CIV_ENV 471-II: Transportation Systems Analysis II
Spring 2024

Course:

Lecture:	Monday/Wednesday 2:00 - 3:50 pm
Location:	M166, Technological Institute
Instructor:	Marco Nie
Office:	A328, Technological Institute (Zoom ID 671 657 3620)
Phone:	847-467-0502
Email:	y-nie@northwestern.edu
Web Page:	http://www.civil.northwestern.edu/people/nie.html
Office Hours:	Monday/Wednesday 1:00–1:50 pm, and by appointment

Description: Building upon the foundation established in CIV_ENV 471-I, this course delves deeper into transportation systems analysis, with a focus on dynamic aspects of travel demand and network flow, as well as the operation and design of urban transit systems. The primary objective of this course is to acquaint students with the fundamental principles and methodologies underpinning these areas of study. Throughout the course, students will explore both classical theories and cutting-edge developments in the field, while also being encouraged to formulate and tackle their own research inquiries. The course is structured around three key pillars. (i) Morning Commute Economic Model: Students will be introduced to a simple yet potent economic model that addresses the morning commute problem. This model not only incorporates departure time choices but also accounts for traffic dynamics. (ii) Dynamic Traffic Assignment (DTA): The course will delve into the core components of the DTA framework, including foundational traffic flow models, time-dependent shortest path problems, and various assignment models. This pillar offers a comprehensive understanding of how transportation systems are analyzed and optimized in real-time scenarios. (iii) Urban Transit System Operation and Design Principles: The final pillar of the course will focus on the principles governing the operation and design of urban transit systems. Through case studies and theoretical discussions, students will gain insight into the intricacies of designing efficient and sustainable urban transit networks.

After taking this course, students should be able to (1) use typical traffic flow models (e.g. bottleneck models, kinematic wave model) in transportation system analysis; (2) solve morning commute problems under simple settings and make economic/policy interpretation of the solutions; (3) solve time-dependent and adaptive shortest path problems; (4) classify and analyze various system optimal and user equilibrium DTA formulations; (6) perform sketch design of simple transit systems; and (7) understand basic transit route choice and frequency-based transit assignment models.

Prerequisites: While students are recommended to take CIVENV 471-1 before taking this course, this is not a prerequisite. Students should be able to write simple computer programs in MATLAB or any equivalent or lower-level languages (such as Java, C++, FORTRAN, C etc.)

Recommended Text:
No textbook required.

References:

Bin Ran and David Boyce (1996) Modeling Dynamic Transportation Networks, Springer.

Sheffi, Y. (1985). Urban Transportation Networks. Prentice-Hall, NJ.

Avishai Cedear (2008). Public Transit Planing and Operation. Elsevier.

Vuckan R. Vuchic (2007) Urban Transit: Systems and Technology. John Wiley & Sons, Inc.

Suggested readings:

Morning commute

Vickrey, W. (1969). "Congestion theory and transport investment." American Economic Review 59, 251-261. 3.)

Henderson, J. V. Road congestion: a reconsideration of pricing theory, Journal of Urban Economics, 1974, 1, 346-355.

Hendrickson, C. & Kocur, G. Schedule Delay and Departure Time Decisions in a Deterministic Model Transportation Science, 1981, 15, 62-77.

Smith, M. J. The Existence of a time-dependent equilibrium distribution of arrivals at a single bottleneck Transportation science, 1984, 18, 385-394.

Smith, M. J. (1984). The stability of a dynamic model of traffic assignment—an application of a method of Lyapunov. Transportation science 18 245–252.

Horowitz, J. L. (1984). The stability of stochastic equilibrium in a two-link transportation network. Transportation Research Part B: Methodological 18 13–28.

Daganzo, C. F. The uniqueness of a time-dependent equilibrium distribution of arrivals at a single bottleneck Transportation science, 1985, 19, 29-37.

Mahmassani, H. and R. Herman. (1984). "Dynamic User Equilibrium Departure Time and Route Choice on Idealized Traffic Arterials." Transportation Science 18, 362-384. 4.

Mahmassani, H. S. and Chang, G.-L. (1987). On boundedly rational user equilibrium in transportation systems. Transportation science 21 89–99.

Arnott, R., De Palma, A., Lindsey, R., et al., 1990. Economics of a bottleneck. Journal of Urban Economics 27, 111-130.

Arnott, R., De Palma, A., and Lindsey, R. (1993). A structural model of peak-period congestion: A traffic bottleneck with elastic demand. The American Economic Review, 161-179.

Arnott, R., A. de Palma and R. Lindsey. (1990). ”Departure Time and Route Choice for Routes in Parallel.” Transportation Research 24B, 209-228. (Recommended for “Morning commute”)

Dynamic network loading and traffic assignment

Merchant, D.K., Nemhauser, G.L., 1978a. A model and an algorithm for the dynamic traffic assignment problem. Transportation Science 12, 183-199.

Merchant, D.K., Nemhauser, G.L., 1978b. Optimality conditions for a dynamic traffic assignment model. Transportation Science 12, 200-207.

Friesz, T. L., D. Bernstein, T. E. Smith, R. L. Tobin and B. W. Wei. (1993). ”A Variational Inequality Formulation of the Dynamic Network Equilibrium Problem.” Operation Research 41, 179-191.

Mahmassani, Hani S., and R. Jayakrishnan, 1991. ”System performance and user response under real-time information in a congested traffic corridor.” Transportation Research Part A: General 25, 293-307.

Smith, M. J. (1993). ”A New Dynamic Traffic Model and the Existence and Calculation of Dynamic User Equilibria on Congested Capacity-Constrained Road Networks.” Transportation Research 26B, 49-63.

Daganzo, C. F. (1994) ”The Cell Transmission Model: a Dynamic Representation of Highway Traffic Consistent with the Hydrodynamic Theory”. Transportation Research 28B, 269-287.

Daganzo, C. F. (1995). ”The Cell Transmission Model, Part II: Network Traffic.” Transportation Research 29B, 79-93.

Nie, Y., Jingtao Ma and H. M. Zhang (2008) A polymorphic dynamic network loading model. Computer- Aided Civil and Infrastructure Engineering, 23, pp. 86 - 103.

A. K. Ziliaskopoulos and H. Mahmassani. Time-dependent, shortest path algorithms for real-time intelligent vehicle highway system applications. Transportation Research Record, 1408:94 - 100, 1993.

I. Chabini. Discrete dynamic shortest path problems in transportation applications. Transportation Research Record, 1645:170-175, 1998.

Transit and ride-hail

Osuna, E.E. and Newell, G.F., 1972. Control strategies for an idealized public transportation system. Transportation Science, 6(1), pp.52-72.

Newell, G.F., 1979. Some issues relating to the optimal design of bus routes. Transportation Science, 13(1), pp.20-35.

Marguier, P. H. J., A. Ceder. 1984. Passenger waiting strategies for overlapping bus routes. Transportation Sci. 18(3) 207-230.

Spiess, H., M. Florian. 1989. Optimal strategies: A new assignment model for transit networks. Transportation Research Part B 23(2) 83-102.

Gentile, Guido, Sang Nguyen, and Stefano Pallottino. "Route choice on transit networks with online information at stops." Transportation science 39.3 (2005): 289-297.

Daganzo, C. F. (2010). Public Transportation Systems: Basic Principles of System Design, Operations Planning and Real-Time Control. Lecture notes, University of California, Berkeley.

Daganzo, Carlos F. Structure of competitive transit networks. Transportation Research Part B: Methodological 44.4 (2010): 434-446.

Douglas, G. W. (1972), Price regulation and optimal service standards: The taxicab industry', Journal of Transport Economics and Policy, 116–127.

Arnott, R. (1996), Taxi travel should be subsidized. Journal of Urban Economics 40(3), 316– 333.

Homework and projects: There will be three homework assignments, a discussion assignment and one course project. Some assignments may involve writing simple computer codes to solve problems studied in the class. For the course project, you will be asked to write a short 5-page research proposal to National Science Foundation (NSF), showcasing one of your brilliant ideas that you believe is worthwhile to be funded. Other than you should make the proposed research a relevant application of what you have learned from the class, there is no other restriction on the subject. Students will make a final presentation on the topic of the course project.

Exams: No exams will be given.

Grading: The final grade will be assigned on the following basis:

Homework	45%
Paper discussion	20%
Proposal	35%

Working Together: Working together on homework is accepted. However, students are expected to write up their own versions of solutions. Depending on the class size, students may be asked to form teams to do the course project. A team may not have more than two members who will submit a joint project report and receive the same grade. Working together on exams, of course, is forbidden.

Table 1: CIV_ENG 471-II Course Schedule (Spring 2024)

Date	Week	Topic	Assignment	Due
26-Mar	1-1	Introduction		
27-Mar	1-2	Introduction		
1-Apr	2-1	Traffic flow theory		
3-Apr	2-2	Traffic flow theory	Proposal	
8-Apr	3-1	Morning commute problem		
10-Apr	3-2	Morning commute problem	Homework 1	
15-Apr	4-1	Morning commute problem		
17-Apr	4-2	Dynamic network loading (DNL)		
22-Apr	5-1	DNL		Homework 1; Discussion 1
24-Apr	5-2	Time-dependent shortest path	Homework 2	
29-Apr	6-1	DTASO		
1-May	6-2	DTASO		
6-May	7-1	General DTA model: UE		Homework 2; Discussion 2
8-May	7-2	Transit system intro		
13-May	8-1	Transit assignment		
15-May	8-2	Transit assignment	Homework 3	
20-May	9-1	Transit design		
22-May	9-2	Transit design		Homework 3; Discussion 3
27-May	10-1	Memorial day (no class)		
29-May	10-2	Transit design		Proposal