CALIFORNIA INSTITUTE OF TECHNOLOGY
Control and Dynamical Systems

CDS 101 - Analysis and Design of Feedback Systems
CDS 110 - Introduction to Control Theory
Fall 2003

Instructor
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Co-instructors
M. Dickinson (BE/Bio)
S. Low (CS/EE)
H. Mabuchi (Ph/CDS)
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Teaching Assistants
Lars Cremean (head TA; lars@cds.caltech.edu)
Michael Reiser (mreiser@its), Demetri Spanos (demetri@its), Abhishek Tiwari (atiwari@cds), Stephen Waydo (waydo@cds)
Office hours: Fri, 3:30–4:30p & Sun 5–6p, 110 Steele

Lectures
M2-3, W1-3, F2-3; 74 Jorgensen

Course Overview CDS 101/110 provides an introduction to feedback and control in physical, biological, engineering, and information sciences. Basic principles of feedback and its use as a tool for altering the dynamics of systems and managing uncertainty. Key themes throughout the course will include input/output response, modeling and model reduction, linear versus nonlinear models, and local versus global behavior.

CDS 101 is a 6 unit (2-0-4) class intended for advanced students in science and engineering who are interested in the principles and tools of feedback control, but not the analytical techniques for design and synthesis of control systems. CDS 110 is a 9 unit class (3-0-6) that provides a traditional first course in control for engineers and applied scientists. It assumes a stronger mathematical background, including working knowledge of linear algebra and ODEs. Familiarity with complex variables (Laplace transforms, residue theory) is helpful but not required.

Class homepage Information on the class is available via the class homepage:

`http://www.cds.caltech.edu/~murray/cds101`

All course handouts and other administrative data about the course are available via the class homepage.

Lectures The main course lectures are on Mondays from 2–3 pm, Wednesdays from 1–3 pm, and Fridays from 2–3 pm in 74 Jorgansen. CDS 101 students are not required to attend the Wednesday lectures, although they are welcome to do so. The Friday lectures are optional for CDS 110 students and will provide supplemental material on applications of control.

Grading The final grade will be based on homework sets, a midterm exam, and a final exam:

- Homework: 50%
  Homework sets will be handed out weekly and due on Mondays by 5 pm to the box outside of 102 Steele. Late homework will not be accepted without prior permission from the instructor.
- Midterm exam: 20%
  A midterm exam will be handed out at the beginning of midterms week (29 Oct) and due at the end of the midterm examination period (4 Nov). The midterm exam will be open book and computers will be allowed (though not required).
- Final exam: 30%
  The final exam will be handed out on the last day of class (5 Dec) and due at the end of finals week. It will be an open book exam and computers will be allowed (though not required).

Homework policy Collaboration on homework assignments is encouraged. You may consult outside reference materials, other students, the TA, or the instructor. All solutions that are handed in should be written up individually and should reflect your own understanding of the subject matter at the time of writing. MATLAB scripts and plots are considered part of your writeup and should be done individually.

Office hours The TAs will hold office hours on Fridays from 3:30–4:30 pm and Sundays from 5–6 pm in 110 Steele.

> **All students must show up for office hours at least once in the first three weeks of the course (even if you just stop in and introduce yourself to the TAs).**

Software Computer exercises will be assigned as part of the regular homeworks. The exercises are designed to be done in MATLAB, using the Control Toolbox and SIMULINK. Caltech has a site license for this software and it may be obtained from ITS (Caltech students only):

`http://software.caltech.edu`

An online tutorial is available at

`http://www.engin.umich.edu/group/ctm/basic/basic.html`

Course Text and References All required reading for the class will be avialable online, via the course homepage. The reading will be drawn from the following sources:

- K. J. Åström and R. M. Murray, Analysis and Design of Feedback Systems, Preprint, 2003.
- K. J. Åström, Control System Design, Preprint, 2002.

You may also find the following texts useful:

- B. Friedland, *Control System Design: An Introduction to State-Space Methods*, McGraw-Hill, 1986.
- G. F. Franklin, J. D. Powell, and A. Emami-Naeni, *Feedback Control of Dynamic Systems*, Addison-Wesley, 2002.
- N. E. Leonard and W. S. Levine, *Using Matlab to Analyze and Design Control Systems*, Benjamin/Cummings, 1992.
- B. C. Kuo, *Automatic Control Systems*, Prentice-Hall, 1995.

These have been put on reserve in the Sherman Fairchild Library. Additional online references may be found on the course homepage.

Course outline

Week	Monday/Wednesday	Friday
1	Intro to feedback and control	MATLAB tutorial (Cremean)
2	Dynamics and modeling	Insect flight control (Dickinson)
3	Stability and performance	Internet congestion control (Low)
4	Linear control systems	Control of segmented telescopes (MacMartin)
5	Controllability and observability	Midterm review (Cremean)
6	Transfer functions	Biological sensing and actuation (Dickinson)
7	Loop analysis of feedback systems	Quantum feedback control (Mabuchi)
8	Frequency domain design	Aerospace control systems (TBD)
9	Limits on performance	Thanksgiving
10	Uncertainty analysis	Final review (Waydo)