Indian Institute of Technology Kanpur

Proposal for a new course

Title: Linear and discrete optimization for process systems engineering

1. **Course No.:** ChE 6xx
2. **Structure:** Lectures: 3 (L), Tutorial: 0 (T), Laboratory: 3 (P), Additional hours [0-2]: 0 (A), credits (3-0-3-0): 12.
3. **Duration of course:** Full semester
4. **Prerequisite:** Linear algebra
5. **Proposing instructor:** Ishan Bajaj (707, ESB-3, ibajaj@iitk.ac.in)
6. **Proposing department:** Department of Chemical Engineering
7. **Other faculty members interested in teaching the course:** Sanjeev Garg, Salman Khan, Raghavendra Ragipani
10. **Course description:**
    A. **Objectives:** This course provides an introduction to linear and integer optimization. Students will learn how to formulate linear and mixed-integer optimization models for practical engineering applications and solve them using state-of-the-art solvers (e.g., Gurobi). The course also covers foundational theory and algorithms for solving these optimization problems. The course has several hands-on laboratory sessions to implement and solve optimization models using Python API of Gurobi. In addition, students will gain exposure to implementing selected optimization algorithms.

    B. **Content:** Lecture-wise break-up (considering the duration of each lecture is 50 minutes)

S. No.	Title	Topics	No. of lectures
1	Introduction to optimization	• Common optimization problems in process systems engineering (PSE) • Optimization in design, scheduling, planning, and supply chain • Categories of optimization models (linear, nonlinear, discrete, etc.)	2
2	Optimization basics	• Linear algebra, convexity, degrees of freedom analysis, feasible region	2
3	Formulating linear programming (LP) models	• Data structures for LP models: sets and parameters • Defining continuous decision variables, objective function, and linear constraints • Approximating nonlinear convex functions	4
4	Formulating mixed integer linear programming (MILP) models	• Defining discrete/binary variables • Modeling logical constraints using binary variables • Approximating nonlinear nonconvex functions	6

5	Linear optimization theory and algorithms	• Structure and geometry of LP models • Simplex method • Duality theory	12
6	Large-scale linear optimization	• Dantzig-Wolfe decomposition • Benders decomposition	6
7	Integer programming methods	• Cutting plane methods • Branch and bound • Integer programming duality	8
Total			40

C. **Laboratory sessions:**

S. No.	**Session**
1	Formulating LP-based supply chain optimization models
2	Blending operations optimization using LP
3	Transshipment model formulation to minimize utility cost in heat exchanger network
4	MILP model formulations for optimal heat exchanger network synthesis
5	Process planning and scheduling using MILP
6	Approximating nonconvex functions using SOS2 variables
7	Implementing Naïve simplex method
8	Implementing tableau simplex method and comparing performance with Naïve simplex method
9	Using callback functions of Gurobi
10	Implementing Benders' cuts to solve large-scale LPs
11	Implementing Gomory cuts for integer programming models

11. **Recommended books:**

- H.P. Williams. *Model building in mathematical programming*. Wiley, 2013.
- D. Bertsimas and J.N. Tsitsiklis. *Introduction to linear optimization.* Athena Scientific, 1997.
- C.A. Floudas. *Nonlinear and mixed-integer optimization*. Oxford, 1995.
- K.G. Murty. *Optimization Models for Decision Making: Volume 1.*
- D. Bertsimas and R. Weismantel. *Optimization over integers.* Dynamic ideas, 2005.

Dated: 12/11/2025 Proposer: Ishan Bajaj

DPGC convenor:

The course is approved/not approved

Chairman, SUGC/SPGC
Dated: