

TMM011 – QUANTITATIVE REASONING (Endorsed December 21, 2015)

Typical Range: 3-4 Semester Hours

Recommendation: This course should significantly reflect the Mathematical Association of America's Undergraduate Programs and Courses in the Mathematical Sciences: CUPM Curriculum Guide 2004:

“Engage students in a meaningful intellectual experience. Students must learn with understanding, focusing on relatively few concepts but treating them in depth. Treating ideas in depth includes presenting each concept from multiple points of view and in progressively more sophisticated contexts. For example, students are likely to improve their understanding more by writing analyses of a single situation that combines two or three mathematical ideas than by solving half a dozen problems using each idea separately.

Increase students’ quantitative and logical reasoning abilities. Departments should encourage and support their institutions in establishing a quantitative literacy program for all students, with the primary goal of developing the intellectual skills needed to deal with quantitative information as a citizen and in the workplace. This program should ensure that all introductory and general education mathematics courses make a significant contribution toward increasing students’ quantitative reasoning abilities . . . Students in these courses should also have the opportunity to use a variety of mathematical strategies—seeking the essential, breaking difficult questions into component parts, looking at questions from various points of view, looking for patterns—in diverse settings.

Improve students’ ability to communicate quantitative ideas. “A Collective Vision: Voices of the Partner Disciplines” reports that nearly every discipline promotes the importance of having students communicate mathematical and quantitative ideas—both orally and in writing.

Encourage students to take other courses in the mathematical sciences. On the one hand, general education courses provide the last formal mathematics experience for most students and so must stand on their own intrinsic merits. On the other hand, they should be designed to serve as gateways and enticements for other mathematics courses.

Strengthen mathematical abilities that students will need in other disciplines. As reported in “A Collective Vision: Voices of the Partner Disciplines,” faculty representing other disciplines emphasized the importance of mathematical modeling. Students should be able to create, analyze, and interpret basic mathematical models from informal problem statements; to argue that the models constructed are reasonable; and to use the models to provide insight into the original problem.”

Undergraduate Programs and Courses in the Mathematical Sciences: CUPM Curriculum Guide 2004. Please see the entire 2004 CUPM for the complete set of recommendations being made

by the MAA on courses for non-STEM majors, which forms the basis for the outcome choices made herein.

An updated CUPM was released in 2015. What follows below is information from its introduction.

“The previous CUPM Curriculum Guide was published in 2004; it was followed by several related publications. Among them we call particular attention to the work of the CUPM subcommittee on Curriculum Renewal Across the First Two Years (CRAFTY) on the Curriculum Foundations Project, which emphasized the use of mathematics in other disciplines, and informs this Guide. Recommendations in this Guide reflect CUPM’s reaffirmation of the principles in the 2004 Guide. Those principles, approved by MAA’s Board of Governors in 2003 and reapproved in August 2014 can be found online. The 2004 Guide addressed the full range of mathematics offerings, including general education, service, and major courses. This Guide does not systematically address these non-major courses. This Guide focuses specifically on the design of mathematics majors, addressing the curricular demands of the wide and widening variety of mathematics programs now found across the nation. That diversity often leads to minors, concentrations, double majors, and interdisciplinary majors, as well as full majors in new and developing mathematically rich fields. The purpose of this Guide is to help departments adapt their undergraduate curricula to this changing landscape while maintaining the essential components of the traditional mathematics major.”

The primary student population of a Quantitative Reasoning course is typically students seeking a Bachelor’s of Arts degree requiring a ‘liberal-arts’ mathematics course. In addition, many other majors such as Nursing, Economics, and those requiring basic chemistry would benefit from such a course offering being included in their program of study.

As such, a Quantitative Reasoning course needs to highly emphasize the core mathematical general education outcome, critical thinking, as its primary objective and outcome. Through class discussion and working together in small groups, students can be facilitated in the development of the following core Quantitative Reasoning outcomes referenced in the 2015 CUPM:

1. *Interpretation*: Ability to glean and explain mathematical information presented in various forms (e.g., equations, graphs, diagrams, tables, words).
2. *Representation*: Ability to convert information from one mathematical form (e.g., equations, graphs, diagrams, tables, words) into another.
3. *Calculation*: Ability to perform arithmetical and mathematical calculations.
4. *Analysis/Synthesis*: Ability to make and draw conclusions based on quantitative analysis.
5. *Assumptions*: Ability to make and evaluate important assumptions in estimation, modeling, and data analysis.
6. *Communication*: Ability to explain thoughts and processes in terms of what evidence is used, how it is organized, presented, and contextualized.”

Boersma, S., Diefenderfer, C. L., Dingman, S. W., & Madison, B. L. (2011). Quantitative reasoning in the contemporary world.

To qualify for TMM011 (Quantitative Reasoning), a course must achieve all of the following essential learning outcomes listed in this document (marked with an asterisk). The Sample Tasks are recommendations for types of activities that could be used in the course.

The successful Quantitative Reasoning student should be able to demonstrate these competencies:

- 1. NUMERACY:** Students will develop and use the concepts of numeracy to investigate and explain quantitative relationships and solve problems in a variety of real-world contexts. *(The teaching of numeracy is intended to both deepen and broaden understanding achieved in K-12, keeping the development and use of all but the most basic algebraic procedures to a minimum. One strategy to help students to deepen their knowledge and understanding is to require students to explain their thinking verbally and/or in writing and to receive feedback as they solve problems. Peer group discussions and reports may be a useful way to achieve this goal. Problems requiring rote use of arithmetic or algebraic procedures should be de-emphasized, except when these procedures are essential to gaining deep conceptual understanding. Traditional textbook word problems are often artificial. In this course, realistic problems from a variety of realistic situations should be presented for discussion and solution. Technology should be used wherever appropriate.)*

- 1.1 Solve real-world problems requiring the use and interpretation of ratios in a variety of contexts: Parts to whole comparisons, converting decimals to percentages and vice versa, quantifying risks by calculating and interpreting probabilities, rates of change, and margins of error.***

Sample Tasks:

- a. Calculate income taxes using federal tax tables.
- b. Interpret a news release of a medical intervention study mathematically by building tables with which false negatives and positives, sensitivity and specificity, can be analyzed to draw conclusions.
- c. Given an excerpt concerning declining newspaper print readership, calculate and report on both the percentage point decline and the percentage decline.

- 1.2 Solve real-world problems relating to rates of change, distinguishing between and utilizing models that describe absolute change and relative change including growth and decay.***

Sample Tasks:

- a. Demonstrate the correct use of absolute differences, reference values and relative changes to compare the rates of depreciation of select autos.
- b. Interpret, analyze and explain a U.S. census report about smoking and distinguish quantitative data referring to absolute changes and that referring to relative changes.

- c. Describe the relationship between absolute change and linear models and the relationship between relative change and exponential models.

1.3 Compare and contrast statements which are proportional and those that are not, applying proportional reasoning appropriately to real-world situations such as scaling, dimensional analysis and modeling.*

Sample Tasks:

- a. Convert between different currencies.
- b. Determine if the weight of a substance is proportional to its volume and compare that to whether the population of an area is proportional to the size of the area.
- c. In general, recognize in a contextual setting the need for dimensional analysis and the ability to apply proportional reasoning to calculate such changes in representation.

1.4 Demonstrate numerical reasoning orally and/or by writing coherent statements and paragraphs.*

Sample Task:

Student proficiency in this area would be demonstrated by the ability to communicate specific and complete information in such a way that the reader or listener can understand the contextual and quantitative information in a situation in addition to whatever quantitative and/or qualitative conclusions have been drawn.

2. Mathematical Modeling: Students will make decisions by analyzing mathematical models, including situations in which the student must recognize and/or make assumptions.

(The teaching of mathematical modeling is intended to both deepen and broaden understanding achieved in K-12, keeping the development and use of all but the most basic algebraic procedures to a minimum. One strategy to help students to deepen their knowledge and understanding is to require students to explain their thinking verbally and/or in writing and to receive feedback as they solve problems. Peer group discussions and reports may be a useful way to achieve this goal. Problems requiring rote use of algebraic procedures should be de-emphasized, except when these procedures are essential to gaining deep conceptual understanding. Traditional textbook word problems are often artificial. In this course, realistic problems from a variety of realistic situations should be presented for discussion and solution. Technology should be used wherever appropriate.)

2.1 Create and use tables, graphs, and equations to model real-world situations including: using variables to represent quantities or attributes, estimating solutions to real-world problems using equations with variables, identifying pattern behavior, identifying how changing parameters can affect results, and identifying limitations in proposed models.*

Sample Tasks:

- a. Create a table and graph depicting a linear relationship between the monthly interest amount and the balance owed at the beginning of the month on a loan.
- b. Describe in words an exponential model of population growth referring to the change as a 'constant rate of change'.
- c. Accurately describe the limitations of a model for the decline of the Social Security Trust Fund over a long period of time.
- d. Create an equation to model periodic compound interest and its relation to credit card balances.

2.2 Model financial applications such as credit card debt, installment savings, loans, etc. and calculate income taxes.***Sample Tasks:**

- a. Use a spreadsheet to model personal savings growth and use it to find patterns of behavior based on national economic growth rates over periods of years.
- b. Use a spreadsheet to forecast retirement savings growth based on varying long term assumptions.
- c. Explain the limitations of mathematical models and risks in extrapolating information.

2.3 Create basic linear and exponential models for real-world problems and be able to choose which one is most appropriate for a given context and describe the limitations of the proposed models.*

(Student proficiency in this area would be demonstrated by beginning with a real-world situation, deciding on the mathematical model and the form (graph, equation etc.), building the model, and finding and reporting on solutions and limitations.)

Sample Tasks:

- a. Use a spreadsheet to model personal savings growth both with a regression line and an exponential curve and accurately assess the validity of both choices.
- b. Make a decision to build an exponential model for growth or decay in a contextual situation based on quantitative information such as a constant percentage rate of change. Create the model.

- c. Make a decision to build a linear model for growth or decay in a contextual situation based on quantitative information such as a constant absolute change. Create the model.

2.4 Use basic logarithm properties to address questions (regarding time periods etc.) arising in real-world situations modeled exponentially.*

Sample Tasks:

- a. Use logarithmic properties to find the time required to achieve a personal savings goal.
- b. Use logarithmic properties to find the time required for savings being compounded periodically to double.
- c. Use logarithmic properties to find the half-life of models of decay.

2.5 Explain and critique models orally and/or by writing coherent statements and paragraphs.*

Sample Task:

Student proficiency in this area would be demonstrated by the ability to communicate specific and complete information in such a way that the reader or listener can understand the contextual and quantitative information in a situation in addition to whatever quantitative and/or qualitative conclusions have been drawn.

3. Probability and Statistics: Students will use the language and structure of statistics and probability to investigate, represent, make decisions, and draw conclusions from real-world contexts.

(The teaching of statistics is intended to both deepen and broaden understanding achieved in K-12, keeping the development and use of all but the most basic statistical procedures to a minimum. One strategy to help students to deepen their knowledge and understanding is to require students to explain their thinking verbally and/or in writing and to receive feedback as they solve problems. Peer group discussions and reports may be a useful way to achieve this goal. Problems requiring rote use of statistical procedures should be de-emphasized, except when these procedures are essential to gaining deep conceptual understanding. Traditional textbook word problems are often artificial. In this course, realistic problems from a variety of realistic situations should be presented for discussion and solution. Technology should be used wherever appropriate.)

3.1 Critically evaluate statistics being presented in the media, journals, and other publications including evaluating the research methodology, critiquing how the author(s) came to their conclusions, identifying sources of bias, and identifying confounding variables. Students will be able to critically evaluate sampling

strategy, the impact of sample size, correlation versus causation, and any inferences made.*

Sample Tasks:

- a. Identify whether a news media article is reporting on a ‘random controlled experiment’ or an observational study to decide if conclusions being made are correlational or causal. Use this identification to discuss any inferences being made.
- b. Identify possible confounding factors in a statistical study.
- c. Identify possible biases in a statistical study.
- d. Critique media reports related to margin of error and statistical significance.

3.2 Summarize and interpret datasets with regard to shape, center, and spread. Use both graphical and numerical information. Use statistics appropriate to the shape. Students will be able to compare two or more datasets in light of this type of information.*

Sample Tasks:

- a. Calculate the mean, median and mode of a data set and interpret their meaning as to the ‘center’ of the set.
- b. Decide whether the mean or median best represent the center of a data set in contextual situations such as housing values.
- c. Calculate basic measures of variation in a data set and explain why variation is an important concept in analyzing a set.
- d. In a contextual situation, explain a reported standard deviation as the spread of the data around the mean.

3.3 Create visual representations of real-world data sets such as charts, tables, and graphs and be able to describe their strengths, limitations, and deceptiveness.*

Sample Tasks:

- a. Create and use visual displays to analyze the variation and distribution of data sets.
- b. Identify key factors such as vertical scaling to evaluate the accuracy and/or possible deceptiveness of charts.

3.4 Calculate probabilities and conditional probabilities in real-world settings, and employ them to draw conclusions.*

Sample Tasks:

- a. Estimate probability in a contextual situation using data from a news article or a table.
- b. Analyze a question such as “is it safer to drive than fly?” using probabilities.
- c. Use probability to assess the real world trade-offs the modern world makes when making decisions such as driving rather than walking.

3.5 Justify decisions based on basic statistical (probabilistic) modeling orally and/or by writing coherent statements and paragraphs.*

Sample Task:

Student proficiency in this area would be demonstrated by the ability to communicate specific and complete information in such a way that the reader or listener can understand the contextual and quantitative information in a situation in addition to whatever quantitative and/or qualitative conclusions have been drawn.

**OHIO TRANSFER MODULE MATHEMATICS, STATISTICS, AND LOGIC:
TMM011 QUANTITATIVE REASONING COURSE WRITING FACULTY PARTICIPANTS**

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