Special Topics in Transportation Engineering: Static Traffic assignment and its Applications

Fall 2025

Course number	CVL8550/CVL851A	**No. of credits**	3
Meeting Time:	Slot A (Mon-Thu 8-9:25 A.M.)	**Instructor's name:**	Pramesh Kumar
Email:	pkk@iitd.ac.in	**Instructor's office:**	322, Block-IV
Location:	LH623	**Office Hours:**	TBD

Course website: Moodle

Course prerequisites: Introductory knowledge of calculus, linear algebra, optimization, and networks. Computer programming is required to do homeworks. For B. Tech. CVL461 is required and M. Tech. CVL741 is required.

Course description: This course is designed to introduce the theory and applications of the traffic assignment problem. Topics include formulation and solution of equilibrium in transportation networks, Braess' paradox, system optimal assignment, stochastic user equilibrium, user equilibrium with elastic demand, joint traffic assignment and mode choice, transit assignment, applications in pricing, and origin-destination estimation and network design.

Student learning aims/outcomes:

- Developing a conceptual understanding of transportation network congestion models
- Translating the conceptual understanding into mathematical modeling
- Large-scale implementation of numerical solution techniques.

References:

- Boyles, S. D., Lownes, N. E., and Unnikrishnan, A. Transportation Network Analysis, Volume I, Version 1.0. (2025) (also referred to as "BLU" book) [Free PDF]
- Sheffi, Yosef. Urban transportation networks. Vol. 6. Prentice-Hall, Englewood Cliffs, NJ, 1985. [Free PDF]
- Patriksson, Michael. The traffic assignment problem: models and methods. Courier Dover Publications, 2015 [Free PDF]
- Ahuja, Ravindra K., Thomas L. Magnanti, and James B. Orlin. Network flows, Pearson; 1st edition (1993). [Free PDF]

Tentative list of topics to be covered (may not cover all the topics)

1. **Introduction to convex analysis**
    - Mathematical preliminaries
    - Convex Optimization Review
    - Shortest Path Algorithms
    - Fixed Point and Variational Inequality theorems

2. **Traffic Assignment and Solution Algorithms**
    - Beckman's formulation for UE
    - System Optimal traffic assignment
    - Link-based algorithms (MSA, Frank-Wolfe method)
    - Path-based algorithms (Projected-gradient, Gradient projection)
    - Bush-based algorithms (Algorithm B, OBA, LUCE)
    - Likely path flow algorithms
3. **Applications**
    - Toll pricing
    - Sensitivity analysis
    - Network design
    - OD estimation
4. **Variants of Traffic assignment**
    - Stochastic User Equilibrium and Dial's algorithm
    - UE with Elastic Demand, Gartner's transformation
    - UE with Link interaction, Multi-class traffic assignment
    - Diagonalization methods, Simplicial decomposition
    - Boundedly rational assignment
5. **Other topics**
    - Congestion games
    - Day-to-day route choice models
    - Frequency-based transit assignment
    - Introduction to Dynamic Traffic Assignment (DTA)

Grading policy: The following is the breakdown for grading:

In-class exercises (20%)
Assignments (30%)
Minor exam (20%)
Major exam (30%)

**Major exam will be cumulative*

1. **In-class exercises (20%)** We will be solving several in-class exercises together during the class. The students are encouraged to collaborate with each other while solving these problems. Student will get full credit as long as they put effort into understanding and solving the problems. In-class exercises should be submitted in the class. They will not be accepted after the class.
2. **Assignments (30%)** Assignments will ask you to formulate or solve traffic assignment problems, prove some propositions, or implement the algorithms using a programming language. I encourage you to use the Python package (`NetAlgo`) skeleton I developed to implement various algorithms. However, there is no compulsion to use that or to use Python as a programming language.
3. **Minor exam (20%)**
4. **Major exam (30%)** Major exam will be cumulative, i.e., it will also cover the material taught before the minor exam.

Note: Participation in all components of this course is required to pass the course.

Other class policies: Other policies are as follows:

- **Letter grades**: For the description of the letter grades and their cut-offs, please refer to this link.
- **Attendance**: If a student's attendance is less than 75%, the student will be awarded one grade less than the actual grade that she has earned. For example, a student who has got an **A** grade but has attendance less than 75% will be awarded an **A(-)** grade.
- **Auditing the course**: If a student is auditing the course, then she has to get at least 50% of the total marks (aggregated) to obtain an audit pass **NP** grade. Otherwise, the student will be awarded **NF** grade.
- **Re-grade requests**: Requests for re-grading questions on an assignment/exam will be considered if submitted in writing within one week from the time the work is returned after grading. Note that the score may change in either direction as a result of a re-grade. The instructor reserves the right to limit the number and scope of re-grades requested by a student.
- **Make-up exams:** Make-up exams can be arranged as per the institute rules.
- **Academic integrity:** All activities in this course must be done independently unless taken permission from the instructor. While solving the problems, you may discuss it with your peers, but the final answer must be your own. Copying from another student or plagiarizing from other sources will be considered cheating. You may be awarded a Fail **F** grade for academic dishonesty. The case will also be forwarded to the student advisor and Dean of academics. For more information about the honor code, refer to Courses of study.
- **Resources for differently-abled students:** If you require assistance in this regard, please refer and contact Office of accessible education.

Tentative Schedule

Monday	**Thursday**
Jul 24: Introduction to the course	Jul 28: Graph theory review
Jul 31: Convex optimization review	
Aug 4: Convex optimization review	Aug 7: Shortest Path Algorithms and Fixed point and VI
Aug 11: Beckman's formulation of UE, SO, PoA	*Aug 14: *Friday timetable*
Aug 18: Beckman's formulation of UE, SO, PoA	Aug 21: Link-based algorithms
Aug 25: Link-based algorithms	Aug 28: Path-based algorithms
*'Sep 1: *Friday timetable*	Sep 4: Path-based algorithms
Sep 8: Bush-based algorithms	Sep 11: Likely path flow algorithms
Sep 15: Mid semester exam	Sep 18: Toll pricing
Sep 22: Sensitivity analysis	Sep 25: Network design/OD estimation
Sep 29: SUE and Dial's algorithm	*Oct 2: Gandhi Jayanti*
Oct 6: Dial's algorithm	Oct 9: UE with elastic demand
Oct 13: Multi-class assignment; link interaction	Oct 16: Diagonalization; simplicial decomposition
Oct 20: Dussera	Oct 23: Boundedly rational assignment
*Oct 25: *Monday timetable*	
Oct 27: Frequency-based transit assignment	Oct 30: Frequency-based assignment
Nov 3: Day-to-day route choice models	*Nov 6: *Wednesday timetable*
Nov 10:Introduction to Dynamic Traffic Assignment	Nov 13: Extra