CE 462/562 Traffic Engineering and Operations (3 Units)
Spring 2017 Course Syllabus

Lecture: 11:00AM ~ 12:15PM on Tuesdays and Thursdays;
Location: Cesar E. Chavez Bldg, Rm 109

Catalog Description: On a national average, poor signal timing causes up to fifteen percent excess vehicle delay, sixteen percent excess vehicle stops, seven percent excess travel time, and nine percent excess fuel consumption. Therefore, this course introduces important concepts and principles of traffic system design, geometric characteristics, and operation of streets and highways, including planning aspects, traffic design and control, and highway safety. Simulation modeling and application of these concepts and principles to actual situations will be emphasized to evaluate traffic system performance.

Objective: The objective of this class is to introduce traffic system design concepts, control components, management strategies, and tools for evaluating their effectiveness. With the instructions, assignments, and projects in this course, students are expected to learn traffic system control devices, working principles, and popular algorithms. Additionally, the VISSIM traffic simulation package will be introduced in greater detail so that students can use it for evaluating the performances of traffic operation plans. Major topics of this course include: (1) traffic control system components; (2) timing plan design; (3) traffic flow characteristics; (4) driver behavior models; (5) advanced control algorithms; and (6) traffic control system modeling and simulation. Knowledge on the above subjects and traffic simulation skills are considered indispensable for modern traffic engineering practice.

Course Outcomes:

- Know traffic system design concepts, control components, and management strategies
- Use computer tools to evaluate traffic system effectiveness and performances of traffic operation plans
- Develop new traffic control strategies to improve transportation systems

ABET: The Accreditation Board for Engineering and Technology (ABET) accredits the Civil Engineering curriculum at the University of Arizona. This course fits in the Civil Engineering curriculum, and satisfies ABET outcomes, as defined below and on the "ABET 2010 Criteria Course Classification Form" that is attached.

Primary ABET Outcomes

- C. Ability to design a system, component, or process to meet desired needs
- L. Pass the FE exam as the first step towards professional registration
- M. Be proficient in the major areas of civil engineering

Secondary ABET Outcomes

- A. Apply mathematics, science, and engineering principles
- B. Ability to design and conduct experiments and interpret data
- E. Ability to identify, formulate, and solve engineering problems
- H. The broad education necessary to understand the impact of engineering solutions in a global context

- K. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Instructor Information:

- Dr. Yao-Jan Wu
  - Civil Engineering Building 324F
  - Office Phone: (520) 621-6570
  - Email: yaojan@email.arizona.edu
  - Open Office Hours: (other times available by appointment)
    - Wednesday 10am~noon'
- Dr. Shu Yang
  - Civil Engineering Building 324G1 (Smart Transportation Lab)
  - Email: shuyang@email.arizona.edu
  - Open Office Hours: (other times available by appointment)
    - CE214
    - TBD in the first class (One hour Monday and one hour Friday)

- **Prerequisite**: CE 363 or instructor's approval.

Textbook:

Required: No Textbook. Materials will be provided on D2L

References:

- Kell, J.H. and Fullerton, I.J.. Manual of Traffic Signal Design. Second Edition. Institute of Transportation Engineers. ISBN 0-935403-19-1. 1998.
- Traffic Signal Timing Manual, FHWA, 2008 (free online -http://goo.gl/xLDOi4)

Grading and Assessment:

	Undergraduate	Graduate
Homework Assignments & Conference Reports	5%	5%
In-Class Exercise and Quizzes	10%	10%
Projects	35%	25%
Midterm Exams	50%	30%
Term Project Report	0%	30%

A = above 90%; B = 80 to 89%; C = 70 to 79%; D = 60 to 69%; E = below 60%.

- **Assigned Readings.** Most lectures have assigned readings (please see the course schedule for details) that you need to finish *before* attending the classes. Though these assigned

readings will not be directly evaluated, it will be greatly beneficial to complete reading them on time because they provide important information for you to understand the class contents and participate in class discussions.

- **Projects.**
  - There are ***three*** projects in this course.
  - Each project is designed to aid skill development for evaluating a specific type of traffic control system using the VISSM microscopic simulation tool: Project One for pre-timed signal timing plan evaluations; Project Two for actuated signal control plan evaluations; and Project Three for specific highway/freeway system operation evaluations, such as ramp metering strategy evaluations, and roundabout performance evaluation, proposed by the instructor, students, and DOT traffic engineers as the course proceeds.
  - All three projects are designed to be completed by teams of students. Each team will consist of **two~three** members.
  - At the end of the semester, each team member will fill out a peer evaluation on all team members including himself/herself.
  - A project report should be typed and submitted by each team just like a consulting firm submitting it to a client. It should be written in clear English, contain the relevant answers and descriptions of the work done for the project, be relatively short (5 to 8 pages), and be backed up by additional pages of relevant equations, assumptions, etc. Electronic files of a project should be submitted.
  - Rubrics
    - Technical content 80%
    - Professionalism 20% (Please refer to the "HOW TO WRITE A TECHNICAL REPORT" document on D2L)
- **Homework.** There will be homework assignments. Each assignment is scored out of 100 points.
  - Working on homework in groups is permitted. However, each person must turn in a separate write-up and solution prepared by his/her own hand. This means that the problem description, steps taken to solve the problem, and any computer input and output must be written by each person individually.
  - **Homework Submission:** You are required to turn in your homework on time in person. The assignment must be turned in by the beginning of the class. 20% off if the homework is submitted during the class. No after-class submission.
  - Copying another person's work without attribution, including copying of any part or the whole of computer files or material from the Internet, is considered plagiarism. It will be prosecuted as a violation of the University of Arizona Student Code of Conduct in

accordance with the Code of Academic Integrity. Both codes are published on-line at http://deanofstudents.arizona.edu/policiesandcodes/. It is the student's responsibility to be familiar with these Codes.

- **Exams.** There are two midterm exams and no final exam. Both exams will be ***open-book and open-notes.*** Everyone should respect each other's space and keep their books and notes within their own space. Exam questions will be from the contents covered in lectures, assigned readings, class videos, assignments, or projects.

- **Term Project Report (Graduate Student Only):** At the end of the semester, graduate students need to finish a research paper related to this course. The research topic and outline (10% of Term Project Report Grade) have to be approved by one of the instructors before Midterm exam 1. The deadline of the term project report is the final exam day. *It is graduate student's responsibility to schedule a time to discuss with one of the instructors.* The paper format should follow the TRB paper author guide (latest version).

- **Conference Reports:** It is very important to talk to transportation practitioners and researchers to gain knowledge outside your textbooks and classes. Several conferences will be held this semester. Please attend ***at least*** one conference and ***at least*** two sessions that are most related to our class. You are required to submit a one-page report summarizing your thoughts with a photo (photos) attached within seven days after the conference.

D2L:
The primary source for homework, solutions, design project activities, and other course materials will be D2L. Students may access D2L through http://d2l.arizona.edu/. It is the students' responsibility to check this site regularly.

Teaching Philosophy/Tips for Success in Course:

1. Check out **D2L** for updates.
2. **Study time:** The normal after-class study time is 2 hours for a one-credit hour class. You're expected to study 6 hours (weekly average) outside this 3-credit-hour class.
3. **Class Attendance:** Information lectured in the class cannot always be found in the assigned readings or course slides. The exams will be based on the lectures in addition to the provided materials. Some random quizzes and bonus questions will be given in the class.
4. Please feel free to give your instructor feedback (in person, mail, or email). Anonymous online feedback is available at https://sites.google.com/site/yaojan/courses/feedback. I will try my best to help you. Note that I cannot reply if the feedback is anonymous.

Course Policy:

1. Respect your classmates (on time and be quiet).
2. Class Attendance. You are expected to attend all lectures and computer labs scheduled for this course. If you cannot attend a specific lecture, please get instructor's permission ahead of the class time or provide relevant document (e.g. doctor's note) afterwards.

   a. All holidays or special events observed by organized religions will be honored for those students who show affiliation with that particular religion,
   b. Absences pre-approved by the UA Dean of Students (or Dean's designee) will be honored.
3. If you have any questions regarding your grade, please let me know **within seven days** after your grade is returned. Any corrections will not be made after seven days.
4. In addition to University of Arizona Student Code of Conduct and Code of Academic Integrity mentioned above, please also review Policy on Threatening Behavior by Students (http://policy.web.arizona.edu/threatening-behavior-students)
5. The University of Arizona is committed to creating and maintaining an environment free of discrimination. In support of this commitment, the University prohibits discrimination, including harassment and retaliation, based on a protected classification, including race, color, religion, sex, national origin, age, disability, veteran status, sexual orientation, gender identity, or genetic information. The University encourages anyone who believes he or she has been the subject of discrimination to report the matter immediately as described in the section below, "Reporting Discrimination, Harassment, or Retaliation." All members of the University community are responsible for participating in creating a campus environment free from all forms of prohibited discrimination and for cooperating with University officials who investigate allegations of policy violations. Please review Nondiscrimination and Anti-harassment policy (http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy)
6. Accessibility and Accommodations:

   It is the University's goal that learning experiences be as accessible as possible. If you anticipate or experience physical or academic barriers based on disability or pregnancy, please let me know immediately so that we can discuss options. You are also welcome to contact Disability Resources (520-621-3268) to establish reasonable accommodations.

   Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable.

Tentative Schedule: ***(Schedules and topics may change, watch D2L for updates)***

Week	Day	Date	Topics	Note	
1	Th	Jan. 12	**TRB Annual Conference (No Class)**		
2	Tu	Jan. 17	Introduction and Course Overview	R#1	
	Th	Jan. 19	Simulation Theory Fundamentals I*	R#2&3	A#1 out
3	Tu	Jan. 24	Simulation Theory Fundamentals II*		
	Th	Jan. 26	Traffic Simulation Models	R#4;	ICE#0 out;
4	Tu	Jan. 31	Traffic Control Introduction (MUTCD)	R#5	
	Th	Feb. 2	Traffic Controller and Standards	R#6	A#1 due; ICE#FD
5	Tu	Feb. 7	Pre-timed Traffic Signal Control I*	R#7	
	Th	Feb. 9	Pre-timed Traffic Signal Control II*		ICE#1 out
6	Tu	Feb. 14	Signal Timing Issues and Simulation	R#8	A#2 out ICE#2 out
	Th	Feb. 16	Traffic Detectors and Applications	R#9	ICE#3
7	Tu	Feb. 21	**Project 1**		P#1 out A#2 due
	Th	Feb. 23	Actuated Signal Control I Midterm 1 Review	R#10	(Shu)
8	Tu	Feb. 28	**Midterm One**	Term Project Topic/Outline Confirmed	
	W	Mar. 1	**ITE Spring Conference (Optional)**		
	Th	Mar. 2	Actuated Signal Control II		ICE#4;
9	Tu	Mar. 7	Advanced Issues in Traffic System Control	R#11	
	Th	Mar. 9	Roundabout Modeling and Analysis	R#12	P#1 due ICE#5
10	Tu	Mar. 14	**Spring Break (No Class)**		
	Th	Mar. 16	**Spring Break (No Class)**		
11	Tu	Mar. 21	Traffic Flow Characteristics*	R#13	P#2 out A#3 out
	Th	Mar. 23	Driver Behavior Models*	R#14	ICE#6
12	Tu	Mar. 28	Freeway Ramp Meter Control	R#15	A#3 due;
	Th	Mar. 30	Vehicle Actuated Programming (VAP)	R#16	ICE#7
13	Tu	Apr. 4	Vehicle Actuated Programming (VAP)	R#17	P#2 due; ICE#8
	Th	Apr. 6	**ASCE PSWC Conference**		
14	Tu	Apr. 11	Freeway Simulation Modeling and Calibration		ICE#9 P#3 out;
	Th	Apr. 13	**Arizona Roads and Streets Conference (No Class) - <u>Highly encouraged to attend</u>**		
15	Tu	Apr. 18	**Midterm Two**		
	Th	Apr. 20	Invited Lecture: TBD		
16	Tu	Apr. 25	Freeway Toll Lane System*	R#18	
	Th	Apr. 27	Active Traffic Management		
17	Tu	May 2	Course Summary (Project 3 Assistance)		
	Th	May 4	**Reading Day**		
18	Mo	May 8	Final Project Presentations (3:30pm~5:30pm)	P#3 due Term project report due	

A#: Homework Assignment Number; P#: Project Number; ICE#: In-Class Exercise (ICE) number ; R#: Reader Number ; CR# Conference report; *: Dr. Shu Yang's lectures

CE 462/562 Course Learning Objectives

Traffic system control and simulation are essential for modern transportation engineers. With the enlarging gap between roadway supply and travel demand, traffic congestion is getting worse worldwide, especially in large metropolitan areas. A quick and effective solution to address the deteriorating traffic condition is to manage the existing roadway infrastructure more efficiently using advanced traffic system control technologies. To identify the most suitable traffic system control technology for a particular facility, traffic simulation experiments and analysis are needed. Therefore, this course is developed to introduce the cutting edge traffic system control technologies and microscopic simulation tools to senior undergraduate and graduate students interested in transportation engineering. It intends to help transportation students develop traffic system control and simulation skills through lectures, in-class exercises, assignments, and projects. Specific topics and corresponding learning objectives are listed below:

Simulation Theory and Probability Fundamentals

Simulation is the process of designing a model of a real system and conducting experiments with this model to understand the behavior of the system or evaluate various strategies for the operation of the system. It is a powerful tool if understood and used properly. To understand a microscopic traffic simulation system, fundamental knowledge about random variable, stochastic process, probability, and event-driven system are needed. Upon completion of this topic, the student will be able to:

- Know commonly used probability distributions
- Calculate moments of random variables
- Understand components of an event-driven simulation system;
- Tell the difference between random number and pseudo random number;
- Conduct hypothesis tests; and
- Test the independence of two random variables.

VISSIM Simulation Experiment Design and Analysis

VISSIM is a popular microscopic traffic simulation package. It will be used to build simulation models and test traffic system control strategies in this course. Due to the dynamic and stochastic nature of traffic demand, simulation experiment design and model calibration are very challenging tasks to produce reliable results. Furthermore, commonly interested traffic variables, such as travel time and speed, may be auto-correlated. Such auto-correlation in simulation outputs must be properly addressed in the analysis on the simulation outputs. Upon completion of this topic, the student will be able to:

- Build simulation models using VISSIM;
- Design simulation experiments;
- Calibrate simulation models using observed data;

- Understand the covariance-stationary process;
- Test the auto-correlation among simulation output series; and
- Calculate confidence interval for auto-correlated variables.

Intersection Traffic Control

Intersections are an important source of travel delays on arterials. There are various kinds of control technologies available for intersection traffic control: stop sign, yield sign, and traffic signal control. For signalized intersections, there are also pre-time control, semi-actuated control, fully actuated control, and more advanced signal control technologies (e.g. adaptive control and transit signal priority) to choose from. Understanding the application scenarios and conditions of these control technologies are very important for traffic engineers to operate arterials efficiently. Upon completion of this topic, the student will be able to:

- Design signal timing plans for pre-time controlled intersections;
- Evaluate signal timing plans using VISSIM simulation experiments and the Highway Capacity Manual approach;
- Conduct queuing and level of services analyses for pre-time controlled intersections;
- Understand traffic detection principles;
- Know prevalent standards for traffic controllers; and
- Apply advanced traffic signal control technologies.

Freeway Traffic Operations

Freeways are important corridors for inter-city freight and passenger transportations. The rapid increases in vehicle population and miles of travel per vehicle have made freeways in large metropolitan areas more and more congested. Advanced freeway operational strategies and regulations on lane usage have been widely employed to mitigate congestion and enhance travel time reliabilities. Active traffic management, integrated corridor management, ramp metering, and managed lanes are covered in this subject area. Upon completion of this topic, the student will be able to:

- Explain the working principle of active traffic management solutions;
- Design and evaluate ramp metering strategies;
- Know different managed lane strategies and their impacts;
- Calibrate freeway simulation models; and
- Understand Wiedemann's car-following and lane-changing models.