Linear Algebra

Instructor

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Course Description

This course introduces the fundamental concepts of linear algebra, emphasizing both theoretical foundations and practical applications in economics and finance. Topics include systems of linear equations, determinants, vector spaces, matrices, linear independence and bases, linear transformations, eigenvalues, and diagonalization. Real-world contexts such as input-output models, least-squares regression, equilibrium analysis, portfolio optimization, and risk modeling provide motivation and application for abstract concepts. The course equips students with tools essential for quantitative economics, econometrics, financial analysis, optimization, and higher-level mathematics.

Students will develop both conceptual insight and practical skills, with an emphasis on clear mathematical reasoning and effective computation. The course combines theory with hands-on problem solving. Format: lectures. Evaluation will be based primarily on homework and exams.

Prerequisites

A semester of calculus or equivalent mathematical preparation. Students should be comfortable with basic concepts of functions, solving equations, and mathematical reasoning. Prior exposure to formal problem solving - e.g., from a course in calculus, discrete math, or mathematical methods for economics - is recommended.

Primary Text

David C. Lay, Steven R. Lay, and Judi J. McDonald – *Linear Algebra and Its Applications, 6th Edition*.

Examination and Assessment

Final Grade Composition:

- Written Exam (60%)
  A comprehensive written exam will assess both theoretical understanding and the ability to apply linear algebra concepts to economic and financial problems. It will include both proof-based and computational questions.
- Homework and Assignments (40%)
  Weekly problem sets and application-based assignments will reinforce the material covered in lectures. These may include both textbook problems and applied tasks using real or simulated economic/financial data.

Grading Scale: A+ to F.

Attendance Policy

Attendance at all lectures is mandatory. Participation is essential to follow the cumulative structure of the course, engage with applied examples, and benefit from in-class exercises.

Intended Learning Outcomes (ILOs)

By the end of the course, students will be able to:

- Solve systems of linear equations using matrix techniques such as Gaussian elimination.
- Perform operations with matrices and understand their algebraic properties.
- Analyze the structure of vector spaces, including subspaces, bases, and dimension.
- Apply concepts of linear independence, rank, and the Fundamental Theorem of Linear Algebra.
- Understand and use linear transformations and their matrix representations.
- Compute and interpret eigenvalues and eigenvectors, and understand diagonalization.
- Apply least squares methods to regression and data fitting problems.
- Interpret economic and financial models using linear algebraic tools, such as input-output models, equilibrium analysis, and risk modeling.
- Translate theoretical linear algebra concepts into practical analysis for real-world economic and financial systems.
- Communicate mathematical reasoning clearly, both in written form and applied contexts.

Week	Topic	Mathematical Content	Economic/Financial Applications
1	Systems of Linear Equations	Gaussian elimination, row echelon form, consistency	Market clearing in competitive markets, labor-leisure trade-offs
2	Matrix Algebra	Matrix operations, inverses, identity, transpose	Input-output models (Leontief), inter-industry trade
3	Determinants	Properties, computation, geometric meaning	Comparative statics, uniqueness of equilibria

4	Vector Spaces I	Definitions, subspaces, span, linear combinations	Feasible production sets, budget sets
5	Vector Spaces II	Linear independence, bases, dimension	Principal component analysis, factor models
6	Rank and Fundamental Spaces	Rank, null space, column/row space, Rank-Nullity Theorem	Identifying degrees of freedom in constrained systems
7	Linear Transformations	Kernels, images, operations with transformations	Input-output flows, equilibrium mappings
8	Matrix Representation & Change of Basis	Coordinate vectors, transition matrices, similarity	Dynamic systems in macroeconomics, portfolio reallocations
9	Orthogonality	Dot product, projections, orthogonal subspaces	Demand decomposition, orthogonal regression
10	Least Squares	Overdetermined systems, normal equations	Linear regression, econometric model estimation
11	Eigenvalues and Eigenvectors	Definitions, diagonalizability, spectral properties	Stability of dynamic systems, Markov chains
12	Diagonalization and Applications	Symmetric matrices, orthogonal diagonalization	Long-run analysis in input-output models, covariance structure in finance