

Semester 1

Mathematical Foundations for Data Analysis

Course # MEDS 5101

Pre-requisites and Co-requisites: Prior exposure to university-level mathematics, especially basic algebra and introductory single-variable calculus. Prior exposure to linear algebra and Python is helpful but not required.

Course Description

Mathematical Foundations for Data Analysis develops the mathematical tools students need for graduate study in economics and data science. The course builds a rigorous but accessible foundation in linear algebra, multivariable calculus, integration, unconstrained and constrained optimization, selected numerical methods, and discrete-time economic dynamics. Economic applications provide the primary context, while selected data-science and machine-learning connections show how the same mathematical structures support quantitative modelling and data analysis. Python is integrated into the two weekly sessions to implement, verify, visualize, and extend methods that have first been developed analytically. The course prepares students for subsequent work in microeconomics, macroeconomics, econometrics, data science, and machine learning without duplicating the probability and inference material taught in Statistics I.

Course Learning Outcomes

Upon successful completion of the course, students will be able to:

1. Apply vectors, matrices, systems of linear equations, projections, quadratic forms, and selected eigenvalue concepts to formulate and solve economic, data-science, and quantitative-analysis problems.
2. Use single- and multivariable differential and integral calculus - including partial derivatives, gradients, Hessians, total differentials, local approximations, and definite/indefinite integrals - to analyze marginal relationships, curvature, accumulation, and comparative changes in economic and data-analytical problems.
3. Formulate and solve unconstrained and constrained optimization problems, and interpret first- and second-order conditions, Lagrange multipliers, introductory Karush-Kuhn-Tucker (KKT) conditions, and selected comparative-statics results.
4. Apply selected numerical methods to nonlinear equations, integration, and optimization problems; assess convergence and numerical accuracy; and compare numerical solutions with analytical benchmarks.
5. Analyze discrete-time economic models using difference equations, steady states, stability concepts, transition dynamics, and computational simulation.
6. Develop and communicate reproducible Python-supported solutions that integrate mathematical formulation, analytical reasoning, numerical computation, visualization, and

interpretation, including selected mathematical foundations relevant to data science and machine learning.

Course Assessments and Grading

The course follows the Grading System outlined in the UCA Academic Policies. Attendance is not assigned a grade.

Item	Description	Due date / Timing	Weight
Analytical Problem Sets	Five graded problem sets (4% each) emphasizing derivation, problem solving, and economic/data interpretation.	Weeks 3, 5, 7, 9, 14	20%
Python Computational Notebooks	Five selected graded notebooks (3% each) emphasizing implementation, verification, visualization, and concise interpretation.	Weeks 3, 5, 6, 10, 12	15%
Short Quizzes	Six short concept/calculation quizzes are offered; the best five count (2% each).	Weeks 2, 3, 5, 6, 10, 12	10%
Midterm Examination	Primarily analytical written assessment covering Weeks 1-7, with economic/data interpretation and limited computational reasoning.	Week 8	15%
Pair Applied Computational Project	Pairs integrate at least two mathematical blocks with Python implementation and interpretation; brief Week 9, pair/topic approval Week 10, progress checkpoint Week 13, final submission and presentation Week 15.	Weeks 9-15	15%
Final Examination	Cumulative written assessment with greater emphasis on post-midterm material. No new teaching occurs in Week 16.	Week 16	20%
Active Effort	Preparation, serious attempts at assigned problems, constructive problem-solving/computational engagement, response to feedback, and demonstrated progress. Attendance alone does not earn these marks.	Midterm and end-of-semester checkpoints	5%
Total			100%