COURSE INFORMATION

Time: Saturday 12:15 pm - 01:45 pm
Location: H2
Credit: 4 ECTS credit points

INSTRUCTOR

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TEACHING ASSISTANTS

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RESOURCES

Web site: Available through course website. Please check regularly for announcements and updates.
Recommended: Mechatronics. Electromechanics and contromechanis (Denny K. Miu)

PREREQUISITES

Students are expected to have a working knowledge of differential equations, linear systems, linear control theory and modeling. Familiarity with programming, mechanical system design and finite element analysis is recommended.

PURPOSE

This course is designed to equip students with fundamental theories and computational methodologies that are used in modeling and control of mechatronics systems.

Students will be introduced to general modeling of mechatronics systems. State-space solution and realizations, stability, controllability, observability, and minimal realizations and coprime fractions will be covered in

this course. Students will be also introduced to state-feedback and state estimations of systems with linear and non-linear dynamics. The emphasis in this course is not on the excessive integration of different disciplines but rather on the ability to provide stable designs with reasonable performance.

COURSE OBJECTIVES

The goal of this course is to allow students to design mechatronics systems. These systems should meet certain specifications and provide reasonable robustness. By the end of the course, each student should be able to do the following:

- Derive the dynamics of a linear and nonlinear systems.
- Analyze the stability and its margins.
- Analyze the controllability and observability.
- Design state observers for linear and nonlinear systems.
- Design of feedback control systems.
- Control of bilateral teleoperation systems with linear and nonlinear dynamics.
- Understand the basics of real-time operating systems.

HOMEWORKS

Homework will be assigned regularly and posted on the course website. Hardcopies will generally not be made available in class, so you will have to produce your own printout.

EXAMS

There will be one mid-term and one final exam. Since the course continually builds upon previous material, all exams will be comprehensive. In class exams are closed book, with one page of personally prepared notes.

LECTURE

Lectures will involve discussions and group activities. Extra lectures and problem solving sessions may be scheduled if necessary. Class participation and cooperation among students are highly encouraged. Student feedback will be collected throughout the semester and adaptation will be undertaken accordingly.

PROJECT

Students will be given the freedom to choose a project topic of their interest subject to instructors approval. A list of possible project topics will also be recommended by the instructor. A candidate project topic should address a real life (possibly related to research) problem and should involve enough to let students demonstrate their proficiency at a technical level. The projects will involve a progress report. All reports should be written in academic paper format.

TENTATIVE SCHEDULE AND TOPICS

WEEK	TOPICS
1 (Linear systems)	Similarity transformations, diagonal form and Jordan form, functions of a square
2	matrix, Lyapunov equation, quadratic form and positive/negative definiteness
3	Singular value decomposition, norms of matrices, solution of LTI state equations Input-output stability of LTI systems, internal stability, Lyapunov theorem
4	Controllability, observability, canonical decomposition, minimal realizations and and coprime fractions, state feedback and state estimators
5 (Bilateral teleoperation)	Transparent teleoperation using two-channel control architectures
6 (Nonlinear systems)	Qualitative behavior near equilibrium points, limit cycles, existence of periodic
7	orbits, Lyapunov stability
8	Input output stability, $\mathcal{L}$ stability, $\mathcal{L}_2$ gain
9	Feedback system: The small gain theorem
10	Passivity, memoryless functions, state models, feedback systems: passivity theorem, absolute stability, circle criterion, Popov criterion
11	Feedback control: Stabilization via linearization, integral control, integral control via linearization
12 (Bilateral teleoperation)	Bilateral control of nonlinear teleoperation
13 (Real-time systems)	Real-time operating systems, requirements of real-time systems, deadlock, resource management, priority, pre-emption
14	Hard real-time scheduling algorithms: Rate monotonic and earliest deadline first, schedulability tests, real-time communication: introduction, necessity, hard and soft real-time, network topologies and main non-real-time protocols.

Additional Reading

- Chen, Linear system theory and design, third edition, Oxford, 1999.
- Khalil, Nonlinear systems, third edition, Prentice Hall, 2002.
- Franklin, Feedback control of dynamic systems, Prentice Hall, 2006.
- Van de Vegta, Feedback control systems, Prentice Hall, 1986.
- De Silva, Mechatronics: an integrated approach, CRC Press, 2005.
- Bolton, Mechatronics: a multidiscplinary approach, 4th edition, Pearson, 2008.

GRADING POLICY

Your course grade is determined from the total points you receive from homeworks, midterm and final exams, and the project. Borderline grades are determined by class participation.

Homeworks and project must be submitted to my office by the end of the date due (midnight). No late problem sets are accepted (Extensions may be granted for special circumstances and only when requested in advance).

You are responsible for all information given in class verbally and/or in writing. Any information about the course on the web may be replaced by the information given in class.

Cooperative efforts at understanding the material and the assignments of the course are encouraged. However, you may only submit work that you have completed individually. For example, you may communicate verbally about methods for solving assigned problems, but sharing of written work is not permitted. Submitting any work that is not the result of a students own effort is considered cheating.

ACTIVITY	WEIGHT [%]
Homeworks	5
Quizzes	10
Project	20
Midterm exam	25
Final exam	40

OTHER NOTES

Any student with a disability requiring accommodation in this course is encouraged to contact the instructor during the first two weeks of the semester.