JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

Applied Mathematics & Statistics 553.797
Introduction to Control Theory and Optimal Control
Spring, 2021 (4 credits)

Instructor
Assistant Professor Nicolas Charon, charon@cis.jhu.edu,
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Office: Clark Hall 320A, 410-516-7848
Office hours: Fridays 2:00–4:00 pm, and by appointment
(same Zoom link as class meetings, see below)

Teaching Assistant
Dai-Ni Hsieh, dnhsieh@jhu.edu
Office hours: Thursdays 3:00–4:30 pm.
Zoom link: https://JHUBlueJays.zoom.us/j/99715494106?pwd=NGhHSWRiSlAycUF0M05aYWp1MW5CUT09
Password: 318069

Class meetings
Monday, Wednesday, 3:00–4:15 pm.
Zoom link: https://wse.zoom.us/j/657116619

Textbook
No textbook required for the class, course notes will be made available throughout the semester. Some suggestions of additional references:
- Optimal Control: *An Introduction to the Theory and Its Applications*. Dovers Books on Engineering. M. Athans and P. I Falb. 2006.
- Mathematical Control Theory: *Deterministic Finite Dimensional Systems.* Texts in Applied Mathematics. E.D Sontag. 1998.
- Optimal Control: *An Introduction to the Theory with Applications*. Oxford Applied Mathematics and Computing Science Series. L. Hocking. 1991.
- Control and Nonlinearity. American Mathematical Society. J-M Coron. 2007.

Online Resources
Please log in to Blackboard for all materials related to this course.

Course Information

- This course will introduce the mathematical foundations of control theory and optimal control for systems governed by ordinary differential equations. The main focus is on the mathematical aspects and results of this important field

which shall be further illustrated by the study of several examples of systems from e.g. mechanics, engineering, population dynamics or epidemics.
The course will also include a numerical component with the implementation/simulation of some of such control systems using scientific computing languages like MATLAB.

- **Prerequisites**
  Calculus 3 (AS.110.202 or equivalent)
  Linear Algebra (AS.110.201 or equivalent)
  Differential equations (AS.110.302 or equivalent)
  Use of scientific programming language like MATLAB or equivalent.

Course Topics

- Reminders on analysis and differential equations: Cauchy-Lipshitz theorem, existence in local time, global solutions, Gronwall's lemma...
- Controllability of linear systems: resolvant, Kalman condition, Brunovski's form...
- Linear time-optimal control.
- Linear-quadratic theory.
- Nonlinear optimal control: calculus of variations, existence of solutions, Pontryagin's maximum principle, Hamilton-Jacobi-Bellman equations...
- Numerical methods for optimal control: trajectory optimization, shooting, dynamic programming.
- If time permits: introduction to optimal control of discrete stochastic systems and connection to reinforcement learning.

Course Expectations & Grading
Final grade will be obtained from the average of assignments' grade (total of around six Assignments).

Assignments & Readings
One assignment approximately every two weeks, available on Blackboard. Homeworks may include mathematical derivations/proofs as well as simulations in MATLAB or equivalent programming language.

Ethics
The strength of the university depends on academic and personal integrity. In this course, you must be honest and truthful. Ethical violations include cheating on exams, plagiarism, reuse of assignments, improper use of the Internet and electronic devices, unauthorized collaboration, alteration of graded assignments, forgery and falsification, lying, facilitating academic dishonesty, and unfair competition.
Report any violations you witness to the instructor.

You can find more information about university misconduct policies on the web at these sites:

- For undergraduates: http://e-catalog.jhu.edu/undergrad-students/student-life-policies/
- For graduate students: http://e-catalog.jhu.edu/grad-students/graduate-specific-policies/

Students with Disabilities

Any student with a disability who may need accommodations in this class must obtain an accommodation letter from Student Disability Services, 385 Garland, (410) 516-4720, studentdisabilityservices@jhu.edu .