Ecole Polytechnique Fédérale de Lausanne *N. Geroliminis*
School of Architecture, Civil and *Fall 2018*
Environmental Engineering

Fundamentals of Traffic Operations and Control (CIVIL-457)

COURSE INFORMATION

Units: 3

Format: 2 hours of lecture per week + 1 hour of exercise-laboratory per week (on average)

Class Meets: *Lectures:* Wednesday 1.15 – 4.00 pm, Meeting room: CM 1120
Final Exam Type: During the Semester – Written

Prerequisites: "Transportation Systems Engineering" or Consent of the Instructor. Students that haven't attended the above course are strongly encouraged to follow week 1 and 2 of the Online MOOC Course that provides a good overview of traffic flow basics. The videos can be downloaded from the course moodle site (see the "Review (MOOC videos)" folder).

Instructor in Charge

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Teaching Assistants: *Claudia Bongiovanni, Isik Sirmatel, Semin Kwak, Oliver Buschor*

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Office Hours for all assistants (OH): Monday 12-1 pm (and by appointment)

*Office hours is an optional time which give students the opportunity to ask in-depth questions and to explore points of confusion or interest that was not fully addressed in class.

Course Description

Introduction to fundamentals of urban traffic engineering, including data collection, analysis, and design. Traffic engineering studies, performance measures of freeways and urban streets. Network analysis and simulation. Different levels of traffic modeling,

micro- (car following), meso- (link level) and macro- (network level). Design of control strategies for simple systems. Application of traffic operations. Public Transportation Operations, Intro to Logistics systems and last mile deliveries.

Course Objectives

The objectives of this course are to present the major elements of traffic operations and to develop basic skills in applying the fundamentals of traffic analysis and control. By the end of this course, students should be able to start applying these skills to model different aspects of congestion in urban transportation systems and develop elegant control strategies to improve mobility in cities. The students are also prepared for further study in this field. The course does not cover all aspects of traffic engineering, operations and control. The kinds of recipes found in handbooks, for example, are de-emphasized. Priority is given instead to logic; i.e., ways of thinking about problems that commonly arise in transportation operations so as to obtain suitable solutions. The ideas covered here are those that, by virtue of their grounding in physical reality, are most likely to stand the test of time.

To this end, the course entails four *themes.*

1. **Transportation Data Analysis and Performance evaluation**
   Observation, Measurement, Stochastic Processes, Estimation methods; the collection and interpretation of transportation data. Performance quality, Estimation of queue lengths, travel times

2. **Traffic Modeling**
   Relations between properties of traffic streams and models describing how congestion changes over time and space at different levels of scale.
   Micro- (Car following) , Meso- (Cell Transmission Model), Macro- (city level)

3. **Control of Traffic Signals**
   Schemes to affect traffic stream properties in some desirable way(s); e.g. coordinating green times at neighboring highway traffic signals to reduce driver delay. Adaptive control, Coordination, Ramp metering

4. **Intro to Logistics and Scheduled transportation systems**
   Basic principles in operating fleets, Allocation of urban space, Design, Instabilities, Intro to Traveling Salesman Problem and Vehicle Routing Problem. Car Sharing. On demand transportation. Preparation for more advanced study.

Lectures: LUTS has recently developed an online MOOC course on traffic modeling and ITS. Some of the material in the FTOC course are included in the MOOC. Students can look at the videos of some lectures as supplementary material (Weeks 2, 3, 4, 5, 6, 9). Week 5 Lecture will be a MOOC only lecture, where students will watch on their own

during the first hour of the course and then questions will be answered by Prof. Geroliminis and the assistants before exercise session begins.

Grading

- Labs (2) 30%
- Mid-term (Written) 30%
- Final Exam (Written) 40%
- Homework (2) 0%
    - (Two problem sets will be given to the students as exercises to practice various problems and prepare for the exams. Solutions will be posted online. No HW have to be submitted by the students for grading)

The midterm and final exam are closed books. One personal A4 written on both sides is allowed per student.

The final grade is estimated based on the relative performance of all students at each exam.

Textbook

• Lecture notes, book chapters and handouts will be distributed throughout the semester, or posted on web.

Labs (Groups of 4 or 5 students)

• There are 2 lab assignments involving data collection, processing and analysis.

• There are lab assignments utilizing various PC-based traffic engineering analysis

Students are recommended to utilize Matlab in the data analysis. A tutorial presentation will be given. Alternative software can also be used.

All lab reports must be prepared professionally. Each submitted lab report would receive two equally weighted grades: one for technical content and one for report quality. The end product of each lab will be a final report (2 in total) describing the work performed and presenting the project findings. The format of each project report should include:

- Abstract (concise summary of the report)
- Introduction (problem statement)
- Research Approach (methodology)
- Findings (results, interpretation)
- Conclusions (key findings, discussion)
- References
- Appendices

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COURSE SCHEDULE (tentative)

SESSION	DATE	TOPIC	THEME
1	9/19	Introduction Traffic stream characteristics (Revisions) - System monitoring and ITS	GENERAL TOOLS
2	9/26	Network-level models (MFDs) (Existence, physical properties), MFD dynamic models (MOOC lecture)	TRAFFIC
3	10/3	Multimodal network models Perimeter control	TRAFFIC
4	10/10	Perimeter control (continued)	CONTROL
5	10/17	Car-following and lane changing (MOOC lecture)	TRAFFIC
6	10/24	Cell transmission model and coordinated ramp metering	TRAFFIC - CONTROL
7	10/31	Fundamentals of traffic assignment (Guest Lecture:Prof. Ludovic Leclercq– ENTPE-Lyon)	TRAFFIC
8	11/7	Midterm exam	
9	11/14	Adaptive traffic signal control – Traffic signal coordination (Guest Lecture: Prof. Tasos Kouvelas – ETHZ)	CONTROL
10	11/21	Scheduled transportation systems Instability and control	PUBLIC TRANSP. CONTROL
11	11/28	Lab #2	
12	12/5	On-demand transportation	LOGISTICS
13	12/12	Course overview – Preparation for final exam	
14	12/19	Final exam	

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Exercise sessions

SESSION	DATE	TOPIC
1	19/9	Exercise I: Shockwave theory
2	26/9	Exercise II: MFD
3	3/10	Lab #1
4	10/10	Lab #1 Exercise III: Parking management
5	17/10	Computer Exercise IV: Car-following and adaptive control
6	24/10	Exercise V: CTM and ramp metering
7	31/10	Solution of an old midterm
8	7/11	Midterm exam Lab #1
Lab# 1 Due Date: November 9, 2018		
9	14/11	Exercise VI: Adaptive traffic signal control
10	21/11	Exercise VII: Public transportation
11	28/11	Lab #2
12	5/12	Exercise VIII: Logistics
13	12/12	Preparation for final exam
14	19/12	Final exam
Lab# 2 Due Date: December 21, 2018		