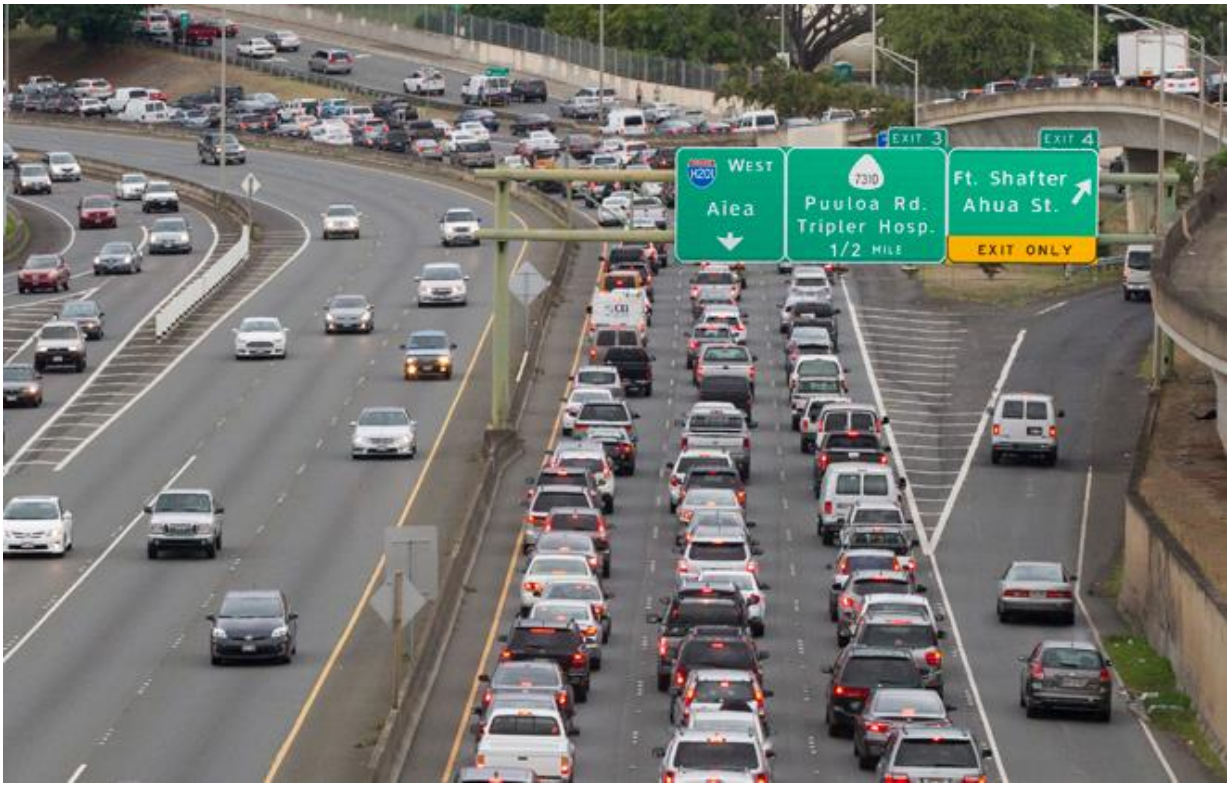
CEE 462

Traffic Engineering

Course Handouts



Guohui Zhang

University of Hawaii at Manoa

Spring 2024

CEE 462 SYLLABUS

Class	CEE 462 Traffic Engineering
Time	1:30 – 2:45 PM on Tuesdays and Thursdays, Spring, 2024
Location	In-person: POST 126; Online: https://hawaii.zoom.us/j/93546237773, Passcode: 111111
Category	Engineering Science
Website	Course materials, including the syllabus, handouts, lectures, projects, assignments, and supplementary material will be posted on a course website. You can access the website by going to the URL https://laulima.hawaii.edu UHM Net ID and password.
Course Catalog and Description	Two-thirds of urban vehicle-miles of travel in the U.S. are on signal-controlled roadways. Traffic control systems are designed and installed to achieve two primary goals – safety and efficiency – by providing orderly movement in all directions. However, present traffic control systems are by no means a perfect solution for delay or crash problems on urban roads. A poorly designed traffic control system can have a negative impact on traffic operations by lengthening vehicle delay, increasing the rate of vehicle crashes, and introducing disruptions to traffic progression. 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. A previous study reported that there are roughly 300,000 traffic signals in the U.S. and about 75 percent of them could be improved easily and inexpensively. This indicates that huge benefits are potentially obtainable through traffic control system optimizations. In recent years, traffic detectors have been intensively deployed in major highway systems across the country. These sensors generate tremendous traffic data that are extremely valuable for traffic management, forecast, and control. How to manage the data efficiently and produce the most useful information out of them have been crucial challenges faced by traffic professionals. 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.
Instructor	Guohui Zhang Office: Holmes Hall 338 Office hours: 12:00 –1:30 PM on Tuesdays and Thursdays, or by appointment Phone: (808) 956-2378 E-mail: guohui@hawaii.edu
Textbook	Required: **Electronic CEE 462 Course Pak**, available download at https://laulima.hawaii.edu. Optional: Kell, J.H. and I.J. Fullerton. **Manual of Traffic Signal Design**. Second Edition. Institute of Transportation Engineers. ISBN 0-935403-19-1. 1998.
Grading Policy	Assignments: 20% Projects: 40% Midterm Exams: 40%

CEE 462 Traffic Engineering

Course Schedule (Tentative) – Spring 2024

Week	Day	Date	Topics	Readings	Note
1	Tue.	Jan. 9	TRB Annual Conference (No Class)	Reader 1	
	Thu.	Jan. 11	TRB Annual Conference (No Class)	Reader 2	
2	Tue.	Jan. 16	Introduction and Course Overview		A#1 out
	Thu.	Jan. 18	Simulation Theory Fundamentals I	Reader 3	
3	Tue.	Jan. 23	Simulation Theory Fundamentals II	Reader 4	
	Thu.	Jan. 25	Traffic Simulation Models		
4	Tue.	Jan. 30	Traffic Control Introduction (MUTCD)	Reader 5	A#1 due;
	Thu.	Feb. 1	Traffic Controller and Standards	Reader 6	A#2 out
5	Tue.	Feb. 6	Pre-timed Traffic Signal Control I	Reader 7	
	Thu.	Feb. 8	Pre-timed Traffic Signal Control II		
6	Tue.	Feb. 13	Signal Timing Issues and Simulation	Reader 8	A#2 due
	Thu.	Feb. 15	Midterm One		
7	Tue.	Feb. 20	Traffic Detectors and Applications I	Reader 9&10	P#1 out
	Thu.	Feb. 22	Traffic Detectors and Applications II		
8	Tue.	Feb. 27	Actuated Signal Control I	Reader 11	P#2 out
	Thu.	Feb. 29	Actuated Signal Control II		
9	Tue.	Mar. 5	Intersection Control Performance Analysis and Signal Control Coordination	Reader 12	P#1 due
	Thu.	Mar. 7	Advanced Issues in Traffic System Control		A#3 out
10	Tue.	Mar. 12	Traffic Flow Characteristics	Reader 13	P#2 due;
	Thu.	Mar. 14	Driver Behavior Models	Reader 14	
11	Tue.	Mar. 19	Spring Recess (No Class)		
	Thu.	Mar. 21	Spring Recess (No Class)		
12	Tue.	Mar. 26	Kuhio Day (No Class)		
	Thu.	Mar. 28	Roadway Capacity Analysis	Reader 15&16	
13	Tue.	Apr. 2	Freeway Ramp Meter Control	Reader 17	A#3 due; A#4 out
	Thu.	Apr. 4	Midterm Two		
14	Tue.	Apr. 9	Vehicle Actuated Programming (VAP) I	Reader 18	
	Thu.	Apr. 11	Vehicle Actuated Programming (VAP) II		P#3 out
15	Tue.	Apr. 16	Freeway Toll Lane System	Reader 19&20	A#4 due
	Thu.	Apr. 18	Freeway Simulation Modeling and Calibration	Reader 21	
16	Tue.	Apr. 23	Active Traffic Management	Reader 22	
	Thu.	Apr. 25	Final Project Presentations: 7:30 - 9:30am		P#3 report due
17	Tue.	Apr. 30	Guest Speech: TBD		

A#n - Assignment Number *n*;
P#m - Project Number *m*.

There will be a final project presentation at the end of the semester. No final exam.

CEE 462 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 Operation

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.

CEE 462 Course Expectations and Policy

We can achieve the objectives of this course most efficiently if we are clear about what we can expect from each other and the course policy. As a result, the following expectations and policy will guide our work together.

Expectations of the Student

- **Conduct yourself as a responsible member of the academic community**. This basically means honesty, integrity, respecting the rights of others, etc. Cheating or plagiarism will not be tolerated. University policies regarding academic integrity are available in the UHM Student Handbook (Pathfinder) and online at http://www.catalog.hawaii.edu/about-uh/campus-policies1.htm .
- **Take an active role in learning.** Contribute feedback and participate in class activities in ways that support course objectives and positive learning environment for all involved.
- **Adhere to deadlines**. Turn in assignments and projects on time: the schedule is set to give you adequate time to complete them and the instructor adequate time to grade and return them.
- **Respect other students' time**. Everyone is paying for their education in one way or another. Class time and time spent working on assignments should be productive and meaningful; respect this by contributing your fair share on team assignments and refraining from any activities (e.g., talking in the background, sleeping in class, etc.) that may distract other students' concentration in learning.
- **Respect the instructor's time**. The instructor has put forth substantial effort to make this class as productive and insightful as possible. Respect this effort by coming to class on time and engaging in the course content for the full class time.

Expectations of the Instructor

- **Clear communication**. I, the instructor, should clearly communicate what is expected of you and how you will be evaluated. If you are at any time unclear on this, let me know.
- **Availability**. I will make myself available to you for discussion and consultation including but not limited to class readings, homework assignments, future courses, and career stuff.
- **Big picture**. I will try and contextualize topics so that you are aware of their significance, why they are being covered, and how they translate to industry use.
- **Timeliness**. I will keep my posted office hours and be accountable for getting your assignments, projects, and exams graded and returned in a timely manner. Just as you are responsible for deadlines, so am I.
- **Fairness and Reasonableness**. Assignments and exams will be fair and reasonable. It is my intention to achieve a fair workload that allows you time for other pursuits as well.
- **Respect your time**. I will come to class prepared to do my best job of supporting your learning. I will begin and end class on time and make our class time productive, insightful, and hopefully somewhat entertaining.

Expectations for Course Work

The work in this course consists of assigned readings, assignments, projects, and exams. All of them are designed to help you achieving the course learning objectives and should be completed as required.

- **Assigned Reading.** 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.

- **Assignments.** There are four regular assignments. Each assignment should be completed by each person in the class individually. They may be completed by hand in pencil/pen on regular or engineering paper. It is also acceptable if you prefer typing and printing your answers using computer. As always with these types of problems, solution steps should be clearly shown with answers clearly denoted (e.g., box or underline the answer). The solution to each assignment will be posted online after the assignment due date.

- **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-time 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 three or four members. At the end of the semester, each team member will fill out a peer evaluation on all team members including himself/herself. In this evaluation, students will be asked to divide up 100 points amongst all team members according to their contributions to the team. An individual's grade for team projects will be a product of the team's overall project grades weighted by the individual's contribution to the team. Therefore, it is possible for an individual to score more than or less than his/her team's project grade.

  Project Three will be evaluated by the traffic professionals in the class during the final project presentation time at the end of the semester. Each team spends about ten to 15 minutes on presenting their work. The external experts and professionals grade all teams' work using a standard evaluation form.

  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.

- **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.

Course Policy

- **Class Attendance.** You are expected to attend all lectures and computer labs scheduled for this course. If you cannot attend a specific lecture or computer lab, please inform the instructor ahead of the class time.

- **Late Homework (Assignment or Project) Turn-ins.** You are required to turn in your homework (including both assignment and project) on time. Late homework is not acceptable except for special cases approved by the instructor.

- **Final Grade Determination.** Your final grade will be determined by combining your scores of assignments, projects, and exams using the following weights:

  - ✓ Assignments: 20%
  - ✓ Projects: 40%
  - ✓ Midterm Exams: 40%