ECON 715, Fall 2023

Course information
Course Title: Mathematical Economics
Number of Units: 3
Course ID: Econ 715
Class Number: 3202
Class Schedule:

- Midterm 1: Monday, September 18
- Midterm 2: Monday, October 23
- Final: Monday, December 11

Instructor's information
Instructor: Michael Bar
Office: HSS 148
Email: mbar@sfsu.edu
Course webpage: https://www.mbarecon.com/teaching/econ-715-mathematical-economics
Office Phone Number: 415-338-3026
Office hour: Wednesday, 4:00 PM – 5:00 PM, on Zoom.

Course Description

Economics 715 provides the essential mathematical foundations of modern economic analysis. In your very first introductory economics class, you heard that economics is defined as the study of decision-making under scarcity. Translating this into mathematics language means that economics is the study of optimization under constraints – a well-developed area of mathematics. Individuals, businesses and societies, are all living in a reality where resources are scarce (constrained), and the goal of economics is to analyze the tradeoffs between alternatives.

Economics 715 presents a collection of mathematical tools (primarily linear algebra and multivariate calculus) and demonstrates their applications for solving economic problems. The course provides an in-depth, rigorous look into some issues that students encountered in earlier courses and gives another opportunity to better understand what you have learned thus far. This course is also essential for anyone who wishes to pursue graduate work in economics or in a related field. Moreover, mathematics is the language of all science, and the tools presented in this course are universal and transferable to any discipline of natural or social science.

My goal is that at the end of the course, students will be able to translate real-life economic problems into the language of mathematics and identify the appropriate methods of solving the problems. Translating the problems into math is a crucial step that allows the use of computers to find solutions. Such real-life problems include the choice of major for a college student, marriage, investment, homeownership, designing the best healthcare system, immigration policies or environment protection policies for a nation, finding optimal selling strategy for eBay or Amazon, or any other problem that involves people making choices.

Some of the mathematical concepts discussed in the course will be illustrated with Matlab – a popular mathematical software and programming language widely used by economists and data analysts.

Student Learning Outcomes

By successful completion of this course, students will be able to:

1. Solve linear models efficiently, using Matlab.
2. Apply matrix algebra methods for analyzing economic models and Ordinary Least Squares estimation.
3. Apply multivariate calculus methods for analyzing economic models.
4. Determine whether an optimization problem (unconstrained or constrained) has a unique global optimum, and find the optimum using Matlab.
5. Represent a real-life economic problem as a constrained optimization problem, and solve it efficiently using Matlab.

The above learning objectives serve goals 1 and 3 of the MA program in economics.

1. Students will learn micro and macroeconomic theories at the appropriate level and will be able to use these theories to analyze economic problems and issues relevant to the local, state, national, or global economy. With this knowledge, students will be able to understand and critically assess scholarly economics articles and propose possible pathways for future research.
3. Students will be able to employ economic reasoning in analyzing real-world economic problems and effectively communicate their knowledge and findings both orally and in written formats.

Prerequisites

Before taking this course, students must have passed the following course with a grade "C-" or better:

1. MATH 226 – Calculus I
2. ECON 301 – Intermediate Microeconomic Theory
3. ECON 302 – Intermediate Macroeconomic Theory

Optional Books

All the required course materials are contained in the course notes, posted on the course webpage. The following sources are recommended but not required:

1. *Fundamental Methods of Mathematical Economics*, 4th Edition, by Kevin Wainwright and Alpha Chiang, McGraw Hill 2004, ISBN-13: 978-0070109100.
2. *Mathematics for Economists*, by Carl Simon and Laurence Blume, W. W. Norton and Company 1994, ISBN-13: 978-0393957334.

Sharing Course Materials

Students may not post any course materials to any third-party sites (such as Chegg) or post any recordings, screenshots, audio or chat transcripts in any setting outside the class. I create all the course materials for students to use for **free**. Most of the materials are available online, for use by students all over the world. Enabling companies to charge money for these materials is a theft and a fraud. Violations of this are subject to student disciplinary action.

Matlab

Matlab is commercial mathematical software and programming language, available for free to SF State students. You will need to register with Mathworks, following the steps here.
Option1 – download Matlab. Follow the steps here. You will need at least the Symbolic and Optimization toolboxes.
Option 2 – follow the same steps to register with Mathworks here, but you don't need to download the program to your computer. Instead, visit Matlab Online, and do all the work there. Matlab Online has all the toolboxes and worked faster than my computer for me.

Credit Hours Policy

This is a 3-unit course requiring at least 3 credit hours (150 minutes) of direct instruction per week and at least 6 credit hours (300 minutes), on average, of out-of-class work per week, for a total workload of at least 450 minutes per week, i.e. 7 hours and 30 minutes.

In this online asynchronous course, "direct instruction" consists of the following online activities: (i) lecture videos, (ii) vignettes posted on the course webpage, (iii) discussion forums, (iv) feedback on assignments and exams, and (v) exams.

Grading

Assignments	20%
Quizzes	20%
Midterm 1	20%
Midterm 2	20%
Final exam	20%

Grading Scale

Highest	Lowest	Letter
100.00 %	93.00 %	A
92.99 %	90.00 %	A-
89.99 %	87.00 %	B+
86.99 %	83.00 %	B

Highest	Lowest	Letter
82.99 %	80.00 %	B-
79.99 %	77.00 %	C+
76.99 %	73.00 %	C
72.99 %	70.00 %	C-

Highest	Lowest	Letter
69.99 %	67.00 %	D+
66.99 %	63.00 %	D
62.99 %	60.00 %	D-
59.99 %	0.00 %	F

Deadlines Policy

All due dates (deadlines) are final and are listed in the course module, assignments description and can be viewed in Canvas calendar. No past-due assignments are accepted and no extra-credit is available. Due to the cumulative nature of the course material, it is essential not to fall behind and not to miss any learning activities.

Course Schedule

Week	Topics and Objectives	Activities
Week1	• Meet the instructor and fellow students. • Review of Prerequisite Knowledge. • Distinguish between linear and nonlinear systems of equations. • Understand the concept of solution set. • Create a Matlab Script and Matlab Live Script which performs basic task (e.g. plotting a graph of a function).	• Watch the course overview video. • Review of Prerequisite Knowledge. • Study Ch.1, section 1.1 in the Course Notes posted on the course webpage. • Watch the Introduction to Linear Systems video. • Watch the Introduction to Matlab videos 1 and 2. • Study the notes "Matlab Basics" posted on the course webpage. • Submit Quiz 1.1. • Submit Assignment 1. • Participate in "Discussion of Challenges" forum (optional).
Week 2	• Represent a linear system in matrix form: $A \cdot x = d$. • Identify special types of matrices (square, symmetric, diagonal, triangular, idempotent). • Perform matrix operations (addition, multiplication, transpose, determinant, inverse).	• Study Ch.1, section 1.2 in the Course Notes posted on the course webpage. • Watch the video "Intro to Matrix Algebra". • Study the vignette "PlottingGraphs" posted on the course webpage. • Submit Quiz 1.2. • Submit Assignment 2.4. • Review the answer key of last week's assignment. • Participate in "Discussion of Challenges" forum (optional).
Week 3	• Use properties of matrix operations (addition, product, determinant, inverse), to simplify calculations. • Solve small linear systems manually, using the matrix inversion and Cramer's rule. • Solve large linear systems using Matlab, and evaluate solution algorithms in terms of speed and accuracy.	• Study Ch.1, section 1.3, 1.4 in the Course Notes posted on the course webpage. • Submit Quiz 1.3-4. • Submit Assignment 3. • Review the answer key of last week's assignment. • Participate in "Discussion of Challenges" forum (optional).
Week 4	• Formulate the social planner's problem in Leontief economy using matrix notation. • Use Matlab to solve for the social planner's production plan in the	• Study Ch.1, section 1.5.6, 1.5.7 in the Course Notes posted on the course webpage. • Study the vignette on Regression posted on the course webpage.

	Leontief economy (general equilibrium multi-industry and consumers sector). • Represent the Least Squares estimation problem using matrix notation. • Use Matlab for estimating multiple regression models via Ordinary Least Squares.	• Submit Quiz 1.5. • Submit Assignment 4. • Review the answer key of last week's assignment. • Participate in "Discussion of Challenges" forum (optional).
Week 5	• Midterm Exam 1	• Review Midterm 1 | Information and Study Guide. • Review the answer key of last week's assignment. • Submit Midterm 1 Quiz. • Submit Midterm 1 Assignment.
Week 6	• Define a set (most basic concept in math) and perform set operations. • Define a function and related concepts (domain, co-domain, image, graph, monotonicity and inverse). • Define a limit of a function, and apply the rules of limits to calculate the limit of a function at a point. • Define continuous functions, and understand the importance of continuous functions in optimization (Extreme Value Theorem). • Use Matlab symbolic toolbox to plot graphs of functions based on mathematical expression, and finding limits of functions.	• Study Ch.2, sections 2.1.1 - 2.1.4 in the Course Notes posted on the course webpage. • Submit Quiz 2.1.1. • Submit Quiz 2.1.2. • Submit Quiz 2.1.3-4. • Submit Assignment 5. • Review the answer key of last week's assignment. • Participate in "Discussion of Challenges" forum (optional).
Week 7	• Calculate derivatives of functions. • Understand the relationship between differentiability and continuity. • Use L'Hôpital's rule for computing limits of functions. • Apply limits and derivatives for obtaining important results in economics: logarithmic scale, CRRA utility, calculating relative risk aversion, marginal products and marginal utility, cost functions of a	• Study Ch. 2, sections 2.1.5 - 2.1.9, 2.2 in the Course Notes posted on the course webpage. • Submit Quiz 2.1.5-9. • Submit Quiz 2.2. • Submit Assignment 6. • Review the answer key of last week's assignment. • Participate in "Discussion of Challenges" forum (optional).

	firm, and continuously compounded yield formula. • Using Matlab's symbolic toolbox to calculate limits and derivatives.	
Week 8	• Apply the concept of differential for calculating linear approximations to a non-linear function. • Apply derivatives and differential for computing elasticities and elasticity of substitution. • Use the elasticity of substitution for predicting functional income distribution in the economy (Hicks contribution).	• Study Ch. 2, sections 2.3 in the Course Notes posted on the course webpage. • Submit Quiz 2.3. • Submit Assignment 7. • Review the answer key of last week's assignment. • Participate in "Discussion of Challenges" forum (optional).
Week 9	• Compute derivatives of variables that are related to each other through implicit function (Implicit Function Theorem). • Perform comparative statics - i.e. evaluating the marginal effects of any exogenous variable, on any endogenous variable in a nonlinear system of equations.	• Study Ch. 2, section 2.4 in the Course Notes posted on the course webpage. • Study the Matlab examples for Implicit Functions and Comparative Statics posted on the course webpage. • Submit Quiz 2.4. • Submit Assignment 8. • Review the answer key of last week's assignment. • Participate in "Discussion of Challenges" forum (optional).
Week 10	• Midterm Exam 2	• Review Midterm 2 | Information and Study Guide. • Submit Midterm 2 Quiz. • Submit Midterm 2 Assignment.
Week 11	• Apply First Order Necessary and Second Order Sufficient conditions to find unconstrained local and global minimum or maximum of functions in one variable. • Use Matlab `diff()` and `solve()` functions to find unconstrained local and global minimum or maximum of functions in one variable. • Use Matlab for illustrating unconstrained optimization problems in single variable.	• Study Ch. 3, sections 3.1, 3.2 in the Course Notes posted on the course webpage. • Study the vignette on Optimization (unconstrained optimization part) posted on the course webpage. • Submit Quiz 3.1-2. • Submit Assignment 9. • Submit Assignment 9 Quiz. • Review the answer key of last week's assignment. • Participate in "Discussion of Challenges" forum (optional).

Week 12	• Calculate growth rates of variables that are functions of time. • Apply First Order Necessary and Second Order Sufficient conditions to solve dynamic optimization problems (Application: optimal holding time of an asset).	• Study Ch. 3, section 3.4 in the Course Notes posted on the course webpage. • Submit Quiz 3.4. • Submit Assignment 10. • Submit Assignment 10 Quiz. • Review the answer key of last week's assignment. • Participate in "Discussion of Challenges" forum (optional).
Week 13	• Apply First Order Necessary and Second Order Sufficient conditions to solving multi-variable unconstrained optimization problems. • Use properties of concave/convex functions to classify critical values into global maximum or global minimum. • Economic applications: profit maximization of (i) multiproduct competitive firm, (ii) multiproduct monopoly, (iii) price discriminating monopoly.	• Study Ch. 3, section 3.5 in the Course Notes posted on the course webpage. • Submit Quiz 3.5. • Assignment 11. • Review the answer key of last week's assignment. • Participate in "Discussion of Challenges" forum (optional).
Week 14	• Apply First Order Necessary Conditions for solving constrained optimization problems with equality constraints (e.g. utility maximization subject to budget constraint). These conditions involve the Lagrange function. • Apply properties of cuasiconcave functions and convex sets to verify the sufficient conditions for constrained global optimum (Theorem 21 in the Course Notes posted on the course webpage, is the most general theorem characterizing constrained global optima, with any constraints). • Use Matlab to solve constrained optimization problems.	• Study Ch. 3, section 3.6.1, 3.6.2 in the Course Notes posted on the course webpage, skipping the Second Order Sufficient conditions for local optimum (conditions involving bordered Hessians). Reasons: (i) a lot of work and (ii) we are interested in global optimum, not local. • Study the vignette on Quisiconcave functions posted on the course webpage. • Study the vignette on Optimization posted on the course webpage. • Submit Quiz 3.6.1. • Submit Quiz 3.6.2. • Submit Assignment 12. • Review the answer key of last week's assignment. • Participate in "Discussion of Challenges" forum (optional).

Week 15	• Interpret the meaning of the Lagrange multiplier. • Apply the Envelope Theorem for calculating the marginal impact of changes in parameters of an optimization problem, on the optimized value of the objective function. • Use Matlab's numerical constrained optimization solver - fmincon, to solve constrained optimization problems numerically.	• Study Ch. 3, section 3.6.2, 3.6.3 Links to an external site.in the Course Notes posted on the course webpage. • Submit Quiz 3.6.1. • Submit Quiz 3.6.2. • Submit Assignment 12. • Review the answer key of last week's assignment. • Participate in "Discussion of Challenges" forum (optional).
Exam week	• Final Exam	• Review Final Exam | Information and Study Guide. • Submit Final Exam Quiz. • Submit Final Exam Assignment.

Statement on Cheating and Plagiarism

Cheating is the actual or attempted practice of fraudulent or deceptive acts for the purpose of improving one's grade or obtaining course credit; such acts also include assisting another student to do so. Plagiarism is a specific form of cheating, which consists of the misuse of the published and/or unpublished works of others by misrepresenting the material (i.e., their intellectual property) so used as one's own work. Penalties for cheating and plagiarism range from 0 or F on a particular assignment, through an F for the course, to expulsion from the university. For more information, see the College of Business Academic Standards. **In this class, copying and pasting parts of my notes into your homework assignments is considered by me as cheating and will result in a grade of "0" for the assignment. Never share or accept electronic versions of assignments in any course. This includes answers/solutions to homework problems, quizzes, exams or any other graded assignment for the course.**

SF State Disability Programs and Resource Center

Students with disabilities who need reasonable accommodations are encouraged to contact the instructor. The Disability Programs and Resource Center (DPRC) is available to facilitate the reasonable accommodations process. The DPRC is located in the Student Service Building and can be reached by telephone (voice/TTY 415-338-2472) or by email (dprc@sfsu.edu). (http://www.sfsu.edu/~dprc).

SF State Student Disclosure of Sexual Violence

SF State fosters a campus free of sexual violence, including sexual harassment, domestic violence, dating violence, stalking, and/or any form of sex or gender discrimination. If you disclose a personal experience as an SF State student, the course instructor is required to notify the Dean of Students. To disclose any such violence confidentially, contact:
The SAFE Place - (415) 338-2208; http://www.sfsu.edu/~safe_plc
Counseling and Psychological Services Center - (415) 338-2208; http://psyservs.sfsu.edu
For more information on your rights and available resources: http://titleix.sfsu.edu

SF State Withdrawal from Courses Policy

The CoB will observe the SF State Withdrawal from Courses policy F15-196:
http://senate.sfsu.edu/policy/withdrawal-courses-active-fall-2018

College of Business Center for Career Services and Professional Development

Please see this link: http://cob.sfsu.edu/resources/career-services or contact cobcareer@sfsu.edu, and (415) 338-2509 or stop by BUS 137.