



॥ त्वं ज्ञानमयो विज्ञानमयोऽसि ॥

Minor In Mathematical and Computational Economics

Objective:

The minor program in mathematical and computational economics is designed to enable the students to model various individual, business, strategic and socio-economic decision-making situations. Fundamental theories and tools are taught along with renewed focus on applications. The program is a platform for the students to identify the social and business needs where they can apply technologies they learn in their B. Tech programs. The emphasis is on incentive design in economic models and formulation of real-time and practical strategic situations, and provide a solid training for undertaking further studies in these areas. These theories will also come in handy in formulating real world scenarios, and providing economic interpretation of different analytical and optimization models.

Graduate Attributes:

- Inculcate the skill of economic reasoning and strategic thinking among the students.
- Provide a thorough understanding of economic theory with a focus on formal modeling and its intersections with AI.
- Provide training in economic tools, techniques and methods that are of current relevance and to familiarize students with their varied applications.
- Formulate real world scenarios mathematically and use computational tools to analyze them.

Learning outcomes:

- Students will be well-versed in foundational knowledge of economic theory and decision making.
- Students will be adept in the mathematical tools in formal modeling of a wide range of economic phenomena.
- Students will acquire the skills to analyze nuanced real world problem settings encountered in industry, think-tank, public policy space etc.

Course Structure:

SEMESTER V				SEMESTER VI			
Cat.	Course No.	Course Title	Credits	Cat.	Course No.	Course Title	Credits
SC	AIL 4XX0	Fundamentals of Economics	3	SC	AIL 4XX0	Games and Economic Behaviour	3
				SC	AIL 4XX0	Econometrics Lab	2
Total			3	Total			5
SEMESTERS VII AND VIII							
Cat.	Course No.	Course Title					Credits
SE	AIL XXXX	Electives / Projects					7
Total						7	

Credit Distribution		
Course Type		Credits
Core Courses		8
Electives	Minimum	1
	Maximum	7
Project Credits	Minimum	0
	Maximum	6
Total		15

List of core courses (8 credits):

Sr. No.	Title	Code	Structure	Level
1	Fundamentals of Economics	AIL 4XX0	3-0-0-0	400
2	Games and Economic Behaviour	AIL 4XX0	3-0-0-0	400
3	Econometrics Lab	AIL 4XX0	1-0-2-0	400

List of elective courses (7 credits):

Sl. No	Title	Code	Structure	Level
1	Decision Sciences Applications	AIL 6XX0	3-0-0-0	600
2	Operations Research for Economics	AIL 7XX0	3-0-0-0	700
3	Modern Macroeconomics	AIL 7XX0	3-0-2-0	700
4	Advanced Macroeconomics	AIL 7XX0	3-0-2-0	700
5	Computational Macroeconomics	AIL 7XX0	3-0-2-0	700
6	Modern Growth Economics	AIL 7XX0	3-0-0-0	700
7	Analysis of Economic Data	AIL 4XX0	2-0-4-0	400
8	Foundations of Operations Analytics	AIL 4XX0	3-0-2-0	400
9	Market Design	AIL 4XX0	3-0-0-0	400
10	Social and Economic Networks	AIL 7210	3-0-0-0	700
11	Behavioral Economics and Decision Theory	AIL 7230	3-0-0-0	700
12	Machine Learning for Economics	AIL 7310	3-0-0-0	700
13	Social Choice Theory	AIL 7270	3-0-0-0	700
14	Introduction to Mechanism Design	AIL 7280	3-0-0-0	700
15	Computational Game Theory	MAL 8XX0	3-0-0-0	800

16	Industrial Organization	HSL 7020	3-0-0-0	700
17	Theoretical Foundations of Econometrics	AIL 7320	3-0-0-0	700
18	Advanced Econometrics	AIL 7610	3-0-0-0	700
19	Causal Econometrics	AIL 7XX0	2-0-2-0	700
20	Mathematics for Economics	AIL 7XX0	3-0-0-0	700
21	Political Economy	AIL 7450	3-0-0-0	700
22	Microeconomics I	AIL 6010	3-0-0-0	600
23	Microeconomics II	AIL 6060	3-0-0-0	600
24	Individual and Strategic Decision Making: Theory and Applications	AIL 6020	2-0-0-0	600
25	Computational Intelligence	MSL 72100	2-0-0-1	700

Note:

1. Students should complete all the core courses before registering for the project courses.
2. Students are encouraged to take project-1 and project-2 in consecutive semesters, and may work on the same or related topic in order to develop adequate expertise.

Core Courses:

Title	Fundamentals of Economics	Number	AIL4XX0
Department/School	AIDE (CMCE)	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech	Type	Core
Prerequisite	None		

Objectives:

1. To introduce the concepts as – learning and unlearning to think like an economist, the fundamentals of economics, and macroeconomics in closed and open economy.
2. To explore how the state can facilitate the functioning of the market economy, development, globalization, and how ideas and machines are useful for economic development and growth.

Learning outcomes:

1. Students will be familiarized with how the basic economic thinking unfolds, how economic agents decide, interact, and how the state can facilitate the functioning of the market economy.
2. Students will understand the functioning of the economics of institutions, development, globalization, and the importance of technology for economic development and growth.

Course Contents:

1. Learning and Unlearning to Think Like an Economist: Principles of Economics, Thinking like an Economist, Strategic Thinking, Prisoner’s Dilemma and Applications. (L11)

2. Unfolding the Subject Matter of Economics: Market Forces of Demand and Supply, Elasticity and its Applications, Supply Demand and Government Policies. (L4)

3. Money in the Modern Economy: History and Concept of money; monetary aggregates; Theories of Demand for money; money supply and credit creation. (L3)

4. Unfolding the Subject Matter of Macroeconomics: Macroeconomic Concerns, The Components and Measurement of Macroeconomic Data, Circular flow, Keynesian Income Determination, Multipliers, Open Economy and Balance of Payments, Exchange Rates. (L9)

5. Finance and Macroeconomy: The Financial System, Economic Growth, and Financial Crises. (L3)

6. Institutions, Development, Globalization, and Inequality: The evolution of democracy and state, Conditions for Modern Democracy and Citizenship, Globalization. (L8)

7. Economics of Ideas and Technology: Economics of Ideas, Economics and AI. (4).

Reference Books:

1. Mankiw, N. G. (2021). *Principles of economics*. Cengage Learning.
2. Karl, E., CASE, F., OSTER, R. C., & Sharon, E. (2017). *Principles of Economics*. Pearson.
3. Jones, C., & Vollrath, D. (2013). *Introduction to Economic Growth* New York, US: WW Norton & Company.

Title	Games and Economic Behaviour	Number	AIL4XX0
Department/School	AIDE (CMCE)	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech	Type	Elective/Core for Minor in CME
Prerequisite	None		
Exclusion	Introduction to game theory MAL4310		

Objectives:

To introduce undergraduate students to basic solution concepts from Game Theory and illustrate their use in different economic contexts.

Learning outcomes:

1. Students will be familiarized with the concepts of Game Forms, Strategies, Actions and Utility Functions.
2. Students will be familiarized with solution concepts such as Value, Nash Equilibrium, Iterated Elimination of Weakly (Strictly) Dominated Strategy, Sub-game Perfect Equilibrium.
3. Students will be able to use these tools to analyze solutions in different economic models such as Auctions, Voting, Bargaining, Oligopoly etc.

Course content (number of lectures are given in parenthesis):

Rational Decision Making: Single person decision problem, Risky Alternatives, Rational decision involving uncertainty, Decisions over time. (5)

Static Games: Zero sum games, Max-min (min-max) strategy and value, Normal form games, Extensive form games, Pure and mixed strategies, Beliefs, Solution concepts: Dominant Strategy Equilibria, Iterated elimination strictly (weakly) dominated strategies, Rationalizability, Nash equilibria. (5)

Applications:

- **Auctions:** Independent private values; Examples: English auction, Dutch auction, First and second price sealed bid auction; revenue equivalence; best response; strategic manipulability, Common Values and the Winner's Curse. (8)
- **Strategic Bargaining:** One round bargaining, Ultimatum game, Rubinstein's model, Legislative bargaining. (8)
- **Voting:** Voting games, voting by committees, manipulability, Nash equilibrium of a voting game, Single peaked preferences, median voter theorem. (8)
- **Oligopoly:** Market structures, Bertrand, Cournot and Stackelberg model. Application of solution concepts. (8)

Text book:

1. "Game Theory: An Introduction": Steven Tadelis (Princeton University Press, 2013).
2. "Handbook Of Social Choice and Welfare, Vol. 1": Kenneth J. Arrow (ed), Amartya K. Sen (ed), Kotaro Suzumura (ed) (North Holland, 2002)

Reference:

1. "Game Theory: A Multi-Leveled Approach": Hans Peters (Springer, 2015).

2. "A Course in Game Theory": Martin J. Osborne and Ariel Rubinstein (The MIT Press, 1994)
3. "A Primer in Game Theory": Robert Gibbons (Pearson Academic, 1992)
4. "Game Theory: Analysis of Conflict": Roger Myerson (Harvard University Press, 1997)
5. "Game Theory": Drew Fudenberg and Jean Tirol (The MIT Press, 1991)
6. "Game Theory": Michael Maschler, Eilon Solan and Shmuel Zamir (Cambridge University Press, 2013)

Online Resource:

1. "Game Theory": Giacomo Bonanno
(https://faculty.econ.ucdavis.edu/faculty/bonanno/PDF/GT_book.pdf)
2. "Decision Making": Giacomo Bonanno
(https://faculty.econ.ucdavis.edu/faculty/bonanno/PDF/DM_book.pdf)

Title	Econometrics Lab	Number	AIL4XX0
Department/School	AIDE (CMCE)	L-T-P [C]	1-0-2 [2]
Offered for	B. Tech.	Type	Core for Minor in CME/ Elective
Prerequisite	None		

Objectives:

To introduce undergraduate students to econometric modelling strategies.
 To introduce students to the use of hypothesis testing and statistical inference techniques commonly used in economics to study empirical questions.
 To give students very hands-on training in econometrics in R programming language

Learning outcomes:

Students will be able to use multiple linear regression to conduct hypothesis testing and statistical inference.
 Students will be able to interpret the results of their analysis and draw conclusions necessary for a variety of economic decision-making.
 Students will be able to use R to build econometric models using commonly used economic data.

Course content:

Review of key statistical concepts: Different sampling strategies, Population versus sample, Statistical distributions used in econometrics: Normal distribution, t-distribution, F-distribution, Chi-square distribution, Law of Large Numbers, Central Limit Theorem, (1)

Simple Linear Regression: Simple Linear Regression Model, least squares method of estimation, Algebraic properties of least squares estimator, properties of R-squared. (3)

Multiple Linear Regression Model: Gauss-Markov theorem, Statistical properties of least squares estimator, Adjusted R-squared, interpretation of regression coefficients, non-linearity and interaction effects, different functional forms - elasticity and semi-elasticity, regression as projection, partialling out interpretation of linear regression (4)

Relaxing the Gauss Markov Assumptions: specification errors, omitted variable bias, measurement error, missing data, outliers, sample-selection issues, multicollinearity: detection, consequences and solutions, heteroskedasticity: detection, consequences and solutions, endogeneity, autocorrelation, stationarity and nonstationarity. (4)

Special types of economic data: Introduction to Panel Data, serially correlated and spatially correlated data, experimental versus observational data, Census versus survey data, hierarchical structure of survey data. (2)

Labs:

1. Revision of key concepts in statistical distributions.
2. Illustrating statistical and econometric properties of SLRM coefficients
3. Illustrating Gauss-Markov properties, Asymptotic properties of estimators, Frisch-Waugh-Lovell Theorem, partialling out regression coefficients, conducting econometric tests of a set of linear restrictions
4. Properties of Estimators after relaxing Gauss-Markov assumptions
5. Understanding panel data, hierarchical survey data, survey weights

Reference Books:

1. Gujarati et al (2009), Basic Econometrics, (5th edition), Mc-Graw Hill Publication.
2. Wooldridge, J. (2014). Introduction to econometrics: A modern approach, 5th ed. Cengage Learning.

Online Resources: NPTEL course: 'Introduction to Econometrics" by Dr. Sabuj Kumar Mandal <https://archive.nptel.ac.in/courses/130/106/130106001/>

Elective Courses:

Title	Decision Sciences Applications	Number	AIL6XX0
Department/School	AIDE (CMCE)	L-T-P [C]	3-0-0
Offered for	B. Tech./P.G.	Type	Elective
Prerequisite	None		

Objectives:

1. To introduce students to decision sciences and operations research.
2. To provide practical motivation for linear programming and its applications.
3. To understand the solution methods and its implementation.

Learning outcomes:

1. Formulate different types of business situations using linear programs
2. Implement linear programs using different tools and packages
3. Summarize duality theory and its economic interpretation
4. Solve special types of linear programs and their applications

Course Content:

Linear Programming: Formulation and Examples, Intuition, Modeling Business Situations, Geometric Motivation and Analysis, Implementation using Different Tools and Packages, Solution Methods (8 lectures). [RB1, RB3, OR]

Economic Applications: Game Theoretic Applications, Queueing and Inventory Models, Data Envelopment Analysis, Network Problems, Other Applications (18 lectures). [RB1, RB4]

Duality for Policy Making: Introduction, Formulation, Economic Interpretation, Duality Applications and Prescriptive Analytics (16 lectures). [RB1, RB2, RB4]

Textbook:

1. Srinivasan, G. (2017). Operations Research: Principles and Applications. PHI Learning Pvt. Ltd.

Reference books:

1. Beilby, M. H. (2014). *Economics and Operational Research*. Academic Press.
2. Solow, D. (2014). Linear programming: An introduction to finite improvement algorithms. Courier Corporation.
3. Thie, P. R., & Keough, G. E. (2011). An introduction to linear programming and game theory. John Wiley & Sons.

Online Resources:

Srinivasan, G. NPTEL course on Operations Research - <https://archive.nptel.ac.in/courses/112/106/112106134/>

Title	Operations Research for Economics	Number	AIL7XX0
Department/School	AIDE (CMCE)	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech./P.G./Ph.D.	Type	Elective
Prerequisite	None		

Objectives:

1. To introduce students to operations research and its role in economics.
2. To provide conceptual understanding of operations research as a tool to solve problems in economics, business and policy making.

Learning outcomes:

1. Formulate economic and business problems using operations research tools
2. Implement operations research tools to solve various economics, business, and policy problems

Course content:

Business formulation: Introduction to Operations Research and Economics, Concepts and examples, Case-based applications, Solution methods (12 lectures) [RB1, RB2, RB5]

Applications to game theory: Computing equilibria, Matrix games - Computing mixed strategy Nash equilibrium, Cooperative games - Computing Core using linear program, Queueing Models, Strategic Queueing (10 lectures) [RB2, RB3, RB6]

Supply chain contracts: Inventory models, Newsvendor model, Supply chain – structure and concepts, Wholesale price contract, Buyback contract and Revenue sharing contract (6 lectures) [RB4]

Policy applications: Comparing the performance of decision making units, Prescription for inefficient units using data envelopment analysis, Other applications (14 lectures) [RB1]

Textbook:

1. Narahari, Y. (2014). *Game theory and mechanism design* (Vol. 4). World Scientific.
2. Srinivasan, G. (2017). *Operations Research: Principles and Applications*. PHI Learning Pvt. Ltd.

Reference books:

1. Vohra, R. V. (2004). *Advanced mathematical economics*. Routledge.
2. Chopra, S. & Meindl, P. (2015). *Supply Chain Management: Strategy, Planning and Operation*. Pearson Education.
3. Beilby, M. H. (2014). *Economics and Operational Research*. Academic Press.
4. Hassin, R., & Haviv, M. (2003). *To queue or not to queue: Equilibrium behavior in queueing systems* (Vol. 59). Springer Science & Business Media.

Title	Modern Macroeconomics	Number	AIL7XX0
Department/School	AIDE (CMCE)	L-T-P [C]	3-0-2[4]
Offered for	B. Tech./PG/ Ph.D.	Type	Elective
Prerequisite	None		

Objectives:

1. To introduce the foundations of modern macroeconomics using basic mathematical tools and data.
2. To introduce the basic theoretical understanding of modern macroeconomic theory and its practice.

Learning outcomes:

1. Students will be familiarized with the aggregate macro models, business cycles, and explore the changes with respect to monetary and fiscal policies.
2. Students will learn to use major mathematical concepts to model the time and data in macroeconomics. They will also be familiarised with the long run phenomenon of economic growth and the role of technology and R&D.

Course Contents:

1. Aggregate Macro Models: IS-LM-AD-AS under classical and Keynesian System, Theories of Expectation, Wage Contract and Policy Implications, IS-LM Open Economy Models; Extended Mundell-Fleming model. (L12)

2. Mathematical Preliminaries with Examples in Economics: Dynamical Systems in discrete time, Dynamic Optimization with Applications in Economics discrete time. (L6)

3. Micro-founded Macro Models: Lucas Critique and representative agent models; the Dynamic General Equilibrium (DGE) approach to macro models: optimization problem of a representative household; and a representative firm. (L8)

4. Growth Models: *Exogenous Growth Models:* Solow-Swan Model, The Ramsey-Cass-Koopmans model; The Samuelson-Diamond Overlapping Generations model, *Endogenous Growth Models.* (L10)

5. Dynamic Inconsistency and Political Economy: Dynamic Inconsistency in Decision Making, Political Economy in Macroeconomics. (L6)

Lab: Introducing the data related to aggregate macro models in closed and open economies, plotting the graphs in dynamical systems, formulating the micro-founded macro models and its simulations using MATLAB/Julia/Python/R, and solving mathematical models of growth economics along with problem sets.

Reference Books:

1. Foundations of Modern Macroeconomics by Ben J. Heijdra, Oxford University Press, 2017.
2. Galor, O. (2010): Discrete Dynamical Systems, Springer-Verlag.
3. Acemoglu, D. (2009): Introduction to Modern Economic Growth, Princeton University Press.

Online Resource:

1. MIT OPENCOURSEWARE on Intermediate Macroeconomics by Prof. George-Marios Angeletos: <https://ocw.mit.edu/courses/14-05-intermediate-macroeconomics-spring-2013/pages/calendar-and-readings/>
2. MIT OPENCOURSEWARE on Advanced Macroeconomics- I by Prof. Ivan Prof. Iván Werning and Prof. George-Marios Angeletos: <https://ocw.mit.edu/courses/14-461-advanced-macroeconomics-i-fall-2012/pages/readings/>

Title	Advanced Macroeconomics	Number	AIL7XX0
Department/School	AIDE (CMCE)	L-T-P [C]	3-0-2 [4]
Offered for	B.Tech./PG/ PhD	Type	Elective
Prerequisite	None		

Objectives:

1. To explore the advanced concept of macroeconomics in modelling time, importance of micro foundation in macroeconomics, labour market, monetary policy, and their policy implications using data and simulations.
2. To introduce recent developments in macroeconomic modelling, such as macroeconomics of pandemic.

Learning outcomes:

1. Students will be able to conceptualize and apply dynamic programming techniques in different macroeconomic theories and policy.
2. Students will learn macroeconomic modelling using different mathematical concepts such as the macroeconomics of pandemic.

Course contents:

1. Notes on Mathematical Preliminaries: Stochastic difference equations; Markov processes; Dynamic Programming, Complete Markets; sequential trading and Arrow securities; Recursive competitive equilibrium; examples of incomplete markets. (L10)

2. Basics of Business Cycle and RBC Models: Some Business Cycle Facts, Basic Structure with and Without Labour; Money in Utility function; Monetary Policy. (L8)

3. New Keynesian Models: Basic Structure, Price Stickiness, Optimum Pricing, Dynamic IS and New Phillips Curve, Monetary Policy Design. (L8)

4. Search, Matching, Financial Frictions, and Unemployment: Labour Market, McCall's model of intertemporal job search, A lake model, A model of career choice, Jovanovic's matching model. (L6)

5. Heterogeneous Agents Model: The New Keynesian Cross, Monetary Policy and Heterogeneity, TANK, HANK, and SAM. (L8)

6. Macroeconomics of Pandemics. (L2)

Lab: Graphical representation of mathematical preliminaries, solving business cycle models and New Keynesian Models, formulating mathematical models on search, matching, financial frictions, unemployment, and their simulations, and simulation techniques in heterogeneous agents models using softwares – MATLAB/Julia/Python/R.

Reference Books:

1. Miao, J. (2013). Economic dynamics: Discrete time. MIT Press.
2. Sargent, T. J., & Ljungqvist, L. (2018). Recursive macroeconomic theory. MIT Press.
3. Foundations of Modern Macroeconomics by Ben J. Heijdra, Oxford University Press, 2017.

Online Resource:

1. MIT OPENCOURSEWARE on Intermediate Macroeconomic Theory by Prof. Huntley Schaller:
<https://ocw.mit.edu/courses/14-06-intermediate-macroeconomic-theory-spring-2003/pages/syllabus/>
2. MIT OPENCOURSEWARE on Advanced Macroeconomics- II by Prof. Guido Lorenzoni and Prof. Olivier Blanchard :
<https://ocw.mit.edu/courses/14-462-advanced-macroeconomics-ii-spring-2007/pages/syllabus/>
3. Notes on Macroeconomic Theory by Prof. Dirk Krueger, Department of Economics University of Pennsylvania:
<https://perhuaman.files.wordpress.com/2014/06/macrotheory-dirk-krueger.pdf>

Title	Computational Macroeconomics	Number	AIL7XX0
Department/School	AIDE (CMCE)	L-T-P [C]	3-0-2 [4]
Offered for	B.Tech./PG/ Ph.D.	Type	Elective
Prerequisite	None		

Objectives:

To introduce advanced numerical and dynamic programming, and advanced computing techniques to solve macroeconomic models using relevant software such as – MATLAB (Dynare), Python, Julia, R etc.

Learning outcomes:

1. Students will be familiarised with programming languages to model dynamic systems and macroeconomic models using software.
2. Students will be able to connect the theory with the programming and solve real world problems.

Course Contents:

1. **Programming with Dynamical Systems:** Deterministic and stochastic difference equations, Markov Process, Ergodic Theory, basic programming with Dynare. (L9)
2. **Dynamic Optimization and its Applications in Economics:** Markov Decision Process Model, Finite-Horizon Dynamic Programming, Infinite-Horizon Dynamic Programming, Applications, exercises using Dynare/ Julia, Linear-Quadratic Models, Control under Partial Information, Numerical Methods. (L9)
3. **Equilibrium with Complete Market:** Application of Neoclassical Growth Models and Overlapping Generations Models, RBC, New Keynesian models and simulation, Bayesian Estimation, log-linearization, and estimation of DSGE Models. (L7)
4. **Equilibrium with Incomplete Market:** Aiyagari model, Krusell-Smith models, Aiyagari-Bewley-Huggett, and their extensions. (L7)
5. **Optimal Policies in Incomplete Market:** Computations of Ramsey Models of Fiscal and Monetary Policy. (L5)
6. **High-performance programming:** Good coding practices, parallelization, exposition of advanced computational techniques. (L5)

Lab: Programming with dynamical systems, applications of dynamic optimization techniques in economics, equilibrium with complete and incomplete market, optimal Policies in Incomplete Market, and high-performance programming.

Reference Books:

1. Miao, J. (2013). *Economic dynamics: Discrete time*. MIT Press.
2. Stachurski, J. (2009). *Economic dynamics: theory and computation*. MIT Press.

3. Hommes, Cars and LeBaron, Blake (2018), Handbook of Computational Economics, Vol 4, Elsevier.

Online Resource:

1. QuantEcon Lectures by founding members and chairs Prof. Thomas J. Sargent and John Stachurski and Team Members: <https://quantecon.org/lectures/index.html>
2. Quantitative Economics with Julia by QuantEcon founding members and chairs Prof. Thomas J. Sargent and John Stachurski, and Team Members <https://julia.quantecon.org/intro.html>
3. MIT OPENCOURSEWARE on Dynamic Optimization & Economic Applications (Recursive Methods) by Prof. Iván Werning:
<https://ocw.mit.edu/courses/14-128-dynamic-optimization-economic-applications-recursive-methods-spring-2003/pages/syllabus/>
4. MIT OPENCOURSEWARE on Dynamic Optimization Methods with Applications by Prof. Guido Lorenzoni:
<https://ocw.mit.edu/courses/14-451-dynamic-optimization-methods-with-applications-fall-2009/>
5. MIT OPENCOURSEWARE on Macroeconomic Theory- III by Prof. Iván Werning:
<https://ocw.mit.edu/courses/14-453-macroeconomic-theory-iii-fall-2006/pages/readings/>

Title	Modern Growth Economics	Number	AIL7XX0
Department/School	AIDE (CMCE)	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech./PG/PhD	Type	Elective
Prerequisite	None		

Objectives:

1. To introduce the advanced growth theories to explore how endogenizing factors can enhance economic growth and turn out to be major causes of creating income differences across countries.
2. To introduce the stochastic nature of growth economics and how the concept of economic growth can be addressed by diffusion of technology, finance, institutions and political economy. It also aims to unfold the importance of culture for economic growth, and the unbalanced growth path.

Learning outcomes:

1. Students will be familiarized with the endogenous and stochastic growth models with applications.
2. Students will learn how finance, culture, AI, and automation can affect economic growth.

Course Contents:

1. Endogenous Growth Theories: One and Two Sector Model of Economic Growth (The AK-Model), Growth with Externalities, Learning by Doing and Knowledge Spillovers, Public Services and Endogenous growth, Natural Resources and Economics Growth. (L10)

2. Endogenous Technological Change, AI and Growth: Expanding variety models, the Schumpeterian Growth Models, Directed Technical Change, and Economic Growth and AI. (L10)

3. Stochastic Growth Models: Stochastic Dynamic Programming, Stochastic Growth Models. (L6)

4. Finance, Development and Economic Growth: Finance and Growth, Structural Change and Economic Growth, Structural Transformation and Market Failure in Economic Development. (L8)

5. Culture, Climate, and the Political Economy of Growth: Institutions, Political Economy and Growth, Political Institutions and Economic Growth, Unbalanced Growth Model, Growth and Climate Change. (L8)

Reference Books:

1. Introduction to Modern Economic Growth, by Daron Acemoglu. Princeton University Press, 2010.
2. Jones, C., & Vollrath, D. (2013). Introduction to Economic Growth New York, US: WW Norton & Company.
3. Aghion, P. and Howitt, P. (2009): The Economics of Growth, MIT Press.

Online Resource:

1. MIT OPENCOURSEWARE on Macroeconomic Theory- I by Prof. George-Marios Angeletos:
<https://ocw.mit.edu/courses/14-451-macroeconomic-theory-i-spring-2007/pages/readings/>
2. MIT OPENCOURSEWARE on Economic Growth by Prof. Daren Acemoglu:
<https://ocw.mit.edu/courses/14-452-economic-growth-fall-2016/pages/syllabus/>

Title	Analysis of Economic Data	Number	AIL4XX0
Department/School	AIDE (CMCE)	L-T-P [C]	2-0-4 [4]
Offered for	B. Tech.	Type	Elective
Prerequisite	None		

Objectives:

1. To give students an in-depth introduction to the wide variety of data used in economics for various economic decision making.
2. To students an understanding of the distinct characteristics of economic data.
3. To give students a bird's eye view of the Indian economy through relevant data.

Learning outcomes:

1. Students will get first-hand experience in handling economic data using statistical software.
2. Students will get a thorough understanding of the various peculiarities of economic data and appreciate the approach taken by empirical modelling in economics that stems from certain aspects of economic data.
3. Students will be able to design their own survey or experiments in economics

Course content:

Broad Types of Economic data: Census versus survey, population versus sample, metadata, paradata, experimental data versus observational data, administrative data, vintage data, understanding the hidden biases in administrative data. (4)

Survey data: Brief history of large-scale surveys. Sampling errors and non-sampling errors, survey weights, hierarchical structure of survey data, commonly used survey datasets in India versus other countries: CPS, PSID, NFHS, NSSO (4)

Economic Data across sectors: International Comparisons: Macroeconomic data from India: Public Finance data: GST collection, Daily customs collections, Export-Import Data
Firms and Labour force data: Annual Survey of Industries, PLFS data (8)

Administrative data from the social sector

NFHS, HMIS data, Rural Health Statistics, DISE, ASER, Jal Jeevan Mission,

Big Data and the Economy: Conflict data, Newspaper reports: Legal data, migration data
 Public procurement data on auctions and tenders, UPI transactions data, Election Commission and voting data (8)

Seminal field experiments, behavioral experiment data,

Making your case with data: Commonly used data-viz for public consumption, choosing the right visualization for a dataset, common pitfalls, examples of bad data visualization, data-visualization versus infographic, data to ink ratio (4)

Labs

1. Identifying gaps in administrative data, Building a research outline combining multiple types of data
2. Designing your own survey, constructing survey weights
3. Tracking the economy over time
4. Tracking the social sector of the economy, Identifying gaps in social sector data
5. Research outline using Big Data in Economics

6. Designing your own experiment in Economics
7. Writing a Data-journalism article

Reference Book:

1. 'Whole Numbers and Half Truths: What Data Can and Cannot Tell us about Modern India' by Rukmini, Westland Books
2. 'The Art of Statistics: Learning from Data' by David Spiegelhalter
3. 'Fundamentals of Data Visualization: A Primer on Making Informative and Compelling Figures' by Claus O. Wilke
4. 'Exploratory Data Analysis' by John Tukey

Title	Foundations of Operations Analytics	Number	AIL4XX0
Department	AIDE (CMCE)	L-T-P [C]	3-0-2 [4]
Offered for	B.Tech.	Type	Elective
Prerequisite	None		
Exclusions	None		

Objectives

1. To introduce students to a decision making toolkit to solve problems in engineering, economics, business.
2. To provide implications of operations research implementation in practice.

Learning Outcomes:

1. Formulate engineering and business problems using prescriptive analytics techniques
2. Develop an algorithmic view of different techniques and its implementation

Course Content:

Prescriptive analytics: Building optimization models, Primer on linear algebra, Decision science modelling approaches, Decision analysis, Assumptions, Linear and Integer optimization [RB1, RB2] (12 lectures)

Algorithmic implementation: Algebraic methods, Geometric analysis, What-If analysis, Computational implementation, Parametric analysis [RB1, RB3] (12 lectures)

Extended applications: Engineering and business applications, Performance measurement, Decision making under uncertainty, Repeated and Sequential decisions, Spreadsheet analytics [RB2] (18 lectures)

Lab: Implementing formulation in Python using different packages, Solution analysis and its interpretation, Economic implications, Python and Spreadsheet implementation using different packages, Formalizing a problem statement in the prescriptive analytics framework and generating multiple approaches

Reference Books:

1. Solow, D. (2014). Linear programming: An introduction to finite improvement algorithms. Courier Corporation.
2. Hiller, F., & Hiller, M. (2009). Introduction to management science: a modeling and case studies approach with spreadsheets (ed.). Tata McGraw-Hill.

3. Srinivasan, G. (2017). Operations Research: Principles and Applications. PHI Learning Pvt. Ltd.
4. Luenberger, D. G., & Ye, Y. (1984). Linear and nonlinear programming (Vol. 2). Reading, MA: Addison-wesley.

Online Resources:

1. Srinivasan, G. NPTEL course on Operations Research - <https://archive.nptel.ac.in/courses/112/106/112106134/>

Title	Market Design	Number	AIL4XX0
Department/School	AIDE (CMCE)	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech	Type	Elective
Prerequisite	None		

Objectives:

To introduce undergraduate students to different types of markets and the solution concepts associated with these markets.

Learning outcomes:

1. Students will be familiarized with the concepts of markets with public information and private information.
2. Students will be familiarized with solution concepts such as price mechanisms, contracts, auctions, and matching algorithms.
3. Students will be able to use these tools to analyze solutions in different markets.

Course content (number of lectures are given in parenthesis):

Markets with public information: General Equilibrium: examples; Pure Exchange: The Edgeworth Box; Price mechanisms: The One-Consumer, One-Producer Economy; The 2x2 Production Model; Optimal Employment Contracts without Uncertainty, Hidden Information, or Hidden Actions; Optimal Contracts under Uncertainty. (10)

Markets with private information:

- Markets with hidden information: Insurance Market; Adverse selection; inefficiency of optimal contract. (8)
- Markets with hidden action: Principle-Agent problem; Moral Hazard; inefficiency of optimal contract. (8)
- Allocation of indivisible objects with monetary side payments: Auctions; direct and indirect mechanisms; Examples; VCG mechanism and its properties. (8)
- Allocation of indivisible objects without monetary side payments: One-sided matching problem; Top-Trading-Cycle algorithm; Two-sided matching problem; Deferred-Acceptance algorithm; College admission problem; Boston Mechanism. (8)

Reference:

1. "Microeconomic Theory": Andreu Mas-Colell, Michael D. Whinston, Jerry R. Green (Oxford University Press).
2. "Intermediate Microeconomics": Hal R. Varian (Norton).
3. "Contract Theory": Patrick Bolton, Mathias Dewatripont (MIT Press).

4. "Putting Auction Theory to Work": Paul Milgrom (Cambridge University Press).
5. "Auction Theory": Vijay Krishna (Academic Press).

Online Content

1. "Minimalist Market Design: A Framework for Economists with Policy Aspirations": Tayfun Sönmez <https://www.tayfunsonmez.net/wp-content/uploads/2023/02/Minimalist-Market-Design-February2023.pdf>
2. "Lecture Notes on Mechanism Design": Debasis Mishra <https://www.isid.ac.in/~dmishra/gmdoc/mdnotes.pdf>
3. "Mini Course on Matching": Tayfun Sönmez <https://www.tayfunsonmez.net/mini-course/>

Title	Social and Economic Networks	Number	XXL7XX0
Department/School	AIDE (CMCE)	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech., Post-grad, Ph.D	Type	Elective
Prerequisite	Individual and strategic decision making: theory and applications		

Objectives:

1. To introduce students to formal methods of modeling formation and evolution of networks.
2. To provide conceptual understanding of applications of network theory to social and economic problems.
3. To provide knowledge of benchmark models.

Learning outcomes:

1. Students will be equipped to model and analyze a wide variety of social and economic networks.
2. Students will gain an understanding of key concepts and important models.
3. Students will be familiar with the tools required for strategic analysis of networks.

Course content:

Introduction to networks: need for modeling networks, applications in economics and society. (3 lectures)

Representing and measuring networks: nodes, players and graphs; types of networks; degree and density; degree distribution; clustering; cliquishness; centrality. (7 lectures)

Random networks: Poisson networks; Markov graphs; Expected degree model etc.; properties of random networks. (8 lectures)

Network games: stability; efficiency; diffusion and learning; strategic interactions and network structure; equilibria notions; dynamic behavior and contagion. (16 lectures)

Economic applications: trade; information transmission and beliefs; public goods; influence etc. (8 lectures)

Reference Books:

1. Matthew O. Jackson, "Social and Economic Networks", Princeton University Press (2008).
2. Gabrielle Demange and Myrna Wooders Eds. "Group Formation in Economics Networks, Clubs, and Coalitions", Cambridge University Press (2005).
3. Bhaskar Dutta and Matthew O. Jackson Eds. "Networks and Groups: Models of Strategic Formation", *Studies in Economic Design*, Springer (2003).

Research papers:

1. Galeotti, A., Sanjeev Goyal, M. O. Jackson, Fernando Vega-Redondo, and Leeat Yariv. "Network Games." *The Review of Economic Studies* 77, no. 1 (2010): 218-44.
0. Jackson, M.O. "[Allocation Rules for Network Games](#)," *Games and Economic Behavior*, Volume 51, Issue 1, April 2005, Pages 128-154.

Online resources:

"Social and Economic Networks: Models and Analysis", SOHS-YECON0001, Stanford School of Humanities and Social Sciences. <https://online.stanford.edu/courses/sohs-yecon0001-social-and-economic-networks-models-and-analysis>

Title	Behavioral Economics and Decision theory	Number	XXL7XX0
Department/School	AIDE (CMCE)	L-T-P [C]	3-0-0[3]
Offered for	B. Tech./P.G./Ph.D.	Type	Elective
Prerequisite	Microeconomics-1 (for BTech/PG)		

Objectives:

1. To familiarise students with standard models of individual decision-making.
2. To equip students with different modeling techniques.
3. To provide an overview of current literature in bounded rationality and it's intersections with AI.

Learning Outcomes:

1. Knowledge of fundamentals of decision theory and modeling techniques.
2. A deep understanding of bounded rationality and formal approaches for modeling behavioral phenomena.
3. Development of conceptual understanding required for application of decision theoretic models and framework to various relevant settings such as online e-retailing, search algorithms, etc.

Course Content:

Rational choice: binary relations, preference orderings, representation theorems (7 lectures)

Important axioms in choice theory, their relevance in characterizing choice and underlying behavioral intuition: WARP, GARP, Independence axioms etc. (7 lectures)

Decision theory models with boundedly rational agents: imperfect attention, cognitive constraints, attribute based models, framing effects, etc. (7 lectures)

Stochastic choice models: random utility model, Luce rule, two-stage decision making etc. (6 lectures)

Decision-making under uncertainty: subjective probabilities, V-N-M theorem, de-Finetti's theorem, Savage's theorem, Anscombe-Aumann framework. (9 lectures)

Applications of decision theory in AI: list-based decision making models and online search, e-retailing platforms, stop-and-choose decision rules, attention and online advertising etc. (6 lectures)

Reference Books:

1. David M. Kreps, "Notes on the Theory of Choice", Westview Press (1988).
2. Itzhak Gilboa, "Theory of Decision under Uncertainty", CUP (2009).
3. Paul Anand, Prasanta Pattanaik and Clemens Puppe, "The Handbook of Rational and Social Choice", OUP (2009).
0. Ariel Rubinstein, "Modeling Bounded Rationality", MIT Press (1998).
0. Ran Spiegler, "Bounded Rationality and Industrial Organisation", OUP (2018).

Title	Machine Learning for Economics	Number	XXL7XX0
Department/School	AIDE (CMCE)	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech., Post-grad, Ph.D.	Type	Elective
Prerequisite	None		

Objectives:

1. To introduce students to commonly used supervised and unsupervised machine learning algorithms in economics.

0. To introduce students to recent advancements in integrating Machine Learning with Causal Inference techniques relevant for economic applications.

3. To provide conceptual understanding of applications and scope of Machine Learning to address economics and policy problems.

Learning outcomes:

1. Students will be able to identify and distinguish between problems of prediction and inference in empirical economics and data-analytics.

2. Students will gain an understanding of various commonly used Machine Learning algorithms with a focus on their applications in Economics and policy analysis

Course content:

Introduction to Machine Learning: inference vs prediction, supervised vs unsupervised algorithms. (5 lectures)

Family of penalized models: Ridge regression, Lasso, Elastic Net, Hierarchical Lasso, Group Lasso, Fused Lasso, Sparse Group Lasso (8 lectures)

Tree-based algorithms: Decision Trees, Bagging, Random Forest, Boosting (8 lectures)

Intersection of Machine Learning and Economics: Double/De-biased Lasso, Causal Forest, Heterogenous treatment effects, Model Selection, high-dimensional settings, post-selection inference. (10 lectures)

Economic applications: poverty and inequality, health, education, crime, labour, business, and finance (11 lectures)

Reference Books:

1. James, G., Witten, D., Hastie, T., & Tibshirani, R. (2000). *An Introduction to Statistical Learning*. Springer.
2. Hastie, T., Tibshirani, R., & Friedman, J. (2009). *The Elements of Statistical Learning (Second)*. Springer.
3. Hastie, T., Tibshirani, R., & Wainwright, M. (2016). *Statistical Learning with Sparsity: The Lasso and Generalizations*. Chapman and Hall/CRC.
4. Kuhn, Max and Kjell Johnson (2013). *Applied Predictive Modeling*. Springer.

Research papers:

1. Athey, S., & Imbens, G. (2017). The State of Applied Econometrics - Causality and Policy Evaluation. *Journal of Economic Perspectives*, 31(2), 3–32.
2. Kleinberg, J., Ludwig, J., Mullainathan, S., & Obermeyer, Z. (2015). Prediction Policy Problems. *American Economic Review*, 105(5), 491–495.
3. Mullainathan, S., & Spiess, J. (2017). Machine Learning: An Applied Econometric Approach. *Journal of Economic Perspectives*, 31(2), 87–106.
4. The Impact of Machine Learning on Economics by Athey (NBER, 2018)
5. Machine Learning Methods Economists Should Know About by Athey and Imbens (ArXiv, 2019)

6. Belloni et al. (2014) 'High Dimensional Methods and Inference on Structural and Treatment Effects' Journal of Economic Perspectives
7. Wager, S., & Athey, S. (2018) 'Estimation and Inference of Heterogeneous Treatment Effects using Random Forests', Journal of American Statistical Association.
8. Athey, S., Tibshirani, J. & Wager, S., (2019) 'Generalized Random Forests', Annals of Statistics
9. Belloni, A., Chernozhukov, V., & Hansen, C., (2013) "Inference on Treatment Effects After Selection Amongst High-Dimensional Controls (with an Application to Abortion and Crime)", Review of Economics and Statistics.
10. Belloni, A., Chernozhukov, V., Hansen, C., & Fernandez-Val, I., (ArXiv 2013) "Program Evaluation with High-Dimensional Data".

Title	Social Choice Theory	Number	XXL7XX0
Department/ School	AIDE (CMCE)	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech, P.G., Ph.D.	Type	Elective
Prerequisite	Microeconomics-1, Individual and Strategic Decision making: Theory and Applications		

Objectives

1. Introduce the fundamental principles of preference aggregation.
2. Formalise the preference aggregation rules.
3. Introduce strategy-proofness as a major desirable property and impossibility theorems of preference aggregation.

Learning Outcomes:

1. Understanding of axiomatic approach of preference aggregation.
2. Learning of modeling preference aggregation rules.

3. Learning to apply the rules to design markets.

Course Content:

Preference theory, choice theory (6 lectures)

The social preference framework (5 lectures)

Majority rule, May's theorem (6 lectures)

Condorcet's paradox, McGarvey's theorem, conditions on social preferences, Arrow's impossibility theorem (9 lectures)

Single-peaked preferences, the median voter theorem (6 lectures)

The Gibbard-Satterthwaite theorem and its implications (5 lectures)

Domain restrictions and the possibility results. (5 lectures)

Reference Books:

1. Social Choice Theory: An Introduction, by Jerry S. Kelly, Springer-Verlag, 1988.
2. Fair Division and Collective Welfare by Hervé Moulin, The MIT Press, 2004.
3. Microeconomic theory, by A. Mas-colell, M. Whinston and J. Green, OUP, 1995.
4. A Primer in Social Choice Theory, W. Gaetner, OUP, 2009.
5. Social Choice and Mathematics of Manipulation, A. D. Taylor, CUP, 2009.

Title	Introduction to Mechanism Design	Number	XXL7XX0
Department	AIDE (CMCE)	L-T-P [C]	3-0-0
Offered for	B. Tech., Post-grad, Ph.D.	Type	Elective
Prerequisite	Microeconomics- 1; Individual and Strategic Decision Making: theory and applications		

Objectives:

Collective decision making is an important social issue, since it depends on individual preferences that are not publicly observable. Therefore, the question is, whether it is possible to elicit the private information available to individuals and then how to extract the private information to construct a societal choice in various strategic environments – mechanism design theory deals with these questions. This course will be taught from two broad perspectives. These are based on the assumptions on individual preferences, namely ordinal and cardinal. The particular topics to be covered in this course are given in the course content section.

Learning outcomes:

1. Students will be able to mathematically model scenarios involving collective decision making.
2. Students will gain an understanding of various commonly used techniques from Game Theory/Mathematics to analyze these models.
3. Students will be able to apply these tools to decide what is the “best” collective choice in these scenarios.

Course content:

Introduction to strategic social choice model with examples and social choice function.

1. Ordinal Preferences

- a. Introduction to some desirable properties (strategy-proofness, unanimity, anonymity, neutrality etc.) (4 lectures)
- b. Discussion of Gibbard-Satterthwaite impossibility theorem. (4 lectures)
- c. Restricted domains (single peaked domain) as a way out of the impossibility theorem. (6 lectures)
- d. Fairness criteria (envy-freeness, proportionality etc.) through fair division (cake cutting) problems. (6 lectures)
- e. Matching (both sided and one sided) problems. (4 lectures)

0. Cardinal Preferences

1. Introduction to mechanism design models and corresponding incentive compatibility constraints (DSIC and BIC) and revelation principle. (4 lectures)

2. Introduction to VCG mechanism and discussion about budget balanced criteria and individual rationality. (4 lectures)
3. Illustration through several types of single object auction (First Price, Second Price, Ascending Price, Descending Price etc.). (3 lectures)
4. Mechanisms for single object auction and discussion about revenue equivalence. (3 lectures)
5. Discussion on optimal mechanism for single object auction. (2 lectures)
6. Discussion on interdependent valuations. (1 lecture)
7. Discussion on multi-object auctions. (1 lecture)

Books:

1. [Lecture notes on Mechanism Design by Debasis Mishra.](#)
2. An Introduction to the Theory of Mechanism Design by Tilman Börgers With a chapter by Daniel Krähmer and Roland Strausz, Oxford University Press 2015
3. Game Theory and Mechanism Design by Y Narahari, IISc Lecture Notes Series — Vol. 4, World Scientific Publishing Co. Pte. Ltd., 2014
4. [Lecture Notes on Fair Division by Ulle Endriss](#)
5. Abdulkadiroğlu, A., & Sönmez, T. (2013). Matching Markets: Theory and Practice. In D. Acemoglu, M. Arellano, & E. Dekel (Eds.), *Advances in Economics and Econometrics: Tenth World Congress (Econometric Society Monographs)*, pp. 3-47). Cambridge: Cambridge University Press. doi:10.1017/CBO9781139060011.002

Research papers: As discussed in class

Title	Computational Game Theory	Number	MAL8XX0
Department/School	Mathematics	L-T-P [C]	3-0-0 [3]
Offered for	M.Tech. (DCS)/ PhD (MA)	Type	Elective
Prerequisite	Basics of Optimization Theory		

Objectives:

1. Provide background in the area of computational game theory.
2. Provide sufficient knowledge of the subject which can be used by students for further applications in their respective domains of interest.

Learning outcomes:

1. Understanding of fundamentals like Nash equilibrium, dominant strategies and their applications.
2. Basic understanding of the Co-operative games, iterated games and mixed strategies.
3. Knowledge of non-co-operative games, Zermelo's algorithm and their applications.

Course content:

[12 lectures]: Von Neumann and Morgenstern utility functions, expected utility and expected utility maximization, Paradoxes of expected utility maximization, Compact representations for preference relations, Dichotomous preferences and goals. Representations for specifying goals, Strategic Form Non-Cooperative Games, Basic model and solution concepts, pure strategy Nash equilibrium, dominant strategies, notable games, coordination games and focal points, complexity of pure strategy Nash equilibrium.

[14 Lectures]: Mixed strategies: Nash's theorem and Nash equilibrium, Computing mixed strategy Nash equilibria, Lemke-Howson algorithm, Zero sum games, Minimax Theorem, Compact representations for strategic form games, Boolean games, congestion games, Iterated Games: Finitely repeated games and backward induction, Infinitely repeated games, measuring utility over infinite plays modelling strategies as finite state machines with output (Moore machines); The Folk theorems, Iterated Boolean games, Axelrod's tournament, the Hawk-Dove game, evolutionary game theory, evolutionarily stable strategies.

[16 lectures]: Extensive Form Non-Cooperative Games: Zermelo's algorithm and backward induction, subgame perfect equilibrium, Zermelo's theorem, Compact representations for extensive form games, PEEK games and EXPTIME-completeness results, the Game Description Language (GDL), Imperfect information games, PEEK games with incomplete information, Cooperative Games: Transferable utility (TU) characteristic function games, basic model, stability & fairness solution concepts, cost of stability, Shapley value, Banzhaf index, induced subgraph representation, marginal contribution nets, Simple TU games, swap and trade robustness, weighted voting games, vector weighted voting games, network flow games, NTU games and their representations

Textbooks:

1. G. Chalkiadakis, E. Elkind, and M Wooldridge, Computational Aspects of Cooperative Game Theory, Morgan-Claypool, 2011.
2. Machler, E. Solan, S. Zamir, Game Theory, Cambridge U.P., 2013.
3. M. J. Osborne, An Introduction to Game Theory, Oxford U.P., 2004.

Reference Books:

1. R. D. Luce and H. Raiffa, Games and Decisions, Wiley, 1958
2. M. J. Osborne and A. Rubinstein, A Course in Game Theory, 1994

Online course material:

Not available

Title	Industrial Organisation	Number	HSL7XX
Department	Humanities and Social Sciences	L-T-P [C]	3-0-0
Offered for	B. Tech., Post-grad/Ph.D	Type	Elective
Prerequisite	None		
<p>Objectives</p> <ol style="list-style-type: none"> 1. To familiarise students with fundamental concepts used for economic analysis of firm behavior. 2. To equip the students with knowledge of benchmark models and strategic interactions. 3. To introduce students to varied applications of theoretical models. <p>Learning Outcomes</p> <ol style="list-style-type: none"> 1. A detailed understanding of various market structures and their implications for firms and consumers. 			

2. Ability to formally analyze firm behavior from an economic and strategic perspective.
3. Knowledge and understanding of important models and observable applications.

Contents

1. *Introduction to concepts for economic analysis*: what is industrial organisation, overview of theoretical and empirical perspectives, law of diminishing marginal returns, demand function, cost function, profit maximization. (7 lectures)
2. *Market structures and strategic techniques*: perfect competition, monopolistic competition and monopoly, market power, efficiency and public policy, firms as strategic agents and Nash equilibrium. (7 lectures)
3. *Price discrimination*: perfect price discrimination, multi-market price discrimination, arbitrage and screening, non-linear pricing. (6 lectures)
4. *Static and Dynamic competition*: Bertrand paradox and capacity constraints, Cournot model, concentration indices, static approach to dynamic pricing, repeated interaction and collusion, price rigidities and excess capacity. (8 lectures)
5. *Non-price competition*: advertising, market power, information, R&D and innovation. (3 lectures)
6. *Product differentiation*: spatial competition models, advertising and information, vertical differentiation. (5 lectures)
7. *Entry, accommodation and exit*: natural monopoly and barriers to entry, stackelberg competition and applied strategies for deterrence. (5 lectures)
8. Network effects, auctions, strategic policy commitment and international trade. (3 lectures)

Textbooks

1. Jeffrey Church and Roger Ware (2000), *Industrial Organization: A Strategic Approach*, McGraw Hill.
2. Jean Tirole (1998). *The Theory of Industrial Organization*, MIT Press.
3. Luis Cabral (2000) *Industrial Organization: An Introduction*, MIT Press.
4. Lynne Pepall, Dan Richards and George Norman (2014). *Contemporary Theory and Empirical Applications*, Wiley.
5. Xavier Vives (1999). *Oligopoly Pricing: Old Ideas and New Tools* , MIT Press.

Reference books:

1. Anindya Sen (1996). *Industrial organization*, Oxford University Press.
2. Richard Schmalensee and R. Willig (1989). [Handbook of Industrial Organization](#), vol. 1-2, 1 ed., Elsevier.

3. Mark Armstrong and Robert Porter (2007). Handbook of Industrial Organization, vol. 3, 1 ed., Elsevier.

Research papers

1. Spence, A., (1976), Product Differentiation and Welfare, *American Economic Review*, **66**, issue 2, p. 407-14.
2. Dixit, Avinash, (1986), Comparative Statics for Oligopoly, *International Economic Review*, **27**, issue 1, p. 107-22.
3. Maskin, Eric and Riley, John, (1984), Monopoly with Incomplete Information, *RAND Journal of Economics*, **15**, issue 2, p. 171-196.
4. d'Aspremont, Claude, Gabszewicz, Jean and Thisse, Jacques, (1979), On Hotelling's "Stability in Competition", *Econometrica*, **47**, issue 5, p. 1145-50.
5. Milgrom, Paul and Roberts, John, (1982), Limit Pricing and Entry under Incomplete Information: An Equilibrium Analysis, *Econometrica*, **50**, issue 2, p. 443-59.
6. Rochet, Jean and Tirole, Jean, (2003), Platform Competition in Two-Sided Markets, No 152, IDEI Working Papers, Institut d'Économie Industrielle (IDEI), Toulouse.

Online resources:

1. Industrial Organisation 1, MIT Open Courseware,
<https://ocw.mit.edu/courses/economics/14-271-industrial-organization-i-fall-2005/index.htm>

Title	Theoretical Foundations of Econometrics	Number	AIL7XX0
Department/School	AIDE (CMCE)	L-T-P [C]	3-1-0 [3]
Offered for	B. Tech., Post-grad, Ph.D.	Type	Elective
Prerequisite	Statistics		

Objectives:

1. To introduce students to fundamental concepts in econometric theory.
2. To provide knowledge of the theoretical underpinnings of applied econometric methods.
3. To provide an understanding of estimation in econometrics and its associated concepts.

Learning outcomes:

1. Students will gain an understanding of foundational knowledge of inference and estimation techniques.
2. Students will develop an intuition for the generalizability of different econometric models.
3. Students will understand the links between the theory for econometric models, the computations required for inference, and the application of the models to real examples.

Course content:

Revision of key statistical concepts: Descriptive statistics, Random variables, Joint distributions, conditional distribution and their properties, Moment generating functions, Normal distribution and other related distributions, Central Limit Theorem, Population, parameters and random sampling, sampling distributions, chi-square distribution, t distribution, F-distribution (6 lectures)

Estimation: Finite sample properties of estimators – unbiasedness and efficiency, Asymptotic or large sample properties of estimators – consistency, asymptotic normality (4 lectures)

General Approaches to parameter estimation: Method of moments, maximum likelihood estimation method, Least Squares method. Interval estimation and confidence intervals (3 lectures)

Linear Regression Model: multiple linear regression models, Gauss Markov Theorem, inference and hypothesis testing in the context of linear regression, multiple hypothesis testing, calculating marginal effects, mechanics and interpretation of ordinary least

squares, Frisch-Waugh-Lovell Theorem, different econometric tests (LM test, LR test and Wald test) and their principles. (15 lectures)

Issues related to OLS: Heteroskedasticity and White test, Breusch-Pagan/Godfrey Test, Goldfeld-Quandt Test, Generalized Least Squares, Multicollinearity, Functional form misspecification and Ramsey RESET test, specification errors – errors of omission and errors of commission, restricted least squares, omitted variable bias, measurement errors and properties of OLS under measurement error, missing data, outliers and influential observations, sample-selection issues, Endogeneity and Instrumental variables. (15 lectures)

Reference Books:

1. "Introductory Econometrics: A Modern Approach" by Jeffrey Wooldridge, International Edition, Cengage
2. "Econometric Analysis of Cross-section and Panel Data" by Jeffrey Wooldridge, MIT Press, 2010
3. "Econometric Analysis" by William Greene, Pearson, 2018
4. Kennedy, P., *Guide to Econometrics* (6th ed.) MIT Press
5. Kmenta Jan, "Elements of Econometrics", Macmillan

Title	Advanced Econometrics	Number	AIL7XX0
Department/School	AIDE (CMCE)	L-T-P [C]	3-2-0
Offered for	B. Tech., Post-grad, Ph.D.	Type	Elective
Prerequisite	Statistics, Econometrics		

Objectives:

1. To introduce students to a wide range of advanced econometric techniques beyond simple linear regression analysis.
2. To provide an understanding of theoretical foundations of these modelling strategies.
3. To provide knowledge of choosing appropriate modelling strategies.

Learning outcomes:

1. Students will be equipped to apply suitable econometric and computational methods for tackling an array of econometric problems.
2. Students will gain an understanding of the theoretical foundations of advanced econometric models.
3. Students will learn how to estimate these models in software such as R/Stata and interpret the results.

Course content:

Revision of Linear Regression Model: Gauss Markov Theorem, multiple linear regression models, Linear regression as projection, Partialling out interpretation of multiple regression, Frisch-Waugh-Lovell Theorem, (3 lectures)

Econometric tests: General formulation of LR, LM and Wald tests with specific examples. (3 lectures)

Issues related to Regression models: specification errors, omitted variable bias, measurement errors, missing data, outliers and influential observations, sample-selection issues, Endogeneity and Instrumental variables (5 lectures)

Panel Data Models: Panel Data and pooled independent cross-sections, pseudo-panel data, Least-squares dummy variable model, Incidental parameters problem, fixed effects model, within-estimator, random effects model, Hausman test, random coefficients model, differencing models, Applying panel data methods to other data structures (12 lectures)

Limited Dependent Variable models: logit, probit, ordered probit, tobit, count data models (poisson, negative binomial), Heckman's sample selection model, duration models/survival analysis, fractional response model, discrete choice modelling. (12 lectures)

Dynamic panel data models: Importance of dynamic panel, Sargan's test, Arellano Bond estimator (2 lectures)

Simultaneous system of equations (2 lectures)

Non-parametric econometrics: local constant regression, local linear regression, kernel estimation, optimal bandwidth, semi-parametric models (2 lectures)

Productivity analysis: Stochastic frontier approaches. (2 lectures)

Reference Books:

1. "Introductory Econometrics: A Modern Approach" by Jeffrey Wooldridge, International Edition, Cengage
2. "Econometric Analysis of Cross-section and Panel Data" by Jeffrey Wooldridge, MIT Press, 2010
3. "Econometric Analysis" by William Greene, Pearson, 2018
4. Limited-Dependent and Qualitative Variables in Econometrics: (Econometric Society Monographs, Series Number 3 by G.S. Maddala
5. Analysis of Panel Data by Cheng Hsiao
6. Microeconometrics: Methods and Applications by Cameron and Trivedi
7. Nonparametric Econometrics by Aman Ullah
8. Nonparametric Econometrics: Theory and Practice by Racine and Li

Title	Causal Econometrics	Number	AIL7XX0
Department/School	AIDE (CMCE)	L-T-P [C]	2-0-2 [3]
Offered for	B. Tech., Post-grad, Ph.D.	Type	Elective
Prerequisite	Theoretical Foundations of Econometrics		
<p>Objectives:</p> <ol style="list-style-type: none"> 1. To introduce students to a wide range of techniques popularly used in the econometrics literature to estimate causal effects. 2. To familiarize students with the key concepts of identification strategies and potential outcomes framework. 3. To provide knowledge in the theoretical foundations of different causal inference techniques. <p>Learning outcomes:</p> <ol style="list-style-type: none"> 1. Students will be equipped to understand and discern causal effects from correlations from large observational data. 			

2. Students will gain an understanding of the identification strategies and conditions leading to estimating causal effects.
3. Students will be able to understand the theoretical foundations of different causal inference techniques and how to choose the appropriate one.
4. Students will learn how to estimate causal effects from these models in software such as R/Stata.

Course content:

Fundamental concepts in causal inference: potential outcomes, Roy Rubin framework, fundamental problem of causal inference, counterfactuals, confounders, colliders, independence assumption, stable unit treatment value assumption (SUTVA) assumption, concept of identification condition and identification strategy, Natural Experiments (9 lectures)

Randomized inference: Selection bias, Randomized Control Trials, famous experimental papers in economics. (5 lectures)

Difference-in-difference technique: double difference model, parallel trends assumption, some recent advances in two-way fixed effects and difference-in-difference estimators, event-studies, differential treatment timing, triple difference model, (9 lectures)

Instrumental variables: two-stage least squares, problems of weak instruments, popular IV designs, lotteries, judge-fixed effects, Bartik instruments, shifts and shares. (6 lectures)

Regression Discontinuity techniques: Sharp RD and Fuzzy RD, instrumental variables, interrupted time-series, regression kink design. (6 lectures)

Synthetic Control techniques: Comparative case studies, Falsification tests. (3 lectures)

Matching techniques: Matching estimators, Curse of dimensionality in matching, Exact matching versus approximate matching, propensity score matching. (5 lectures)

Reference Books:

1. "Introductory Econometrics: A Modern Approach" by Jeffrey Wooldridge, International Edition, Cengage
2. "Econometric Analysis of Cross-section and Panel Data" by Jeffrey Wooldridge, MIT Press, 2010
3. "Econometric Analysis" by William Greene, Pearson, 2018
4. "Mostly Harmless Econometrics: An Empiricist's companion" by Joshua D. Angrist, Jörn-Steffen Pischke,
5. "Causal Inference: the mixtape" by Scott Cunningham, Yale University Press
6. "The Effect" by Nick Huntington-Klein <https://theeffectbook.net/>

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Title	Political Economy	Number	AIL7XX0
Department/School	AIDE	L-T-P [C]	3-0-0
Offered for	B. Tech., M.Tech, Ph.D	Type	Elective
Prerequisite	Microeconomics-1, Individual and Strategic Decision Making: Theory and Applications		

Objectives

1. To familiarise students with formal modeling and analysis of collective action, voting and political processes
2. To equip the students with knowledge of benchmark models of political systems, institutions and structures with applications.

Learning Outcomes

1. Ability to formally model and analyze behavior of political parties, voters, institutions, groups etc. with strategic interactions.
2. Knowledge and understanding of important models and their applications.

Contents

1. *Collective Choice and Voting*: Introduction to collective choice, static models of voting, models with imperfect information and preference aggregation through voting (6 lectures)
0. *Strategic voting and empirical evidence*: motives, evidence on median voter theorem, political decisions and preferences of median voter. (3 lectures)
0. *Constraints of electoral politics*: lobbying, vote buying, coercion, patron-client relationships, modeling political agency of voters in democratic process. (6 lectures)
0. *Political structure and economic policy*: representative democracy and economic policy, legislative bargaining, policy competition, non democratic institutions. (6 lectures)
0. *Strategic interactions of groups*: dynamic interactions, political compromise (4 lectures)
0. *Price discrimination*: perfect price discrimination, multi-market price discrimination, arbitrage and screening, non-linear pricing. (6 lectures)
0. *Conflict and collective action*: Modeling commitment, misaligned interests, indivisibilities, private information, group size, heterogeneity. (6 lectures)
0. *Media, Bureaucracy and Corruption*: Modeling media bias, reputation, signals and beliefs, modeling incentive structures, empirical evidence. (5 lectures)

Reference books:

1. Smith, David A. and Banks, Jefferey S.; *Positive Political Theory- Vol. I-II*, The University of Michigan Press 1999.
2. Persson, Torsten and Tabellini, Guido; *Political Economics- Explaining Economic policy*, MIT Press 2002.

Title	Microeconomics-1	Number	AIL6010
Department	AIDE (CMCE)	L-T-P [C]	3-0-0
Offered for	B. Tech.	Type	Core for M.Sc-CSS, Elective for all streams
Prerequisite	None		

Objectives

1. Introduce the fundamental principles of individual decision-making.
2. Formalize the decision-making behavior for consumers as well as producers.
3. Set up the general equilibrium model and price determination.

Learning Outcomes:

1. Understanding of axiomatic approach of economic decision-making.
2. Modeling economic decision-making in a tractable form and analyze the comparative-static.
3. Understanding of basic market mechanisms and fundamentals behind price determination.

Course Content:

Preferences: axiomatic approach and examples. (4 lectures)

Utility theory: representation theorem and examples. (4 lectures)

Cardinal vs ordinal approaches. (3 lectures)

Utility maximisation problem. (4 lectures)

Demand analysis. (2 lectures)

Expenditure minimisation problem as dual and Hicksian demand. (2 lectures)

Integrability and recoverability (2 lectures)

Weak axiom of revealed preference (2 lectures)

Producer theory: profit maximisation and cost minimisation. (3 lectures)

Welfare theorems (3 lectures)

Market structures: Perfectly competitive market , Monopoly and discrimination (4 lectures)

Strategic aspects in market structure: oligopoly (3 lectures)

General equilibrium. (6 lectures)

Reference Books:

1. A Short Course in Intermediate Microeconomics with Calculus. Feldman, A. & Serrano, R. , CUP, 2018.
2. Microeconomic theory. Mas-colell, A., Whinston, M.D., Green, J. R., Oxford University Press, 1995.
3. A Course in Microeconomic Theory. David M. Kreps, Princeton University Press, 1990.
4. Advanced Microeconomic Theory. G. A. Jehle, P. J. Reny, Prentice Hall, 1991.

Title	Microeconomics-2	Number	XXL4XX0
Department/School	AIDE (CMCE)	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech (All Branches), P.G., Ph.D.	Type	Core for minor, Elective for all streams
Prerequisite	Microeconomics-1		
<p>Objectives</p> <ol style="list-style-type: none"> 1. To introduce strategic interactions among the rational economic agents in the general equilibrium framework 2. To equip students with concepts from market design such as auction theory. 3. To provide a thorough analysis of general equilibrium theory. <p>Learning Outcomes</p> <ol style="list-style-type: none"> 1. In depth understanding of strategic interactions in various economic models. 2. Understanding of dual economic decision-making of rational agents in a general equilibrium setting. <p>Course Content</p>			

Game theory: normal form games, common knowledge assumption, strategies, Nash equilibrium, simultaneous move games and examples, games of perfect information, games of imperfect information. (5 lectures)

Information economics: adverse selection and moral hazard problems, examples, information and market performance, Signaling games. (12 lectures)

Auctions and mechanism design problems. (13 lectures)

General equilibrium theory: Debreu's axiomatic approach to characterize equilibrium in competitive market - existence, uniqueness and stability; core and equilibria. (12 lectures)

Reference Books:

1. Microeconomic theory, Mas-colell, A., Whinston, M.D., Green, J. R., OUP, 1995.
2. Game theory, Fudenberg, D., Tirole, J., MIT Press, 1991.
3. Advanced microeconomic theory, Jehle, G.A., Reny, P.J., Pearson, latest edition.

Online Course Material:

1. <https://online.stanford.edu/courses/soe-ycs0004-game-theory-ii-advanced-applications>

Title	Individual and strategic decision making: theory and applications	Number	AIL4020
Department	AIDE (CMCE)	L-T-P [C]	2-0-0 [2]
Offered for	B. Tech/P.G.	Type	Core for M.Sc CSS, Elective for all streams
Prerequisite	None		
Exclusions	Introduction to game theory MAL4310		
<p>Objectives</p> <ol style="list-style-type: none"> 1. Introduce students to the fundamentals of game theory and strategic behaviour. 2. To provide a formal and intuitive understanding of solution concepts in game theory. 3. To equip students with knowledge of simultaneous and extensive form games. 4. To familiarise students with economic and behavioral applications of game theory. 			

Learning Outcomes:

1. Understanding of fundamentals of game theory: game forms, strategies, equilibrium notions, rationalizability, solution concepts and techniques.
2. Students will be able to model strategic behaviour in various economic settings.
3. Students will be equipped with formal knowledge of solution concepts and techniques which have broad applications for problem solving in various strategic settings.

Course Content:

Introduction to strategic games (2 lectures)

Strict and weak domination (2 lectures)

Rationalizability and iterated elimination (4 lectures)

Nash equilibrium: Pure and mixed strategies (5 lectures)

Correlated equilibrium and strategies (1 lectures)

Bayesian games and Bayesian equilibrium (3 lectures)

Extensive form games (2 lectures)

Games of perfect and imperfect information (2 lectures)

Backward induction procedure (2 lectures)

Repeated games: finite and infinite (3 lectures)

Folk theorems (2 lectures)

Reference Books:

1. Steven Tadelis, "Game theory: An Introduction", Princeton University Press (2013).
2. Drew Fudenberg and Jean Tirole, "Game Theory", MIT Press (1991).

Online Resources:

1. Game Theory, SOE-YCS4002 Stanford School of Engineering.
<https://online.stanford.edu/courses/soe-ycs0002-game-theory>.
2. Martin J. Osborne and Ariel Rubinstein, "A Course in Game Theory", MIT Press (1994)

Title	Computational Intelligence	Number	MSL71200
Department	School of Management and Entrepreneurship	Structure L-T-P-D [C]	2-0-0-1 [3]
Offered for	PhD	Type	Elective
Prerequisite	None		
Preclusion	Requires the student's Department/School Research Chair approval to enroll in this course. The course is precluded for the student if he/she has undertaken an equivalent course in the past 5 years.		
<p>Objectives</p> <p>1. The emphasis would primarily be on research methodologies and the</p>			

research trends in the computational intelligence Area.

2. The focus shall also be to equip students to develop a thought process to find interesting research problems in the literature, and addressing them with applications.
3. The students would be expected to identify a research problem and a working paper as a part of the project work.

Learning Outcomes

Students should get a perspective on:

1. Recent theoretical developments in the computational intelligence field
2. Real Applications
3. Recent research problems and methodologies

Contents

- Evolutionary computation (8 hrs):
 - Multi Objective Optimization
 - Genetic Algorithms
- Soft Computing (10 hrs)
 - Fuzzy sets and systems
 - Rough Set theory
 - Information set theory
 - Multi criteria decision aiding models
 - Information fusion and aggregations
- Machine Learning Techniques (10 hrs)
 - Overview
 - Design cycle
 - Training and Testing
 - Underfitting and overfitting
 - Classification
 - Preference Learning
 - Neural networks
- Project Work

The course would be taught using journal articles published in reputed academic journals.

Textbook

1. Fogel, D. B., Liu, D., and Keller, J. M., (2016), *Fundamentals of Computational Intelligence: Neural Networks, Fuzzy Systems, and Evolutionary Computation*, Wiley

2. Relevant research articles and other material would also be provided.

Reference Books:

1. Lee, K.H., (2005), *First Course on Fuzzy Theory and Applications*, Springer-Verlag Berlin Heidelberg
2. Furnkranz, J., and Hullermeier, E.,(2010), *Preference learning*, Springer.
3. Duda,R.O., Hart, P.E., and Stork, D.G., (2001), *Pattern Classification*, 2nd edition, John Wiley and Sons
4. Klir, G., Yuan, B., (1995), *Fuzzy sets and fuzzy logic. Theory and applications*, Prentice Hall.
5. Zimmermann, H.-J., (1993), *Fuzzy set theory and its applications*, Kluwer Academic Publishers, Boston.
6. Yager R., Filev, D. (1994), *Essentials of Fuzzy Modeling and Control*, New York: John Wiley & Sons