diagrams, or tables
- The ability to communicate quantitative information through the use of English text, mathematical expressions, or mathematical equations

Describe what direct assessments you will use in order to demonstrate improvement of such skills among your students.

Bullet 1: Several quiz questions (tagged as 'CG') occur between weeks 3 and 14 of the term. In such questions, motion is described, and students must express this motion graphically and/or diagrammatically. Initial student CG score and final average CG score are reported.
Bullet 2: Several quiz questions (tagged as 'CGEQ') occur between weeks 3 and 14 of the term. In such questions, students are presented with graphical information and are asked to re-express the information using mathematical equations. Initial student CGEQ score and final average CGEQ score are reported.

Area 3: Mathematical Fluency

Briefly describe contexts in which your course will require students to do one or more of the things listed in the following bullet point:

- Use algebraic, geometric, arithmetic, and statistical methods when appropriate in the solutions of problems.

Algebra, geometry, arithmetic, trigonometry, and calculus are required in the solution of almost all Physics 161 quiz and homework problems.

Your course is asked to demonstrate improvement in one or more of the following student skills:

- The understanding of mathematical expressions, including variables and functions of variables
- The understanding of mathematical equations
- The ability to manipulate mathematical expressions, including the ability to perform simple algebraic operations

Describe what direct assessments you will use in order to demonstrate improvement of such skills among your students.

Bullets 1, 2, & 3: Almost every quiz question in Physics I (weeks 3-14) requires all three of the skills listed in the bullet points above. 25 mathematically intensive quiz questions are tagged as "MF" questions. Initial student MF score and final average MF score are reported.

Area 4: Data Driven Argumentation

Briefly describe contexts in which your course will require students to do one or more of the things listed in the following bullet point:

- Analyze quantitative data, understand any limits and/or assumptions inherent in a set of data, and be able to use data to formulate and defend arguments based upon that data.

Data taking and the interpretation thereof occurs during every laboratory in Physics 161.

Your course is asked to demonstrate improvement in one or more of the following student skills:

- The ability to use quantitative data to make coherent arguments for or against various conclusions that might be drawn from the data
- The ability to examine critically conclusions claimed to follow from a set of quantitative data by using the data itself
- The understanding of the sources of uncertainty in empirical data, and the ability to estimate the sizes of such uncertainties
- The understanding of the assumptions, uncertainties, and limits of applicability inherent in a given quantitative analysis
- The ability to estimate/approximate quantities when a complete measurement and/or calculation is impossible.

Describe what direct assessments you will use in order to demonstrate improvement of such skills among your students.

Bullet 3: 7 laboratories distributed equally throughout the term will have “data & uncertainty” sub-scores. Student improvement will be tracked by reporting class average performance on these sections by week.
Bullet 5: Following Unit 2, Order of Magnitude questions (tagged “OOM”) appear sporadically on quizzes. Class average performance on OOM questions is tracked by week.