CE 376: Transportation System Operations
Fall 2019

Course:
Time:	MW 8:00 - 9:50 am
Room:	LG52
Final exam:	7-9 PM, 12/11/2019

Instructor:
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Description: The purpose of this course is to introduce students to the principles of transportation engineering with a focus on highway engineering and traffic analysis. The course covers fundamental concepts and principles that guide road design, as well as the movement and control of vehicular traffic. Specifically, these include geometric design, traffic flow theory, highway capacity analysis, and traffic signal operations.

The materials learned are intended to provide the basic skill set that will allow students to solve transportation problems that are likely to appear in professional practice and on the Fundamentals of Engineering exam (FE) and the Principles and Practice of Engineering exam (PE). The materials also serve as a foundation for future coursework in transportation.

The course is designed for upper level undergraduate students and entry-level graduate students.

Prerequisites: Basic undergraduate calculus and statistics courses.

Course requirement:

- Eight problem-oriented assignments. The objective of these assignments is to assist in the learning of course material, so discussion of assignments among students is encouraged.

- One mid-term and one final exam will be given. Both exams will be closed-book but the student is allowed to bring one 8-1/2 by 11 inch "cheat sheet" to the exam.

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

Homework	40%
Mid term exam	25%
Final exam	30%
Participation	5% (Students are expected to actively participate in class discussions)

Text: The required text is "Principles of Highway and Traffic Engineering" Fifth Edition, by Fred L. Mannering, Scott S. Washburn, and Walter P. Kilareski, John Wiley & Sons, 2011. Available at bookstores, amazon.com, bn.com, and other sources. The textbook will be supplemented by class notes.

References:

Nicholas J. Garber and Lester A. Hoel. (2002) Traffic and Highway Engineering, Third Edition, PWS Publishing Company.

James H. Banks. (2002) Introduction to Transportation Engineering, Second Edition, McGraw-Hill.

Other requirements

- Late submission: Students are expected to submit their homework and project reports in time. The base grade of late homework will be depreciated 10% for every 24-hour delay (up to 30%), unless it is the result of an officially excused absence.

- Working together: Working together on homework is encouraged, although students are expected to write up their own versions of solutions. Working together on exams is forbidden.

- Calculator: Students may use a graphic calculator on exams and homework. Students may not use laptop computers and/or any machine with symbolic manipulation capabilities on exams.

Subject area and learning objectives

Introduction
- *Topics*: Transportation and society; challenges arising from transportation systems; basic components of highway systems.
- *Learning objectives*: to understand basics and fundamental challenges in transportation systems, particularly highway systems.

Basic vehicle dynamics
- *Topics*: Space-time diagram; vehicle movement analysis based on constant accleration/deceleration; stopping distance; safe following distance; vehicle performance (resistance, acceleration, deceleration, braking)
- *Learning objectives*: to understand fundamental physical rules that govern vehicle movement and influence vehicle performance; to be able to apply these rules to solve simple traffic and road design problems.

Geometric design of highways
- *Topics*: Sight requirements; superelevations; horizontal and vertical alignments.
- *Learning objectives:* to be familiarized with the elements involved in geometric design and the safety concerns that motivate vertical and horizontal curve design; to be able to perform a rudimentary geometric design of a highway section.

Elements of traffic flow theory
- *Topics*: Definition and measurement of traffic quantities; relationship between traffic quantities; time-mean vs. space-speed; inductive loops; identify and measure traffic congestion.

- *Learning objectives*: to be familiarized with basic quantities that describe vehicular traffic; to build a foundation for understanding highway capacity, as well as more advanced traffic flow theory that explains the mechanism of traffic congestion.

Traffic control at signalized intersections
- *Topics*: Signal control hierarchy and warrants; signal timing design methods.
- *Learning objectives*: to be familiarized with the elements of signal operations and signal timing analysis methods; to be able to use both analytical methods and commercial software (Synchro) to solve simple signal design problems.

Car-following behavior and traffic stream models
- *Topics*: California Motor Code Rule; General-Motor car-following models.

- *Learning objectives*: to understand the relationship between car-following behavior and the macroscopic properties of traffic stream; to be able to derive various speed-density and flow-density models from corresponding car-following models.

Queueing theory
- *Topics*: Deterministic first-in-first-out queuing theory; bottleneck traffic model; stochastic queuing theory (M/M/1, M/D/1)
- *Learning objectives*: to be familiarized with fundamental principles in queuing analysis; to be able to apply simple deterministic and stochastic queueing models to analyze various traffic phenomenon; to develop a foundation for understanding more complex queuing systems.

Highway capacity analysis
- *Topics*: Basic freeway segments; multi-lane highways.
- *Learning objectives*: to understand the basic highway capacity analysis methods; to be able to use these methods to conduct simple LOS (level of service) analysis for freeway and multi-lane highways; to develop a basis for understanding Highway Capacity Manual (HCM) and the HCM-based commercial design software.

Kinematic wave theory
- *Topics:* Conservation law; LWR model and its basic solution; acceleration, deceleration and shock waves.
- *Learning objectives*: to understand the concept of kinematic wave (KW) theory and its application in traffic analysis; to be able to use the KW theory to analyze the formation and propagation of traffic congestion in simple cases; to develop a basis for understanding advanced traffic analytical tools including traffic simulation.

ABET Program Educational Objectives

For students completing undergraduate degree programs in civil engineering or in environmental engineering, this course addresses the following Program Outcomes [1]:

(1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. (H,E) [2]

(2) an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. (H,E)

(4) an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts. (H,E)

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[1]These outcomes correspond to the "1-7" Learning Outcomes specified by the Accreditation Board of Engineering and Technology (ABET)

[2]Homework (H), Exams (E), and Written Reports (R) refer to the deliverables that are used to meet the learning outcomes.

Table 1: Tentative course schedule

Date	Week	Topic	Text	Assignment	Due
			CIV_ENG 376 Course Schedule (Fall 2018)		
23-Sep-19	1-1	Introduction	Chapter 1 + notes		
25-Sep-19	1-2	Basic vehicle dynamics	Chapter 2 + notes	HW1	
30-Sep-19	2-1	Basic vehicle dynamics	Chapter 2 + notes		
2-Oct-19	2-2	Geometric design	Chapter 3		HW1
7-Oct-19	3-1	Geometric design	Chapter 3	HW2	
9-Oct-19	3-2	Elements of Traffic Flow Theory	Chapter 5+ notes		HW2
14-Oct-19	4-1	Elements of Traffic Flow Theory	Chapter 5+ notes	HW3	
16-Oct-19	4-2	Car-following behavior and traffic stream	Chapter 5 + notes		HW3
21-Oct-19	5-1	Car-following behavior and traffic stream	notes	HW4	
23-Oct-19	5-2	Queuing theory	notes		HW4
28-Oct-19	6-1	Queuing theory	Chapter 5 + notes	HW5	
30-Oct-19	6-2	Highway capacity analysis	Chapter 5 + notes		HW5
4-Nov-19	7-1	Highway capacity analysis		HW 6	
6-Nov-19	7-2	**Midterm (in-class)**	Chapter 6		
11-Nov-19	8-1	Traffic control	Chapter 6		
13-Nov-19	8-2	Traffic control	Chapter 7+notes	HW7	
18-Nov-19	9-1	Traffic control	Chapter 7+notes		
20-Nov-19	9-2	Kinematic wave theory	Chapter 7+notes	HW8	HW-7
25-Nov-19	10-1	Cancelled (Thanksgiving Holiday)	Chapter 7+notes		
27-Nov-19	10-2	Kinematic wave theory	Notes		
2-Dec-19	11-1	Review			HW8
4-Dec-19	11-2	**Final exam (7-9 PM)**			
12-Dec-18					