INDIRA GANDHI INSTIUTE OF DEVELOPMENT RESEARCH

SEMESTER: I

COURSE TITLE: Mathematics for Economists

INSTRUCTOR(S): Dr. Gopakumar Achuthankutty

COURSE DESCRIPTION:

This course transforms students into proficient economic modelers, guiding them through the powerful intersection of advanced mathematical principles and practical problem-solving using Microsoft Excel and VBA. Beyond understanding abstract concepts, you will actively build, analyze, and optimize economic scenarios - from consumer choices and market equilibria to firm production and intertemporal decisions. By focusing on hands-on application of numerical differentiation, integration, matrix operations, and comprehensive optimization techniques, this course will empower you to not only analyze complex data but also to formulate data-driven strategies that drive real-world economic value and entrepreneurial success.

COURSE OBJECTIVES:

This course equips students with a powerful analytical toolkit, blending core mathematical economics with practical computational skills in Excel and VBA to solve complex economic challenges. Students will gain the unique ability to translate abstract economic theories into actionable insights by implementing models with numerical methods, optimization, and linear algebra. Through advanced analytical techniques, the course fosters a robust quantitative and entrepreneurial spirit, empowering students with critical thinking and problem-solving skills highly valued in today's job market.

COURSE OUTCOMES:

CO1 Students will be adept at translating complex economic problems into computationally solvable models, demonstrating proficiency in utilizing advanced mathematical and Excel-based techniques to generate actionable insights.

CO2 Students will confidently apply optimization and linear algebra techniques to real-world economic scenarios, enabling them to make data-driven decisions that enhance efficiency, profitability, and resource allocation for businesses and organizations.

CO3 Upon completion, learners will possess a highly sought-after blend of rigorous theoretical understanding and practical computational expertise, positioning them as invaluable analytical assets capable of driving innovation and strategic growth in diverse professional environments.

COURSE REQUIREMENTS: No pre-requisites.

COURSE CONTENTS:

Module 1: Analysis on the Real Line

- **Sequences of Real Numbers, their Convergence and Bolzano-Weierstrass Property**
- **Functions: Continuity and Limits, Extreme and Intermediate Value Theorems, Uniform Continuity**
- **Differentiation and Critical Points, Mean Value Theorems and Applications**
    - **Computational Aspect: Finite differences and numerical differentiation; Deriving the Marginal Cost Function from the Total Cost Function; Deriving the Marginal Propensity to Save from the Savings Function**
- **The Riemann Integral, The Fundamental Theorem of Calculus**
    - **Computational Aspect: Numerical Integration; Capital Formation from an Investment Function**

Module 2: Matrix Algebra

- **System of Linear Equations and Gaussian Elimination**
    - **Computational Aspect: Solving a system of linear equation using Excel Solver**
- **Matrix Operations and Determinants**
    - **Computational Aspect: Built-in Excel Matrix Functions for Matrix Operations like MMULT, MDETERM, MINVERSE, TRANSPOSE and so on.**
- **Eigenvalues and Eigenvectors, Orthogonality, and Projections**
    - **Computation Aspect: Eigenvalue and Eigenvector search using Excel**
- **Positive Definite Matrices, Linear Programming and the Simplex Method**
    - **Computation Aspect: Leontief Model with a numerical example and its implementation using Excel Solver**

Module 3: Optimization Techniques

- **Unconstrained Static Optimization**
- **Static Optimization with Equality and Inequality Constraints**
    - **Computational Aspect: Demand derivation under the cardinal and the ordinal utility approach using VBA.**
- **Discrete-time Dynamic Optimization**
    - **Computational Aspect: Multi-stage allocation problems using the Excel Solver**
- **Continuous-time Dynamic Optimization**
    - **Computational Aspect: Steepest descent numerical approach for optimal control problems using VBA with economic examples**

EVALUATION: Mid-semester exam (20% weightage), End-semester exam (50% weightage) and Project (30% weightage)

REFERENCES:

- **"A First Course in Analysis" by John B. Conway**
- **"Elementary Real Analysis" by Brian S. Thomson, Judith B. Bruckner, and Andrew M. Bruckner**
- **"Linear Algebra and its Applications" by Gilbert Strang**
- **"Introductory Mathematical Economics" by D. Wade Hands**
- **"Elements of Numerical Mathematical Economics with Excel: Static and Dynamic Optimization" by Giovanni Romeo**

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INDIRA GANDHI INSTITUTE OF DEVELOPMENT RESEARCH

Semester: Aug-Dec Semester, 2025

Course Title: Microeconomics 1

Instructor: Shubhro Sarkar (shubhro@igidr.ac.in)

Office hours: By appointment.

Office: 204, RB III.

Phone: 6909-6543.

Teaching Assistants: Yashika Chugh (yashika@igidr.ac.in), Avanish Mishra,

and Shubham Sharma (shubham.s@igidr.ac.in)

Course Description

The focus of the course will be on Microeconomic Theory and its applications. While the course will be theoretical in emphasis, its coverage will be at the intermediate graduate level. We will spend some time discussing the intuition behind the various concepts while we define the same with formal, precise statements.

Course Objectives

The course aims to

(I) provide a rigorous introduction to the essential tools and techniques used in Microeconomic Analysis

(II) prepare students to read academic papers on various topics in Microeconomic Theory and related fields

(III) help students develop a step-by-step problem-solving approach.

Course Outcomes

Upon completion of the course, students should be able to

(a) appreciate some of the important results in Microeconomic Theory

(b) construct theoretical models that analyze the behavior of individual economic agents in various settings and, if possible, test them with appropriate empirical techniques

(c) comprehend the underlying intuition behind the salient micro-level issues in a policy debate.

Course Requirements

Calculus; Set Theory; Probability Theory; Linear Algebra; Unconstrained Optimization over a Single Variable

Course Contents

PART ONE: INDIVIDUAL DECISION MAKING

1. Preference and Choice
2. Consumer Choice

Commodities
The Consumption Set
Competitive Budgets
Demand Functions and Comparative Statics
The Weak Axiom of Revealed Preference and the Law of Demand

3. Classical Demand Theory

Preference Relations: Basic Properties
Preference and Utility
The Utility Maximization Problem
The Expenditure Minimization Problem
Comparative Statics – Implicit Function Theorem
Duality: A Mathematical Introduction
Relationships between Demand, Indirect Utility and Expenditure Functions
Integrability
The Strong Axiom of Revealed Preference

4. Production

Production Sets
Profit Maximization and Cost Minimization
The Geometry of Cost and Supply in the Single-Output Case
Aggregation
Efficient Production

PART TWO: GAME THEORY

7. *Static Games of Complete Information*

7.1 Normal/Strategic form games and Nash Equilibrium
7.2 Pure and Mixed Strategies
7.3 Iterated Elimination of Strictly Dominated Strategies (IESDS)
7.4 Nash Equilibrium – pure and mixed strategies

8. *Dynamic Games of Complete Information*

8.1 Complete and Perfect Information
8.2 Game Trees/Extensive Form Representation
8.3 Backwards Induction

8.4 Complete and Imperfect Information
8.5 Subgame Perfection
8.6 Repeated Games
8.7 Renegotiation Proof Equilibrium

Evaluation

50% will be on the final examination, 40% on a mid-semester examination, and the remaining 10% on (four) assignments handed out in class.

Students may work together on homework assignments, but must write their answers independently. Answers that are merely copies of one another will be treated as violations of academic integrity, and appropriate action will be taken.

As a general policy, there will be no make-up midterm exams. If you miss a midterm exam and have a valid excuse, your grade will be based on the remaining elements of the course. Students should plan to be on campus till the end of the semester. Travel plans do not constitute a valid excuse for missing an exam.

References

1. *Microeconomic Theory*, Andreu Mas-Colell, Michael D. Whinston, and Jerry Green, Oxford University Press.

2. *Advanced Microeconomic Theory*, Geoffrey Jehle and Philip Reny, 2nd ed. Reading, MA: Addison-Wesley.

3. *Microeconomic Analysis*, Hal Varian, Third Edition, W.W. Norton and Company.

4. *Game Theory for Applied Economists*, Gibbons, Princeton

5. *Game Theory*, Fudenberg and Tirole, MIT Press.

6. *A Course in Game Theory*, Osborne and Rubinstein, MIT Press.

7. *A First Course in Optimization Theory*, Rangarajan K. Sundaram, Cambridge University Press.

8. *Mathematics for Economists*, Carl P. Simon and Lawrence Blume, W.W. Norton and Co.

Expectations

I believe that learning is a team effort. Students are the most vital part of this effort. There is a lot that students can do to help create a good learning environment. This includes coming to lectures on time, handing in assignments on time, and participating actively in class discussions.

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Fall Semester 2025, Course code: (5201)
IGIDR-Mumbai

Macroeconomics I

Course Syllabus

Fall 2025 (Aug-Dec 2025)

Course Instructor: Sargam Gupta
Class Timings: TBA
Office hours: TBA
Office: RB-I, Room-202
Contact: sargam@igidr.ac.in; Ext: 544 (O)

Course Objective

This course intends to motivate students to learn the concepts and applications of major workhorse models of the macroeconomics discipline. The idea is to provide a solid grounding to tackle more complex and detailed material in this _eld. This course will cover the stylized facts governing the basics of output growth, consumption, investment and savings in various economies. It will later introduce the standard macroeconomic growth models to understand the mechanics of the empirical facts observed in the data. This course will also acquaint students with the concept of equilibrium to understand the dynamics of economic systems comprehensively.
Prerequisites for this course are a familiarity with multivariate calculus, real analysis and linear algebra.

Grading

Class Participation and attendance: 5%

Homeworks/ Quizzes: 15%

Mid-Term Exam: 35%

Final Exam: 45%

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IGIDR-Mumbai

Outline and Readings

Broadly the lectures will cover the following macro-economic growth models:

- Solow-Swan growth model : theory and empirics
- Ramsey-Cass-Koopmans growth model and extensions
- Overlapping generations model
- Endogenous growth models

Core textbooks

1. Acemoglu, Daron. (2010). Introduction to Modern Economic Growth Princeton University Press. ISBN: 9780691132921.
2. Barro, Robert J. and Xavier Sala-i-Martin (2004), Economic Growth, 2nd Edition.
3. Romer, David. (2012), Advanced Macroeconomics, 4th Edition.

Additional textbooks

1. Aghion, P and Howitt (1998), Endogenous Growth Theory, MIT Press.
2. Ljungqvist, L and T Sargent (2012), Recursive Macroeconomic Theory, MIT Press.
3. Stokey, N and R E Lucas (1989), Recursive Methods in Economic Dynamics, Harvard University.

Reading list

1. Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. Quarterly Journal of Economics, 70, 1, 65-94
2. Mankiw, N.G., D. Romer and D. N.Weil. (1992). A Contribution to the Empirics of Economic Growth. Quarterly Journal of Economics, 107, 2, 401-437.
3. Ramsey, F.P. (1928). A Mathematical Theory of Saving. Economic Journal. 38, 152, 543-559.
4. Cass, D. (1965). Optimum Growth in an Aggregative Model of Capital Accumulation. Review of Economic Studies. 32, 233-240.
5. Romer, P. M. (1986). Increasing Returns and Long-Run Growth. Journal of Political Economy. 94, 5, 1002-1037.
6. Barro, R.J. (1990). Government Spending in a Simple Model of Endogenous Growth. Journal of Political Economy. 98, 5, part 2, 103-125.

7. Jones, Charles I. (1995). RD-Based Models of Economic Growth. Journal of Political Economy. 103, 759-784

8. Jones, L. and R. Manuelli. (1990). A Convex Model of Equilibrium Growth. Journal of Political Economy. 98, 1008-1038.

9. Romer, P.M. (1990). Endogenous Technological Change. Journal of Political Economy. 98, 5, part 2, 71-102.

10. Aghion, P. and P. Howitt. (1992). A Model of Growth Through Creative Destruction. Econometrica. 60, 2, 323-351.

11. Young, A. (1991). Learning-by-doing and the Dynamic E_ects of International Trade, Quarterly Journal of Economics. 106, 2, 369-406.

12. Grossman, G.M. and E. Helpman. (1990). Comparative Advantage and Long-Run Growth. American Economic Review. 80, 4, 796-815

13. Krugman, P.R. (1979). A Model of Innovation, Technology Transfer, and the World Distribution of Income. Journal of Political Economy. 87, 2, 253-266.

14. Grossman, G.M. and E. Helpman. (1991). Endogenous Product Cycles. Economic Journal. 101, 408, 1214-1229.

Reference books for Mathematics

1. Fuente, Angel de. (2000). Mathematical Methods and Models for Economists. Cambridge University Press.

2. Chiang, C. Alpha (1984). Fundamental Methods of Mathematical Economics. McGraw-Hill Publishing Co.

3. Pontryagin, Lev S., et al. (1962). The Mathematical Theory of Optimal Processes. New York: Interscience Publishers.

Software

The course would also introduce you the basic programming of macroeconomic models in MATLAB or GNU-Octave.

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Econometrics – I

Instructor: Bharti Nandwani

Course Outline:

The objective of the course is to give students an exposure to basic econometric theory and a practical understanding of the subject through examples and empirical applications. Designed for graduate students, the course will cover simple linear regression and multivariate regression, finite sample and asymptotic properties of OLS, inference and prediction, generalized and restricted least square, multicollinearity, heteroscedasticity and generalized methods of moments. Elementary knowledge of probability, statistics, and matrix algebra would be helpful, but is not required. A review of the relevant concepts would be done as and when required.

Recommended Texts:

1. *Econometric Methods* (4th edition), Jack Johnston and John DiNardo, McGraw-Hill Publishers, ©1997. (Referred to as JJ below)
2. *W.H. Greene, Econometric Analysis, 7th. ed., Upper Saddle River, NJ: Pearson Education (Prentice-Hall), 2012* (Referred to as Gr below)
3. *Econometric analysis of cross section and panel data,* by Jeffrey M. Wooldridge, MIT press, 2010.
4. *Introductory Econometrics: A Modern Approach,* by Jeffrey M. Wooldridge, Cengage learning, 2015. (Referred to as WD below)
5. *Estimation and Inference in Econometrics*, by Russell Davidson and James G. Mackinon, Oxford University Press, 1993.
6. *Microeconometrics*, by A.C. Cameron and P.K. Trivedi, Cambridge University Press, 2005. (Referred to as CT below)

Course Grading:

Grading for the course will be based on home assignments (15%), one empirical project (15%), one midterm examination (30%), and a final examination (40%). Class participation will count for borderline grades. Regular attendance is required.

Course outline

Topic 1 (Lectures 1 to 5): Introduction

- Review of Probability Theory (Random variable, Joint and conditional distribution, independence, features of probability distribution, covariance, normal and related distributions) – Ref: WD Appendix B
- Primer on Matrix Algebra (Matrices, Matrix Differentiation, Inverse of a matrix, Rank, quadratic forms, positive definite matrices, Matrix Statistics) – Reference JJ Appendix A and B.

Topic 2 (Lectures 6 to 10): Classical Linear Regression Models

- Least squares: assumptions
- Estimation
- Statistical properties
- Hypothesis testing and Inference

Topic 3 (Lectures 11 to 14): Classical Linear Regression Models: Special Topics

- Partitioned regression
- Dummy variables
- Choice of Functional form and tests of model specification
- Omission of relevant variables
- Inclusion of irrelevant variables

Topic 4 (Lectures 15 to 20): Large sample theory

- Convergence concepts
- Classical regression model with large samples

Topic 5 (Lectures 21 to 24) Endogeneity

- Causes of Endogeneity
- Instrumental Variables Estimation methodology
- Two Stage Least Square Estimation

Topic 6 (Lecture 25 to 28) General Model: Free Variance - Covariance Matrix

- The Generalised least squares estimator
- Heteroskedasticity
- Autocorrelation (including spatial autocorrelation)
- Inference and testing

Topic 7 (Lecture 29 to 32) Non-linear Regression Models

- Non-linear regression
- Maximum Likelihood Estimation
- Generalised Methods of Moments

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