Fall 2024, Introduction to Transportation Systems Analysis 12-644/94-893
Thursday 6:40 to 9:30 pm, HBH 1202

Instructor: Tao Tao, taot@andrew.cmu.edu

Office Hours: Thursday 4-5 pm, 118Q thesis room in Porter Hall (starting from September 5th, 2024) or virtually available by appointment

Teaching Assistant: Jiachao Liu, jiachaol@andrew.cmu.edu

Office Hours: Tuesday 5-6 pm, CEE student lounge in Porter Hall (starting from September 3rd)

Optional Recitation Session: Tuesday 11 am to noon, A7F in Porter Hall (starting from September 3rd)

Course materials are available on Canvas. Discussion board is for you to interact with others in the course. TA and the instructor will check the discussion board at least once every other day, but please plan your time accordingly so questions can be answered in a timely manner. The best way to communicate with the instructor and TA is through emails.

Textbook and Materials:

- Required
  - Textbook: F. Mannering & S. Washburn (2020), *Principles of Highway Engineering and Traffic Analysis*, **Seventh Edition**
  - Slides: Posted weekly on Canvas
  - One computing tool of your choice: Excel, R, Python, *etc.*
- Optional
  - Other reading materials will be posted on Canvas

Prerequisites: Basics of statistics, probability theory and calculus, equivalent course, or permission of instructor.

Student Well-being: Take care of yourself. Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress.

All of us benefit from support during times of struggle. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is almost always helpful.

If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. Counseling and Psychological Services (CaPS) is here to help: call 412-268-2922 and visit their website http://www.cmu.edu/counseling/. Consider reaching out to a friend, faculty or family member you trust for help getting connected to the support that can help.

Diversity and Inclusion: We must treat every individual with respect. We are diverse in many ways, and this diversity is fundamental to building and maintaining an equitable and inclusive campus community. Diversity can refer to multiple ways that we identify ourselves, including but not limited to race, color, national origin, language, sex, disability, age, sexual orientation,

gender identity, religion, creed, ancestry, belief, veteran status, or genetic information. Each of these diverse identities, along with many others not mentioned here, shape the perspectives our students, faculty, and staff bring to our campus. We, at CMU, will work to promote diversity, equity and inclusion not only because diversity fuels excellence and innovation, but because we want to pursue justice. We acknowledge our imperfections while we also fully commit to the work, inside and outside of our classrooms, of building and sustaining a campus community that increasingly embraces these core values.

Each of us is responsible for creating a safer, more inclusive environment.

Unfortunately, incidents of bias or discrimination do occur, whether intentional or unintentional. They contribute to creating an unwelcoming environment for individuals and groups at the university. Therefore, the university encourages anyone who experiences or observes unfair or hostile treatment on the basis of identity to speak out for justice and support, within the moment of the incident or after the incident has passed. Anyone can share these experiences using the following resources:

- Center for Student Diversity and Inclusion: csdi@andrew.cmu.edu, (412) 268-2150
- Report-It online anonymous reporting platform: reportit.net username: tartans password: plaid

All reports will be documented and deliberated to determine if there should be any following actions. Regardless of incident type, the university will use all shared experiences to transform our campus climate to be more equitable and just.

Course Objectives: The objective of this course is to provide students with a solid introduction to the principles of transportation system analysis with the focus on planning and traffic operation. The material learned will provide the basic skill set that will allow students of either engineering or public policy background to solve transportation problems that are likely to appear in professional practice, on the Fundamentals of Engineering exam (FE), and in development of transportation policies. The material also serves as foundation for future coursework in transportation and smart communities.

This course covers fundamentals of planning and operation of roadway transportation. Topics covered include basic traffic flow theory, traffic signal design and evaluation, transportation planning, pricing of transportation systems, and basic data analytics techniques. The objective is to develop the capability to: 1) understand the principles of transportation planning and system management; 2) analyze transportation systems with emerging mobility data; and 3) apply methodologies to solve transportation system problems and develop management strategies/policies.

Grades:

Homework	50% (10% each)
Term Project	30%
Final (a written reflection)	20%

Grading: Homework can be submitted in class or Canvas. Feedback and scores will be returned to you in the following week of submission. If you would like to have it re-graded, please contact the TA who grade it to resolve this issue. Please ask for re-grading of an assignment within *one* week after it is returned to you in the first place.

Homework Submission Policy: No late homework will be accepted after the due time unless previously arranged with me 48 hours prior to the deadline. No late homework will be accepted after the solutions are posted to Canvas. No exception.

Academic Honesty: As a CMU student, you have agreed to abide by CMU's policies on ethics and discipline, which can be found in http://www.cmu.edu/academic-integrity/. No cheating and plagiarism will be tolerated.

Using information directly from websites, books, papers and other literary sources without appropriate attribution is plagiarism. Assignments submitted for this class will be reviewed by the instructor and TAs and may be scanned through web-based academic integrity software. Occurrences of cheating or plagiarism will be handled according to the university policy on Cheating and Plagiarism, https://www.cmu.edu/policies/student-and-student-life/academic-integrity.html. Students are expected to have read this policy and conform to the highest standards of academic integrity. For incidents of academic misconduct, the University Academic Disciplinary Actions Policy, found at https://www.cmu.edu/student-affairs/theword/academic-discipline/index.html, will be followed.

Artificial Intelligence: AI language models, such as ChatGPT, can only be used to improve writing. Students cannot use AI language models to generate answers and solve problems for their assignments directly. Students who use AI language models to improve their writing should have a clear statement in the final section of their assignments. Students are responsible for fact checking statements composed by AI language models. Unattributed use of AI language models are forms of scholastic dishonesty and will be treated as such.

Homework: Homework must be *individual* work unless otherwise stated. Discussions with other students about concepts and overall approaches to completing individual assignments are permitted, but you must do individual problem solving and derive your own solutions, including your own computer work.

You are not permitted to be in possession of any assignments from another student or other source either from the current semester or from past semesters whether they are electronic or paper. Possession of or sharing such files constitutes an infraction of the academic integrity policies of this course.

Subject Areas and Learning Objectives

1. Fundamentals of Traffic Flow and Queuing Theory
   - Traffic flow characteristics
   - Fundamental diagrams
   - Queuing theory (D/D/1, M/D/1, M/M/1, M/M/N)
   - Traffic delay computations
   - **Learning objective**: Queuing theory has broad impacts in transportation engineering, and it builds upon student's basic math and probability knowledge. The objective of this section is to give the student a very basic understanding of queuing theory and familiarity with the deterministic and probabilistic assumptions made for arrivals and departures. After completing this section, the student is expected to have the tools to understand

basic queuing principles and have the underlying basis for understanding complex queuing systems.

2. Highway Capacity and Level of Service Analysis
   - Basic freeway segments
   - Multilane highways
   - Rural two-lane highways
   - **Learning objective**: Basic level of service analysis serves as a basis for determining highway construction needs and other transportation resource allocations. This section provides students with the knowledge needed to conduct level of service analysis, familiarity with the terminology used in such analysis, and the background needed to use Highway Capacity Manual (HCM) level of service software.

3. Traffic Control and Analysis at Signalized Intersections
   - D/D/1 queuing
   - Probabilistic arrivals
   - Traffic signal timing
   - **Learning objective**: Determining and forecasting travel demand is a complicated process because it involves predictions of human behavior. This section presents various mathematical and statistical models that have been developed to predict individuals' travel behavior. Many of the methods originated in social science fields but are now used widely by engineers for behavioral predictions. The objective is to give students a basic understanding of the various modeling approaches and to have them become familiar with the terminology and potential applications.

4. Travel Demand and Traffic Forecasting
   - Travelers' Decisions
   - Trip Generation and Distribution
   - Mode and Destination Choice
   - Highway Route Choice
   - **Learning objective**: Determining and forecasting travel demand is a complicated process because it involves predictions of human behavior. This section presents various mathematical and statistical models that have been developed to predict individuals' travel behavior. Many of the methods originated in social science fields but are now used widely by engineers for behavioral predictions. The objective is to give students a basic understanding of the various modeling approaches and to have them become familiar with the terminology and potential applications.

5. Transit planning
   - Transit quality of service
   - Capacity analysis
   - Route scheduling
   - **Learning objective**: The objective is to give students a basic understanding of transit planning process and calculation. Students will learn how to evaluate the quality of transit service. In addition, students will understand what factors contribute to transit

capacity and how to estimate transit capacity. Finally, students will learn about the basic concepts and process of transit route scheduling.

6. Traffic safety analysis
   - Crash data
   - Safety regression analysis
   - **Learning objective**: Safety analysis works with sophisticated statistical models to discover insights on safety measures, improvement strategies and policies. The objective of this section is to give students a basic understanding of roadway crash data, as well as concepts of various modeling approaches and to have them become familiar with the safety terminology and how safety analysis is conducted in engineering and policy practice.

Course Agenda:

8/29	**Week 1: Traffic flow (Chapter 5.1-5.4)**
	• Lecture 1: Housekeeping; overview; why systems and how • Lecture 2: Traffic flow characteristics, fundamental diagram, Poisson arrivals • Assignment 1 out
9/5	**Week 2: Queuing theory and LoS analysis (Chapter 5.4-5.7, Chapter 6.1-6.3)**
	• Lecture 3: Queuing theory, highway bottleneck analysis, autonomous vehicles • Lecture 4: Highway capacity analysis • Assignment 2 out • Assignment 1 due 11:59 pm
9/12	**Week 3: Highway capacity and traffic control (Chapter 6.1-6.7, Chapter 7.1-7.3)**
	• Lecture 5: Highway capacity analysis; level of service determination • Lecture 6: Design of signalized control at intersections • Assignment 3 out • Assignment 2 due 11:59 pm
9/19	**Week 4: Traffic control and analysis at signalized intersections (Chapter 7.4-7.5)**
	• Lecture 7: Signal timing plans • Lecture 8: Traffic analysis at signalized intersections • Assignment 4 out • Assignment 3 due 11:59 pm
9/26	**Week 5: Demand modeling and forecasting (Chapter 8.1-8.7)**
	• Lecture 9: Trip generation and distribution • Lecture 10: Modal and destination choice; highway route choice; demand modeling in practice • Final project out (in-class discussion in Lecture 10) • Assignment 5 out

	• Assignment 4 due 11:59 pm
10/3	**Week 6: Transit planning part I**
	• Lecture 11: Transit quality of service • Lecture 12: Transit capacity analysis • Final reflection out • Assignment 5 due 11:59 pm
10/10	**Week 7: Transit planning part II and Safety analysis**
	• Lecture 13: Crash data; safety models; safety performance factors • Lecture 14: Transit route scheduling • Final reflection due 11:59 pm
10/12	Final project due 11:59 pm