MAT 108 Mathematics for the Natural Sciences

Department of Mathematics
Southern Connecticut State University

I. Catalog Description

Elementary mathematical modeling using linear functions, exponential functions, and power functions. Additional topics include logarithms, curve sketching, and curve fitting. Examples from the natural sciences.

II. Purpose

The purpose of MAT 108 is to provide a solid mathematical foundation for students who are interested in the study of the natural sciences or nursing but who do not plan on taking a calculus course.

III. Credit

(A) MAT 108 carries 3 semester-hours of university credit.

(B) MAT 108 satisfies the University's Liberal Education Program Quantitative Reasoning requirement.

(C) MAT 108 satisfies the University's General Education Mathematics Requirement.

(D) MAT 108 is required of all Nursing majors and is a mathematics option for Earth Science and Biology majors.

IV. Prerequisites

MAT 100 or MAT 100P or MAT 102 with a grade of C- or better or appropriate mathematics placement.

V. Format

MAT 108 is primarily a lecture based course with time provided for discussion and problem solving.

VI. Liberal Education Program

This course satisfies the University's Liberal Education Program (LEP) requirement in Quantitative Reasoning (QR). It addresses the key elements of the QR requirement as indicated in Section VII: Course Objectives. Further, as a Tier 1 LEP course, it will do the following:

(A) Address at least one *Area of Knowledge and Experience* through the choice of data sets or word problems that are applied to one of the sciences, *Natural World I: Physical Realm* or *Natural World II: Life and the Environment.* For example, when covering exponential models, students are asked to find and interpret half-life, doubling time, and tripling time for applications such as radioactive decay, population growth, and pollution growth or decay.

(B) Incorporate at least one *Discussion of Values*. For example, *Environmental Awareness* could be discussed through modeling data that comes from an environmental issue such as the number of manatee deaths in Florida due to the increase in numbers of watercraft. *Rational Thought* can be emphasized by asking students to interpret and make predictions from a given mathematical model. For example, students might be asked to find a regression line and then interpret the slope, decide whether the vertical intercept has any physical meaning, make predictions from the model, and decide how reliable those predictions are based upon what they know about regression. *Civic Engagement* is another area that could be discussed by choosing to model data that directly affects students' local communities.

(C) Address at least one *Embedded Competency* in a significant manner. Instructors may choose to address this requirement by incorporating one of the following requirements into their course: *Oral Communication* by requiring students to present the results of their work through oral presentations, *Interpersonal Effectiveness* by requiring students to work in group settings, *Information Literacy* by requiring students to find and evaluate their own data for a project, or *Creative Thinking* by requiring students to create a model for a set of data or scenario in which they have not already been told what type of model is most appropriate.

(D) Present the Quantitative Reasoning aspects of Precalculus in context. The key elements QR1–Quantitative Situations, QR2–Quantitative Data, QR3–Methods, QR4–Reliability of Data and Solutions, and QR5–Mathematical Process are addressed in the course objectives listed below.

VII. Quantitative Reasoning Key Elements

(A) **QR1**: Quantitative Situations - Identifying the essential quantitative elements in both routine and novel situations and understanding the relationships between those quantitative elements, and producing mathematical models appropriate for the intended analysis (e.g., writing equation(s) to represent the situation).

(B) **QR2**: Quantitative Data - Representing quantitative information in both technical and common language by using symbolic, graphical, and tabular formats, and drawing correct inferences from quantitative information through the interpretations of such representations.

(C) **QR3**: Methods - Acquiring the tools and methods necessary to resolve both routine and novel quantitative questions, including a correct sequencing of procedures, and using them appropriately, given the nature and constraints of a situation. In addition to using knowledge previously acquired in intermediate algebra, students will demonstrate proficiency with information presented in numerical or statistical form and mathematical concepts of growth and decay with their applications (e.g., linear, quadratic, exponential, etc.).

(D) **QR4**: Reliability of Data and Solutions - Correctly evaluating the level of accuracy stated or implied for given data, and assessing the correctness and accuracy of an analysis, including the assessment of the method and model used and the reasonableness of the solution.

(E) **QR5**: Mathematical Process - Using discovery (e.g., exploration and pattern-recognition), conjecture, and testing to develop mathematical formulas, theorems, and then giving persuasive mathematical arguments to establish their validity.

VIII. Course Objectives

In addition to satisfying LEP Tier 1 requirements, MAT 108 has some specific course objectives. The Key Elements of Quantitative Reasoning(QR) are referenced. By the end of the course, a successful student should be able to do the following:

(A) Understand the role of mathematics as a language with which to express physical laws and scientific concepts. Students should also learn to use terminology and notation correctly as their knowledge is devalued if they cannot properly communicate it to others. In particular, notation provides us with precise and succinct identification of concepts, objects, and processes, and in its clearest forms, a path to follow. (QR 2)

(B) Set up and use simple mathematical models. In particular, students should be able to translate word problems into corresponding mathematical problems and then interpret the results in terms of the conditions of the word problems. (QR 1, QR 2, QR 3, QR 4, QR 5)

(C) Recognize variational relationships among quantities. Students should be able to express these relationships both in words and in formulas using symbolic notation. (QR 1, QR 2, QR 3, QR 4, QR 5)

(D) Know and work with a standard core of functions, including linear functions, the power functions, exponential functions, and logarithmic functions. Students should understand the relationship between these functions and their graphs and be proficient at working with these graphs. Students should also be able to recognize these basic graphs and related graphs from their shapes and other key characteristics. (QR 3, QR5)

(E) Analyze and interpret deterministic data through various means, including curve-fitting, the method of least squares, and the use of special types of graph paper. Students should know the strengths and weaknesses of each of these techniques. (QR 4, QR 5)

(F) Work with approximate numbers, the kinds of numbers usually produced from measurements in applications. Students should understand the concepts of precision and accuracy and be able to interpret both in terms of significant digits. Students should also be able to interpret the results of arithmetic operations using approximate numbers. (QR 4)

(G) Use scientific calculators to aid in the computations done in the course. Students should know the advantages and disadvantages of using the calculator to produce solutions and should be able to interpret those solutions properly with respect to the use of approximate numbers.

IX. Outline

Note: This course is required of nursing majors. To be accepted into the nursing program, students must pass a test involving ratios, proportions, and drug dosages. The students are not allowed to use a calculator on that exam. For that reason, students in this course should be required, or at least advised, to do related problems or a reasonable number of problems without the use of a calculator.

Introduction (8%)

(a) An introduction to mathematical modeling. The discussion of mathematical modeling will be continued in the context of looking at specific families of functions.

(b) Working with powers of 10.

(c) Review of scientific notation.

(d) Orders of magnitude.

(e) Units and conversions.

Error analysis (11%)

(a) Measurement.

(b) Significant digits.

(c) Absolute and relative error.

(d) Accuracy and precision.

(e) Propagated error using the Significant Digits methods.

Working with data (6%)

(a) Mean and median of a set of single-variable data.

(b) Graphical interpretation of two-variable data.

(c) Review of the relationship between equations of two variables and their graphs.

Functions and their graphs (11%)

(a) Definition of a function.

(b) Domain and range.

(c) Graphing functions using the point-plotting method and using a technology.

(d) Interpreting graphs using the properties of increasing and decreasing, maxima and minima, and concavity. These properties are only covered graphically, not analytically.

Linear functions (22%)

(a) Review of the graphing of straight lines.

(b) Average rate of change.

(c) Linear functions.

(d) Applications of linear functions in problems in which the rate of change is constant or almost constant.

(e) Direct variation.

(f) Fitting lines to data visually.

(g) Fitting lines to data using linear regression, or equivalently the method of least squares. Some of the curve fitting should be done using a technology.

Exponential functions (16%)

(a) Definition of increasing and decreasing exponential functions.

(b) Graphs and properties of exponential functions.

(c) Natural exponential function and its properties.

(d) Modeling exponential growth and decay using exponential functions.

(e) Comparison of linear and exponential models.

(f) Fitting exponential functions to data using technology.

Logarithmic functions (21%)

(a) Common logarithms and their properties.

(b) Logarithmic scales.

(c) Solving exponential and logarithmic equations.

(d) Natural logarithms.

(e) Logarithmic functions and their properties.

(f) Graphs of logarithmic functions.

(g) Working with mathematical models based on logarithmic functions.

(h) Semi-logarithmic plots.

(i) Optional: Fitting exponential functions to data using a technology.

Power functions (5%)

(a) Power functions.

(b) Direct and inverse variation with power functions.

(c) Graphs of power functions.

(d) Working with mathematical models based on power functions.

(e) Log-log plots.

(f) Fitting power functions to data using log-log plots and using a technology.

Additional topics as time permits

(a) Quadratic functions.

X. Assessment

Individual instructors may vary assessment modes, but typically grades will be based on a combination of homework assignments, quizzes, and exams.

	QR 1 Quantitative Situations	QR 2 Quantitative Data	QR 3 Methods	QR 4 Reliability of Data and Solutions	QR 5 Mathematical Process
Homework	Individual instructors decide which QR will be assessed appropriately.				
Quizzes	Individual instructors decide which QR will be assessed appropriately.				
Tests	✓	✓	✓	✓	✓
Final Exam	✓	✓	✓	✓	✓

XI. Recommended Texts

(A) *Explorations in College Algebra*, Fourth Edition, Linda Almgren Kime, Judith Clark, and Beverly Michael, John Wiley & Sons, Inc.

(B) *Error Analysis*, Ross Gingrich and Terri Bennett Handout distributed to MAT 108 classes.

XII. Bibliography

(A) *Easy Mathematics for Biologists*, Peter C. Foster, Harwood Academic Publishers, 1998.

(B) *Calculation of Drug Dosages*, Eighth Edition, Sheila Ogden, Mosby Elsevier, 2007.

(C) *Elementary Mathematical Modeling, Functions and Graphs*, Second Edition, Mary Ellen Davis and C. Henry Edwards, Pearson Prentice Hall, 2007.

(D) *A First Course in Mathematical Modeling*, Frank R. Giordano, William P. Fox, Maurice D. Weir, and Steven B. Horton, Cengage Learning 2008.

(E) *Quantitative Reasoning and the Environment: Mathematical Modeling in Context*, Greg Langkamp and Joseph Hull, Pearson Prentice Hall, 2007.

XIII. Waiver Policy

MAT 108 may be waived.

XIV. Preparation

- Proposed outline prepared by Ross Gingrich, April 12, 2010.
- Approved by the MDCC, 9–0–0, April 28, 2010.
- Approved by the department of mathematics, 18–1–0, February 11, 2011.
- Revised outline prepared by J. Hong, November 1, 2020.
- Approved by the MDCC, 9–0–0, November 5, 2020.
- Revised outline prepared by MDTC, November 17, 2020.