Birla Institute of Technology & Science, Pilani
Hyderabad Campus

SECOND SEMESTER 2023-2024

COURSE HANDOUT

09.01.2024

In addition to Part-I (General Handout for all courses appended to the timetable), this portion gives further specific details regarding the course.

Course No.	**: BITS F314**
Course Title	**: Game Theory & Its Applications**
Instructor-in-charge	**: Durgesh Chandra Pathak**

1. Scope and Objective: The breadth of field of Economics mesmerizes some and astonishes many. While studying such a vast subject that draws upon a plethora of branches of knowledge, one needs not just one or two skills but a set of skills that should be an eclectic blend of tools and techniques from various branches of knowledge. Game Theory is such a tool and stands as a beautiful mix of mathematics, economics, and psychology.

Game theory is a technique that can be used to analyze strategic problems in diverse settings. The foundation of Game Theory was laid by John von Neumann, who in 1928 proved the basic minimax theorem, and with the publication (co-authored with Oskar Morgenstern) of the Theory of Games and Economic Behaviour in 1944, the field was established. Game Theory became a buzzword and attained a particular glamor with the coveted Nobel Prize going to John Nash for his contribution in Game Theory that has found applications in almost every branch of knowledge. Its application is not limited to a single discipline such as economics or business studies. This is used in many decision-making problems be it a firm that needs to take strategic decisions for optimum output or a couple deciding whether to go for a music concert or a football match or a global issue like minimum credible level of nuclear deterrence to be maintained by two warring countries. It can help suggest a solution in cases where a deadlock looms large. Games are a convenient way in which to model the strategic interaction among the self-interested economic agents. Broadly, Game Theory can be divided into cooperative and non-cooperative game theory. Typically, a game is cooperative if the players are allowed to communicate and make binding agreements, **t**hey work as coalitions. In the non-cooperative game theory, player can't make binding agreements, they act independently, and we only deal with self-enforceable contracts. The course deals with non-cooperative games only.

Objective:

1. The main objective behind this course is to introduce Game Theory as a tool of logical thinking to the stud ents.
2. Students will learn the basics of game theory and strategic behavior and explore the ways in which game theory applies to real life. The Course would attempt at illustrating economic concepts with the help of Game Theory and making students adept in approaching economic problems in a game theoretic perspective.
3. Illustrating with the help of examples how the theory can be applied in almost every field of knowledge.
4. Game Theory would equip the students with an understanding and analytical perspective toward real life situations like market behavior, voting patterns and outcome etc.

5. World is becoming more and more complex. To analyze and understand such a complex world student n eed better tools and game theory is one such tool. The new knowledge would then be applied to areas such as competitive policy, designing and implementing incentives, regulations, auctions etc., just to name a few. This would give an edge to students when their professional life.

2. Text Book:

i. **Gibbons, R (1992): Game Theory for Applied Economists, Princeton University Press.**

ii. **Osborne, M.J. (2004): An Introduction to Game Theory, Oxford University Press, India.**

3. Reference Books:

i. **Bierman Scott H, Luis Ferandez (2005): Game Theory with Economic Applications, Pearson Education, Singapore.**

ii. **Drew Fudenberg, Jean Tirole (2005): Game Theory, MIT Press.**

iii. **González-Díaz Julio, Ignacio García-Jurado, M. Gloria Fiestras-Janeiro (2010): An Introductory Course on Mathematical Game Theory, Graduate Studies in Mathematics, Volume 115, American Mathematical Society.**

iv. **Osborne Martin J, Ariel Rubinstein (1994): A Course in Game Theory, The MIT Press Cambridge.**

v. **Rasmusen, E (2007): Games and Information: An Introduction to Game Theory, 4th ed., Basil Blackwell.**

4. Course Plan:

Topic	No. of Lectures	Learning Objectives	Topics to be Covered	Chapter in the Text Book
1	01-03	To introduce students to 'rational' thinking & Game Theory	1. What is Game Theory? 2. Theory of rational choice	Chapter 1 (TB ii), Notes
2	04-11	To introduce strategic games and solution concepts including Nash equilibrium	1. Strategic games: examples 2. Dominance 3. Rationalizability 4. Nash equilibrium: concept and examples 5. Best response functions 6. Symmetric games and symmetric equilibria	Chapter 2 & 12 (TB ii), Chapter 1 (TB i) Notes
3	12-17	Illustrations of Nash equilibrium in different settings	1. Cournot's model of duopoly market 2. Bertrand's model of duopoly market 3. Electoral Competition 4. War of Attrition 5. Auctions	Chapter 3 (TB ii), Chapter 1 (TB i) Notes
4	18-21	To introduce and apply mixed strategy Nash equilibrium	1. Strategic games with randomization 2. Dominated Actions 3. Formation of Players' beliefs	Chapter 4 (TB ii), Chapter 1 (TB i) Notes

			4. Mixed strategy Nash equilibrium: concept and examples	
5	22-26	To introduce extensive form representation of games, and application of Nash equilibrium there	1. Introduction to extensive games 2. Strategies and outcomes 3. Nash equilibrium 4. Sub-game perfect Nash equilibrium 5. Backward induction	Chapter 5 (TB ii), Chapter 2 (TB i) Notes
6	27-31	Illustrations of Extensive Games and Nash Equilibrium	1. Stackelberg model of duopoly markets 2. Ultimatum game 3. Multistage (finite and infinite) Bargaining	Chapter 6 (TB ii), Chapter 2 (TB i) Notes
7	32-34	To introduce the Repeated Games and its implications on sustainability of the cooperation	1. Introduction to repeated games 2. Finitely repeated games 3. Infinitely repeated games	Chapter 14-15 (TB ii) Notes
8	35-40	To introduce and analyze games with imperfect information	1. Bayesian games 2. Illustrations	Chapter 9 (TB ii), Chapter 3 (TB i) Notes

5. Learning Outcomes:

Topic 1: Introduction to Game Theory?
The students should be introduced to the idea of rational thinking in the case strategic interaction. They will be exposed to game theoretic way of thinking.

Topic 2: Strategic Games and Nash Equilibrium
The students should be able to formulate different situations from all walks of life in game framework. We will be covering solution concepts like dominance, rationalizability and Nash equilibrium; this will make them appreciate the concept of a reasonable solution concepts and implications. We will be going through examples from different settings.

Topic 3: Illustrations of Nash Equilibrium
The Nash equilibrium has become the corner stone of the analysis of strategic interaction in many fields including economics. Here students will learn to apply the concept of Nash equilibrium in different settings.

Topic 4: Mixed Strategy Nash Equilibrium
The concept of mixed strategy will be introduced. Its interpretation and applications in different setting will be analyzed.

Topic 5: Extensive Games and Nash Equilibrium
The students will learn the extensive form representation of a game. We are going to cover a refinement of Nash equilibrium, called subgame perfect Nash equilibrium (SPNE). SPNE is suitable when a game is played in a sequential, which is the case in many real-life settings.

Topic 6: Illustrations of Extensive Games and Nash Equilibrium
We go through different illustrations of sequential games; we discuss the application of Nash equilibrium and subgame perfect Nash equilibrium. The students will become comfortable with the SPNE concepts.

Topic 7: Repeated Games
We have seen earlier that often individual as-well-as institutions can be stuck in `bad' equilibrium. How does this analysis change if these individual or institutions are engaged in repeated interactions? This is applicable in many situations like companies operating in same industry, two nations dealing with each-other, etc. We are going to look particularly when is it possible to sustain cooperation.

Topic 8: Games with Imperfect Information
Here we deviate from our assumption of perfect information. We introduce the concept of Bayesian games and application of the Nash equilibrium in this setting. We will go through many applications from different areas. Auctions and firms operating in same industry can be modelled using this setup.

6. Evaluation scheme:

Component	Duration	Weightage (%)	Date and Time	Nature of Component
Mid-semester exam	90 minutes	30	14/03 - 2.00 - 3.30PM	**CB**
Quiz (surprise)/assignments		30		**OB**
Comprehensive examination	180 minutes	40	15/05 FN	**CB**

7. Chamber Consolation Hour: To be announced in the class

8. Notices: Notices, if any, would be put on CMS.

9. Make-up Policy: Make-up will be granted only on genuine grounds and if prior permission is taken through official email only. Request for make up after the test/exam would not be entertained at all. No make-up shall be granted for quizzes.

10. Academic Honesty and Integrity Policy: Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

Instructor-in-Charge
BITS F314