

Syllabus for MAE281a

Nonlinear Systems - Spring 2013

Jorge Cortés

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This course covers analysis and design of nonlinear dynamical systems. Topics include: existence and uniqueness of solutions of ODE's, sensitivity equations. Stability, direct and converse Lyapunov theorems, LaSalle's theorem, linearization, invariance theorems. Center manifold theorem. Stability of perturbed systems with vanishing and nonvanishing perturbations, input-to-state stability, comparison method. Perturbation theory and averaging. Singular perturbations. Prerequisite: MAE 280A.

Instructor

Jorge Cortés, `cortes at ucsd.edu`. Office at Engineering Building I, # 1608

Course Objectives

By the end of the course, you would/should have:

1. learned and used various tools for the analysis of nonlinear systems, specially in what concerns equilibria and stability
2. got a feeling and gained insight into the complexity of nonlinear systems.
3. known and played around with a wide variety of interesting, inherently nonlinear examples.

This course is part of the nonlinear control sequence (together with MAE 281b), which is a necessary introduction for more advanced courses on adaptive control, hybrid systems, and cooperative control.

Prerequisites

MAE280a. Knowledge of calculus, linear algebra, and ordinary differential equations is assumed. Familiarity with simulation software of your choice (e.g., Matlab/Mathematica/Maple).

Text

Our main reference will be H. K. Khalil. *Nonlinear Systems*. Prentice Hall, 3 edition, 2002.

Additional recommended texts and readings

You will also find great insight in

- A. Isidori. *Nonlinear Control Systems*. Communications and Control Engineering Series. Springer, 3 edition, 1995
- S. S. Sastry. *Nonlinear Systems: Analysis, Stability and Control*. Number 10 in Interdisciplinary Applied Mathematics. Springer, 1999.
- H. Nijmeijer and A. J. van der Schaft. *Nonlinear Dynamical Control Systems*. Springer, 1990
- E. D. Sontag. *Mathematical Control Theory: Deterministic Finite Dimensional Systems*, volume 6 of *TAM*. Springer, 2 edition, 1998

Course webpage

<http://tintoretto.ucsd.edu/jorge/teaching/mae281a/>

The webpage contains this syllabus and the list of homework due. Please check it periodically for updates and other announcements related to the course.

Calendar

The website will contain some downloadable PDFs to complement the material covered in class. To access them off campus, you will need the username and password provided in class.

Part I

- Introduction (Sa, Ch 1; Kh, Chs 1 and 2)
- Existence and uniqueness of solutions of ODE's, sensitivity equations (Kh, Ch 3)
- Lyapunov stability, LaSalle's theorem, linearization (Kh, Ch 4)
- Comparison functions, input-to-state stability (Kh, Ch 4)

Part II

- Center manifold theorem (Kh, Ch 8)
- Stability of systems with vanishing and nonvanishing perturbations, comparison method (Kh, Ch 9)
- Perturbation theory and averaging (Kh, Ch 10)
- Singular perturbations (Kh, Ch 11)

Exams

The midterm will be on Monday, May 6, 2013, in class.

The final will be on Thursday, June 13, 2013, in class, from 11:30am to 2:30pm.

Homework

There will be a set of homework problems per week (mostly from the main text). The homework will be collected on Wednesdays. *You need to complete all exercises, although only two, randomly selected, will be corrected from each assignment.* Homework assignments are due weekly (specific dates for your reference are included in the webpage). No late homework will be accepted.

Grading policy

Homework: 25%

Midterm: 25%

Final exam: 50%

In exceptional cases, I reserve the right to give extra points for excellent performance on the midterm and final. Please do not count on it as a way to avoid doing the other assignments.

ted

Your grades will be available via ted. Check out <http://ted.ucsd.edu> for instructions on how to register and log in.

Academic honesty

No form of academic dishonesty will be tolerated. For the definition of academic dishonesty and its (ominous) consequences, refer to the UCSD General Catalogue 2012-2013 at <http://ucsd.edu/catalog>

Room location and hours

Lectures take place at Humanities & Social Sciences Building (Map Building #250), room 2152, Mondays, Wednesdays, and Fridays, from 1:00pm to 1:50pm.

Office hours

Instructor: Mondays, from 3:30pm to 4:30pm, at EBU I, room 1603 (conference room). Please, send me email describing the problem before coming to office hours. Be prepared to show attempts at solving the problem.

If you have any questions about the course, please send me email. I will try to respond as quickly as possible. Additionally, I will share questions that are particularly good (and their answers) with the rest of the class by broadcasting my answer to the entire class.