CE 205A – Transportation Logistics (3:1 credits)

Instructor: Tarun Rambha
Email: tarunrambha@iisc.ac.in
Timings and Location: TTh 11:30 – 13:00, CiSTUP Classroom
Course Website: http://civil.iisc.ac.in/~tarunr/ce205a.html

Course Description:
This is an introductory course on transportation logistics which explores some of the classic problems and solution techniques. Most models discussed will require tools from integer programming/combinatorial optimization. The topic of logistics is too broad for a one-semester course. We will thus focus on offline problems and last-mile logistics where the input data is not stochastic and adequate time is available to make optimal or near-optimal decisions. A graduate-level course of optimization in which linear programming was covered in depth is a prerequisite for this course along with sound knowledge of Python programming.

Reading Material:
The following books could be used as references. Additional reading material will be shared during the lectures.

1. Wolsey, L. A. (2020). Integer programming. John Wiley & Sons.
2. Toth, P., & Vigo, D. (Eds.). (2002). The vehicle routing problem. Society for Industrial and Applied Mathematics (SIAM).
3. Gutin, G., & Punnen, A. P. (Eds.). (2006). The traveling salesman problem and its variations (Vol. 12). Springer Science & Business Media.
4. Applegate, D. L. (2006). The traveling salesman problem: a computational study. Princeton university press.

Assignments and Project:
The course is designed in DIY fashion and will only have programming assignments and a project. There are no written exams in this course. The programming assignments require the use of CPLEX and NetworkX and will involve implementing and testing the methods discussed in the class on benchmark datasets. For the final project, students can chose from one of the following two tracks:

Implementation Track: In this option, you are required to replicate the results from a paper on logistics that has been published in the last two decades. You can choose papers from journals such as Transportation Science, Transportation Part B, Operations Research, European Journal of Operations Research, EURO Journal of Transportaiton and Logistics, and Management Science.

Research Track: For this option, you can pick a new problem (which could be a problem on which you are currently carrying out research) and formulate an optimization model, propose a solution that performs better than existing literature on benchmark datasets. The final submission must be of publishable (or nearly publishable) quality.

Students are encouraged to discuss the problems with their classmates but one must write their own code. **Plagiarism is strictly prohibited and will be penalized**.[1]

Grading:
Students will be graded on a 100-point scale. The weights for different components of the course are as follows: programming assignments (50%) and final project (50%).

The programming assignments will be evaluated in a competition mode with two rounds in which all submissions will be tested on the same machine. After Round 1, the outputs and the run times of

[1] http://www.iisc.ac.in/about/student-corner/academic-integrity/

your classmates will be made available to everyone. You will be provided one extra week for making Round 2 submissions where you can improve your codes. Only those who submit Round 1 codes are eligible to compete in Round 2. The evaluation will be done in an all-or-nothing style. If your codes, are correct, you get 8 points and 0 otherwise. The winner of Round 2 will get 2 more points.

The implementation track will be evaluated based on the ability to reproduce results (30 points) and code quality (20 points). For the research track, 30 points are dedicated for performance of the proposed solution and 10 points each will be used to assess writing and code quality.

Lesson Schedule:
Table 1 lists the topics that will be covered in different lectures. Minor adjustments may be made as the semester progresses. We will spend reviewing your code submissions in a few of the classes in lieu of lectures. The course will also include a couple of guest lectures.

Table 1: Course Schedule.

Module I - Background	
Lecture 1	Linear Programming and Simplex Review
Lecture 2	Duality and Dual Simplex Review
Lecture 3	Formulating Integer Programs
Lecture 4	Branch and Bound
Module II - Classic Logistic Problems	
Lecture 5	TSP and Variants (Symmetric, Asymmetric, Prize-collecting, Steiner TSP)
Lecture 6	VRP and Variants (VRPTW, VRPPDTW, DARP, Multi-echelon VRP)
Lecture 7	Matching and Location Problems (Crew Scheduling, Facility Location, SNDP)
Lecture 8	Computational Complexity
Module III - TSP and Cutting Planes	
Lecture 9	Gomory's Cutting Plane and Valid Inequalities – Part I
Lecture 10	Gomory's Cutting Plane and Valid Inequalities – Part II
Lecture 11	TSP with Cutting Planes – Part I
Lecture 12	TSP with Cutting Planes – Part II
Lecture 13	Strengthening Bounds using Lagrangian Relaxation
Module IV - VRP and Column Generation	
Lecture 14	Column Generation and DW decomposition
Lecture 15	Resource Constrained Shortest Paths – Part I
Lecture 16	Resource Constrained Shortest Paths – Part II
Lecture 17	Branch and Price for CVRP
Module V - Miscellaneous Topics	
Lecture 18	Heuristics for TSP
Lecture 19	VNS for VRP
Lecture 20	Collaborative Logistics – Part I
Lecture 21	Collaborative Logistics – Part II