IEOR 4418 – Transportation Analytics and Logistics

Transportation, primarily focused on the movement of people, and logistics, primarily focused on the movement of goods, are two of the most fundamental challenges to modern society. To address many problems in these areas, a wide array of mathematical models and analytics tools have been developed. This class will introduce many of the foundational tools used in transportation and logistics problems, relying on ideas from linear optimization, integer optimization, stochastic processes, statistics, and simulation. We will address problems such as optimizing the routes of cars and delivery trucks, positioning emergency vehicles, and controlling traffic behavior. Moreover, we will discuss modern issues such as bicycle sharing, on-demand car and delivery services, and humanitarian logistics. Concepts will be reinforced with technical content as well as real-world data and examples.

Class Information

Time/Location: Tuesday and Thursday, 11:40am-12:55pm

Professor: Adam Elmachtoub (IEOR & Data Science Institute) adam@ieor.columbia.edu

Office Hours: Tuesday and Wednesday, 5:00pm-6:00pm, 535F S.W. Mudd Building

Teaching Assistant: Yeqing Zhou (IEOR) yz2714@columbia.edu

TA Office Hours: TBD

Location: TBD

Textbooks

There is no required textbook, all required class materials will be available on our Courseworks website.

For those who wish to learn more about transportation and logistics, the following books are a useful resources that will reinforce and expand upon the materials learned in class.

- *Transportation Systems Analysis*, by Ennio Cascetta.
- *Discrete Choice Analysis*, by Moshe Ben-Akiva.
Requirements and Grading

There will be seven individual homework assignments to hand in, preparation assignments for sessions, a group project and a final exam. Grades will be determined as follows:

Participation: 15%
- Attendance is mandatory, and lateness to class will not be tolerated. Students arriving more than 2 minutes late will not receive credit for attending class. You may miss or be late to one class without penalty. Class discussion is also included in participation grade, and includes asking good questions, raising interesting topics, and responding to questions. Students are expected to have completed pre-class reading assignments when appropriate. Use of cell phones and laptops during class is forbidden, and will result in lower participation grade.

Homework: 15%
- There will be two assignments for Module 1, two assignments for Module 2, and one assignment for Module 3. In addition, there will be a blog post assignment. Students are expected to write their own original solutions, but may discuss with others. Copying or cheating is strictly forbidden and will be subject to academic discipline.

Midterm exam 1: 25%
- The exam will be in-class and cover topics on Module 1. You may use 8.5” x 11” piece of paper, front and back, with hand-written notes.

Midterm exam 2: 25%
- The exam will be in-class and cover topics on Module 2. You may use 8.5” x 11” piece of paper, front and back, with hand-written notes.

Group Project: 20%
- You will form a group of 3-4 people and do an extensive project on a topic on Module 3 of your choice. Project details will be given later. Presentation and report will be required. This project should demonstrate a great combination of modeling, analytics, programming, visualization, creativity, clarity, and most of all, practicality.
Topics

This is a preliminary version of the topics we plan to discuss, and is subject to modifications.

Module 1: Optimization-based Models

- Shortest Path Problem
- Traveling Salesman Problem
- Assignment Problem
- Network Flow Problem
- Vehicle Routing Problem
- Joint Replenishment Problem
- Facility Location Problem

Module 2: Probability and Data-Driven Models

- Queueing Theory applied to City Logistics
- Trip Generation and Distribution Techniques
- Discrete Choice Models
- Traffic Assignment and Equilibrium Models

Module 3: Modern Challenges

- Humanitarian Logistics
- Bicycle sharing programs (Citibike, Hubway)
- On-demand car services (Uber, Lyft, Via) and challenges (pooling, surge pricing)
- Modern delivery systems (Peapod, Google Express, Amazon Now, Blue Apron)
- Autonomous vehicles and drones