ECE 732
Nonlinear Control Systems

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

To provide an exposition of methods and tools for modeling, analysis and synthesis of nonlinear dynamical control systems. The course is primarily intended for graduate students with an interest in advanced applications of nonlinear control theory in engineering. Topics range from phase-plane analysis, Lyapunov and input-output stability, to feedback linearization and backstepping control.

SCHEDULE And MODE OF DELIVERY

This course will be offered in person.

INSTRUCTOR

Dr. Shahin Sirouspour
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Office: ITB-319
Phone: 905-525-9140 ext. 26238
Office Hours**:** and by appointment

COURSE WEBSITE/S

http://avenue.mcmaster.ca

ASSUMED KNOWLEDGE

Basic knowledge of feedback control systems typically acquired thorough an undergraduate course such as ELECENG 3CL4, 4CL4 or MECHENG 4R03; a solid background in mathematical analysis.

COURSE MATERIALS

Recommended Text:

- Instructor's lecture notes.
- J.-J. E. Slotine and W. Li, *Applied Nonlinear Control*, Prentice Hall, 1991.

Additional Recommended Reading:

- M. Vidyasagar, *Nonlinear Systems Analysis*, SIAM, 2002.
- S. Sastry, Nonlinear Systems, Analysis, Stability, and Control, Springer, 1999.
- M. Krstic, et al., Nonlinear and Adaptive Control Design, John Wiley, 1995.
- A. van der Schaft, L2-Gain and Passivity *Techniques in Nonlinear Control*, 2nd edition, Springer, 2000.

COURSE OVERVIEW

Week	Topic
1	**Linear vs. Nonlinear Control, an introduction**
1	**Phase Plane Analysis**
2	**Describing Functions**
	Stability Analysis
3	Stability of Linear Systems
3	Linearization and Local Stability
4	Lyapunov's Direct Method
4	LaSalle's Invariance Principle
4	Instability Theorems
	Feedback Linearization
5	Vector fields, Lie Brackets, and Lie Algebra
5-6	Input-State Linearization
7	Input-Output Linearization
7	Zero Dynamics
8	Backstepping Control
8	Feedback Linearization for MIMO Systems
	Robust & Adaptive Nonlinear Control
9	Sliding Mode Control
10	Linear Parameterization Model
10	Prediction-Error-Based Estimation Methods
11	The Least-Squares Estimator
11	Composite Adaptation
12	Adaptive Backstepping Control
13	Application Examples

The instructor may modify elements of the course and/or the timeline, and will notify students accordingly (in class, on the course website).

ASSESSMENT

Component	Weight
Assignments	20%
Course Project	40%
Final Exam	40%
Total	100%

CONDUCT EXPECTATIONS

As a McMaster graduate student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the *Code of Student Rights & Responsibilities* (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online**.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors.

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

ACADEMIC ACCOMMODATIONS OF STUDENTS WITH DISABILITIES

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's *Academic Accommodation of Students with Disabilities* policy.

ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office ***normally within 10 working days*** of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

RESEARCH ETHICS

The two principles underlying integrity in research in a university setting are these: a researcher must be honest in proposing, seeking support for, conducting, and reporting research; a researcher must respect the rights of others in these activities. Any departure from these principles will diminish the integrity of the research enterprise. This policy applies to all those conducting research at or under the aegis of McMaster University. It is incumbent upon all members of the university community to practice and to promote ethical behaviour. To see the Policy on Research Ethics at McMaster University, please go to http://www.mcmaster.ca/policy/faculty/Conduct/ResearchEthicsPolicy.pdf.

www.eng.mcmaster.ca/ece