CE 462/562 Traffic Engineering and Operations (3 Units)
Spring 2019 Course Syllabus

Lecture: 5:00PM ~ 7:30PM PM on Wednesdays;
Location: CE201 (lecture) and Computer room (or Bring your laptop)

Please note that this class will be recorded for the Certificated Master Program

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.

Expected Learning 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.

Primary ABET Outcomes

- 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

Secondary ABET Outcomes

- 1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- 6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

Instructor Information:

- Dr. Yao-Jan Wu
  - Civil Engineering Building 324F
  - Office Phone: (520) 621-6570
  - Email: yaojan@email.arizona.edu
  - Open Office Hours: by appointment (open door policy)

Technical Session Instructor Information

- Abolfazl Karimpour
  - Civil Engineering Ph.D. Student
  - Email: karimpour@email.arizona.edu
  - Open Office Hours:
    - Wednesday 10am~noon
  - Office: CE324G1 (Smart Transportation Lab)

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.
- Signal Timing Manual - Second Edition, FHWA, 2015 http://www.trb.org/Publications/Blurbs/173121.aspx

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%.
Please note that it is a very clear cut between grades. For example, 89.99% is B. There might be several extra credit activities offered during the semester or talk to the instructor. No extra credit activities are allowed after the final exam.

- **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 Policies:

1. Respect your classmates.
2. **Classroom Behavior Policy**: To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.). Students are asked to refrain from disruptive conversations with people sitting around them during lecture. Students observed engaging in disruptive activity will be asked to cease this behavior. Those who continue to disrupt the class will be asked to leave lecture or discussion and may be reported to the Dean of Students.
3. **Class Attendance.**
   Participating in the course and attending lectures and other course events are vital to the learning process. As such, attendance is required at all lectures and discussion section meetings. Absences may affect a student's final course grade. If you anticipate being absent, are unexpectedly absent, or are unable to participate in class online activities, please contact me as soon as possible. To request a disability-related accommodation to this attendance policy, please contact the Disability Resource Center at (520) 621-3268 or drc-info@email.arizona.edu. If you are experiencing unexpected barriers to your success in your courses, the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office is located in the Robert L. Nugent Building, room 100, or call 520-621-7057.

   a. The UA's policy concerning Class Attendance, Participation, and Administrative Drops is available at: http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop.
   b. The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable, http://policy.arizona.edu/human-resources/religious-accommodation-policy.
   c. Absences pre-approved by the UA Dean of Students (or Dean Designee) will be honored. See: https://deanofstudents.arizona.edu/absences.
4. **Dispute of Grade Policy**: 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.
5. **Code of Academic Integrity**: Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See: http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity.

   a. The University Libraries have some excellent tips for avoiding plagiarism, available at http://new.library.arizona.edu/research/citing/plagiarism.
   b. Selling class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor's express written consent. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA e-mail to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student e-mail addresses. This conduct may also constitute copyright infringement.

6. **Threatening Behavior Policy**: The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students.
7. **UA Nondiscrimination and Anti-harassment Policy:** The University is committed to creating and maintaining an environment free of discrimination; see http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy. Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination of others.
8. **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	We	Jan. 09	Introduction and Course Overview Simulation Theory Fundamentals I	R#1 R#2&3	 A#1 out
2	We	Jan. 16	**TRB Annual Conference (No Class)**		
3	We	Jan. 23	Simulation Theory Fundamentals II	 	 ICE#0 out
4	We	Jan. 30	Traffic Simulation Models Traffic Control Introduction (MUTCD)	R#4; R#5;	A#1 due; ICE#FD
5	We	Feb. 6	Traffic Controller and Standards Pre-tied Traffic Signal Control I	R#6 R#7	ICE#1 out
6	We	Feb. 13	Pre-timed Traffic Signal Control II Signal Timing Issues and Simulation Traffic Detectors and Applications	R#8 R#9	A#2 out ICE#2 out ICE#3
7	We	Feb. 20	**Project 1** Midterm 1 Review	 	P#1 out A#2 due
8	We	Feb. 27	**ITE Spring Conference (*Encouraged*)** **Midterm One** **(Rescheduled to Feb. 28: 6:30pm~7:40pm)** ICE#4 (Moved to Mar. 13)	Term Project Topic/Outline Confirmed 	
9	We	Mar. 6	**Spring Break (No Class)**		
10	We	Mar. 13	1. Actuated Signal Control I&II	R#10 & 	ICE#4; P#1 due (Extended to 3/20)
11	We	Mar. 20	1. Advanced Issues in Traffic System Control 2. Roundabout Modeling and Analysis	R#11 R#12 	ICE#5 A#3 out P#2 out
12	We	Mar. 27	1. Traffic Flow Characteristics 2. Driver Behavior Models I&II	R#13 R#14 	ICE#6
13	We	Apr. 3	**ASCE PSWC Conference**	R#15	ICE#7

			1. Freeway Ramp Meter Control 2. Vehicle Actuated Programming (VAP)	R#16	A#3 due (Extended)
14	We	Apr. 10	1. Vehicle Actuated Programming (VAP) 2. Freeway Simulation Modeling and Calibration	R#17	ICE#8 P#3 out;
				R#18	ICE#9
15	We	Apr. 17	**Arizona Roads and Streets Conference - <u>Highly encouraged to attend</u>** 1. Active Traffic Management 2. Freeway Toll Lane System 3. Connected Vehicles 4. Course Summary		
					P#2 due (new deadline)
16	We	Apr. 24	**Midterm Two**		
17	We	May 1	1. Midterm 2 Summary 2. Invited Lecture: Dr. Luana Broshears 3. Project 3 Assistance (Optional)		
18	Th	May 9	**Final Project Presentations (3:30 pm~5:30pm)**	**P#3 due** **Graduate student term project report &presentation due**	

A#: Homework Assignment Number; P#: Project Number; ICE#: In-Class Exercise (ICE) number; R#: Reader Number ; CR# Conference report

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.