

Quantitative Reasoning and / or Quantitative Literacy

CSU Stanislaus Quantitative Reasoning Working Group
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<http://csustan.csustan.edu/qr>

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Our Definition,
Expanded Definition,
and
Rubrics
of
Quantitative Reasoning

A General Mission Statement / Definition

Quantitative Literacy(QL) – also known as Quantitative Reasoning (QR) – is a “quantitative habit of mind”, proficiency, and comfort in dealing with and rationally processing numerical data. Individuals with strong QL skills possess the ability to analyze quantitative problems in everyday life situations using logical reasoning steps. They are able to read and understand numerical data. They can create valid arguments based on quantitative evidence and know how to interpret their conclusions. They are capable of clearly communicating their analyses and arguments in a variety of formats (including words, tables, graphs, mathematical equations and models, as appropriate).

Expanded definition:

The formal definition of Quantitative Literacy implies competency in different fields of basic mathematics, and their application to diverse problems in the sciences, business and administration, politics, economics, and in everyday life. Most importantly, QL requires an understanding of the mathematics that is deeper than mere memorization of, and facility with, calculation procedures. Possession of strong QL skills requires competency in critical areas:

1. Approximation / estimation – The ability to do effective approximation and estimation.
2. Mathematical models – The ability to understand the assumptions behind mathematical models, and the implications that those assumptions have for the validity and scope of conclusions that are drawn.
3. Tables and graphs – The ability to represent and understand data in graphical forms and other visual representations.
4. Algebra – The ability to understand and manipulate algebraic equations, including the ability to draw conclusions from functional dependencies. Competency in this area thus goes beyond the ability to substitute for known variables and to perform the requisite arithmetic.

5. Geometry – The ability to think and visualize in higher dimensions, including an understanding of the dependencies of geometric properties, such as volume, on the dimensions of the shapes. The ability to express properties in terms of angles.
6. Statistics – The ability to draw appropriate conclusions from statistical data, including an understanding of statistical distributions and properties such as average, median, and standard deviation. The ability to incorporate uncertainties in the data when drawing conclusions.

Assessment of Overall Quantitative Literacy (1)

Topic	Proficient	Adequate	Deficient
Logical Quantitative Reasoning and Analysis	Can understand problems and develop their own innovative logical quantitative analyses	Can follow and reproduce logical quantitative analyses	Analyses are based principally on random thoughts and guesswork

Assessment of Overall Quantitative Literacy (2)

Topic	Proficient	Adequate	Deficient
Validity, applicability, and limitations of quantitative arguments	Adept at developing valid quantitative arguments and understanding their assumptions, applicability, and limitations	Can apply learned arguments to similar problems, but also tries to apply them to problems which are beyond the scope of the argument / analysis	Tries to solve all problems using the same strategies without adaptation.

Assessment of Specific Literacies

1. Approximation / Estimation

Proficient	Adequate	Deficient
Can effectively perform meaningful and novel estimates and approximations.	Can incorporate estimated data to estimate expected results.	Over reliance on calculators. Views all answers as precise. Unable to distinguish between accuracy and precision.

Curricular Modules:

We are developing various curricular modules in a variety of disciplines for integration into diverse upper division courses, including both major courses and upper division General Education courses.

Included here are brief overviews of several examples. Additional material is available here:

<http://csustan.csustan.edu/qr>

Example Curricular Modules

- Water
 - Spanish Literature class
 - Sociology Approach
- Estimation
 - Birth rate
 - Radioactive toxicity
- Universal Pre-School

Water

CSU Stanislaus Quantitative Reasoning with Water
Melanie Martin, Sandra Garcia-Sanborn, Jey Strangfeld
Computer Science, Modern Languages, Sociology

This module is designed for a Spanish Literature Class

Water -- A Story

- Read and analyze Costa Rican writer Carmen Naranjo's short story "Y vendimos la lluvia," published in 1989. English title: "And we sold the rain."
- The story satirizes the complexity and consequences of the economic dependency of developing countries.
- The core of the problem is that they have already exported all their primary resources: coffee, rice, sugar cane, vegetables, wood, etc., and the country and its people are still broke.

A Solution

- A middle-eastern Sultan hears of the land where rain abounds and a plan is hatched to sell the water to the Sultan for **10 dollars per cubic centimeter**.
- The consequences are economically and environmentally devastating for this developing country and its people, as they lose their main natural resources (due to the severe drought).
- How can we understand **10 dollars per cubic centimeter** as a price for water?

Water – a Sociology Focus

- Water Footprint Assessment
- Personal Water Footprint Calculator
- <http://waterfootprint.org/en/resources/interactive-tools/personal-water-footprint-calculator/>
- Footprint Calculator – the water footprint calculator in its most simplistic and basic form asks respondents to answer the following questions
 - Country of residence
 - Gender (closed-ended, male/female)
 - Individual portion of family income (open-ended, in dollars)
 - Vegetarian or meat consumer (closed-ended, vegetarian, average, and high meat consumption. “Average” and “High” are subjective)

Pre-Assessment

- Understanding the impact of class and wealth on water use.
- Testing: Rubric 3: Understanding Tables and Graphs (Questions 1-5)
 - Rubric 1: Estimation (Questions 4-5)
 - Rubric 4: Algebraic/Symbolic Approaches (Question 3)
- The pie-charts below indicate water usage by country income level and sector usage. Compare water use information in the three charts. What is water used for primarily in terms of world global consumption, consumption in low and middle income countries, and consumption in high income countries?

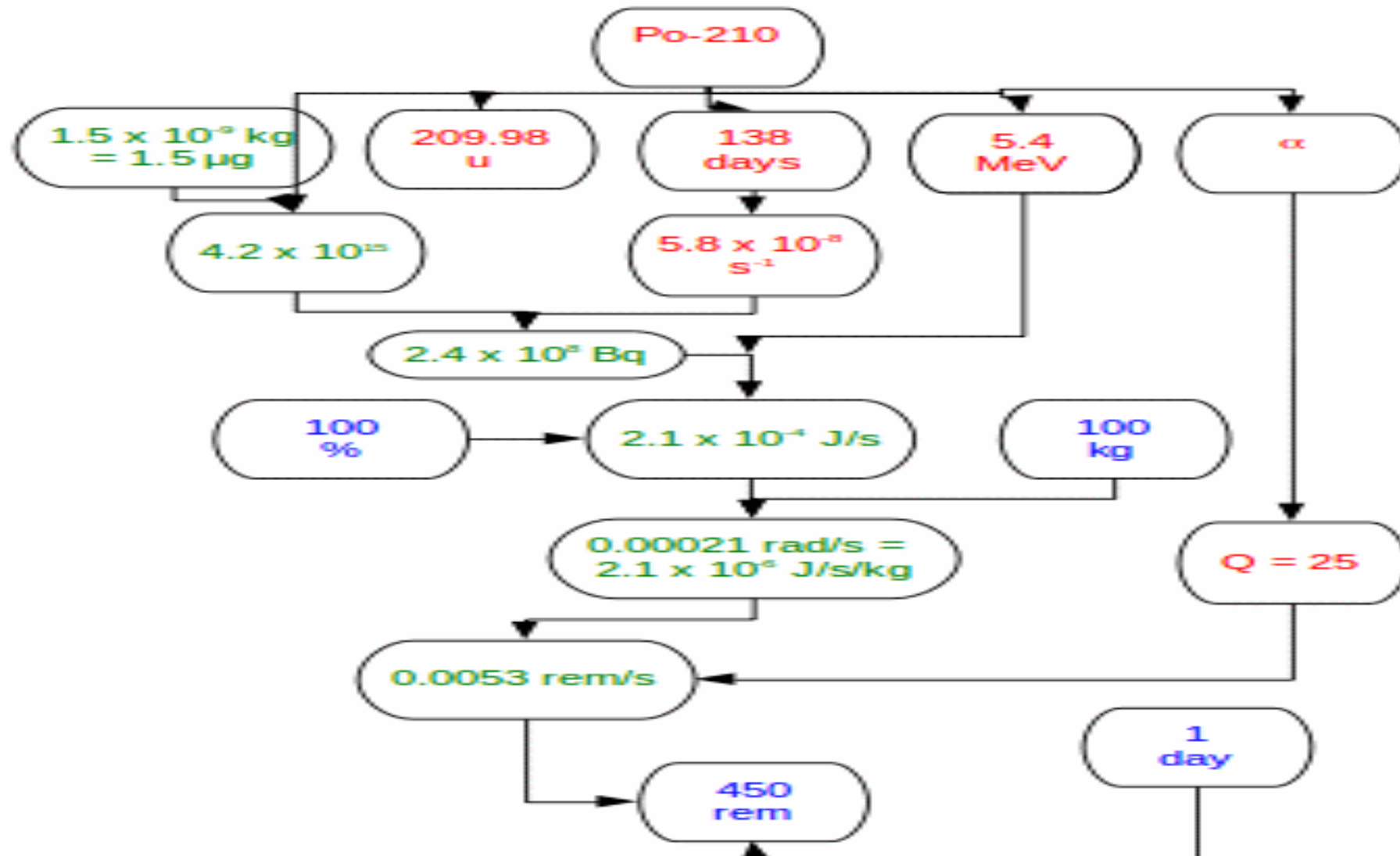
Estimation

This module is being used in upper division General Education, paired courses between English and Physics.

Introduction

- This exercise was meant to develop a class estimate of the amount of radioactive material which was given to Alexander Litvinenko, a Russian dissident living in exile in London. All the required physics has been covered already in class, after which there are two remaining problems
- There are a number of steps involved, and for non-science majors to navigate their way through them is asking a lot.
- Although some quantities are known (principally from the properties of the radioactive isotope) others are not and reasonable assumptions have to be made.
- We start with an unrelated example to introduce the idea of estimation before tackling the problem at hand.

Figure 1b: Assignment of variables. Known variables are in red, assumed variables in blue, and calculated variables in green.



Should the State assure universal pre-school opportunities for all children?

A Quantitative Reasoning Approach

Melanie Martin

Stepping Back

- Why are we asking this?
- Is there a problem?
- If there is a problem what is the scale?
- What is the interest of the state in this?
- How would we make a decision?
 - Money
 - Cheaper than prison later
 - Educational outcomes
 - More likely to finish high school, college

What Data Do I Need?

- What is the current situation:
 - when do kids start school in CA,
 - is Transitional Kindergarten universally available,
 - what preschool programs are available
 - Are available programs effective?

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FIN