

# MATHEMATICAL PROGRAMMING WITH APPLICATIONS TO ECONOMICS

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**Schedule:** Every **Monday and Wednesday 2:00 PM - 3:30 PM.**

**Aim:** The course will cover some fundamental concepts of mathematical programming and graph theory. In mathematical programming, we will mainly cover linear and integer programming. At the end of every topic, we will pause and explore its applications in economic theory - mainly game theory, mechanism design, and cooperative games.

**Prerequisites:** There are no prerequisites for the course. However, familiarity with basic linear algebra and game theory will help.

**Course Material:** I will put electronic notes online on course website. The website for the course is:

<http://www.isid.ac.in/~dmishra/mp.html>

Standard books on linear programming, combinatorial optimization, and graph theory can be used as references.

**Evaluation:** There will be four assignments, one each at the end of each topic (see below). I encourage you to do the assignments on your own or in groups, and discuss it with me in case of doubts. Breakup of weights: class participation and assignments - mid-term - 50%, end-term - 50%.

**Topics:** Here are the main topics for the course.

1. **Basic Graph Theory** (12 lectures)

- Graphs and directed graphs

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- Terminology: path, cycle, degree, cut, tree, connectedness
- Minimum spanning tree problem
- Application: A game on graph
- Hall's marriage theorem
- Application: Matching
- Matching theory
- Max-flow min-cut
- Graph Decomposition
- Shortest paths on directed graphs
- Potentials of graphs
- Application: Selling an object
- Application: Fair prices

## 2. **Convex Sets** (5 lectures)

- Definitions
- Separating hyperplane theorem
- Polyhedra and polytopes
- Farkas Lemma
- Application: core of cooperative games

## 3. **Linear Programming and Duality** (6 lectures)

- What is a linear program?
- Simplex method
- What is a dual?
- Writing down a dual
- Duality theorems
- Application: zero-sum games

## 4. **Integer Programming** (3 lectures)

- What is an integer program?
- Linear relaxation of integer programs
- Totally unimodular matrices
- Application: assignment problem and prices