CALIFORNIA INSTITUTE OF TECHNOLOGY
Control and Dynamical Systems

CDS 111 - Introduction to Control Technology
Spring 1996

Instructor
R. Murray, 317 Thomas
murray@indra.caltech.edu

Teaching Assistants
Mike Kantner, `kantner@hot`
Randy Owen, (805) 254-7660

Organization of the course

The goal of CDS 111 is to teach students how to design and implement linear controllers on a physical system and to allow students to evaluate control designs on experimental hardware using real-time computer control. The physical system will be the *Caltech ducted fan*, a flight test experiment in 08 Thomas. All control design will be done using Matlab and Simulink models of the ducted fan, to be provided on the ECF instructional computing clusters. No prior programming experience is required and all computing will be done within matlab (which can easily be mastered in a few hours).

In order to accomplish the goals of the class, there will be 2 one-hour lectures per week. The lectures will survey the relevant theory and discuss engineering issues relative to implementing linear control designs. Reading assignments will cover the material required to understand and implement the control design methodologies used in the class.

In addition to lectures, there will be a mandatory, weekly "lab meeting" where students will discuss their designs and any problems they are having in the course. Lab meetings will occur at two different times during the week, but each student will only need to attend one lab meeting. There will be no lab meetings during the first week of classes. For the second week of classes, students are free to attend either lab meeting. After the second week, each student will be assigned to a lab group and each lab group assigned to a specific lab meeting.

Schedule:

- Lectures: MW 2–3 pm in 301 Thomas
- Lab meetings: M 3–4 or Th 3–4 in 08 Thomas, starting 8 April

Laboratory work

A substantial portion of the second half of the class will involve using models and simulations to develop control laws for the ducted fan and implementing and testing those control laws in the lab. Access to the lab will be only during scheduled hours, as the lab is also being used for research work. This schedule will be determined during the third week of classes. In the event that the ducted fan experiment is inoperable at any given time, nonlinear simulations, including sampling delays and noise, should be used in place of the physical system. These simulations will be available on the ECF cluster and will also be available via the class homepage (see below).

All students will be assigned to a lab group consisting of 2–3 people. Group assignments will be made in the third week of classes. Each group is expected to divide up the (considerable) work of designing, simulating, redesigning, testing, redesigning, testing, redesigning, and analyzing controllers. It will not be possible for a single individual to complete the amount of work required for an A in the course in the amount of time allotted (9 hours/week).

Each lab group will be expected to present a short (5 minute) status report at the weekly lab meeting to describe their efforts over the past week and communicate problems they have encountered to the other members of the class. A different student should present the group status report each week (this will count as part of the lab participation portion of your grade).

Class homepage

Information on the class is available via the World Wide Web in the CDS 111 homepage:

`http://avalon.caltech.edu/cds/courses/cds111`

All couse handouts, lab group schedules, and other administrative data about the course will be available via the class homepage. In addition, pointers to analytical and computer models of the experiment will be available.

Grading

The final grade will be based on homework sets, lab participation, and a final report.

- Homework: 50%
  There will be 3 two-week problem sets, due in class. *Late homework will not be accepted without* **prior** *permission from the instructor.*
- Lab meeting participation: 25%
  All students are required to attend and participate in a weekly lab meeting. Each member of your lab group should present at least one status report during the course of the term.
- Project and final report: 25%
  During the last four weeks of the class, students will do individual and group projects. Each student will be required to write a final report for the class describing their project. The data for the reports may be collected as a group, but all reports must be written individually.

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 reflect your understanding of the subject matter at the time of writing.

The final reports are to be prepared individually. You may discuss your report with anyone you please, but all writing must be your own. Data presented in the report can be shared between members of your lab group.

Course Text and References

There is no required text for the course. You may find the following books useful:

1. N. E. Leonard and W. S. Levine, *Using Matlab to Analyze and Design Control Systems*, Benjamin/Cummings, 1992. (Available in the bookstore)
2. J. Doyle, B. Francis, A. Tannenbaum, *Feedback Control Theory*, Macmillan, 1992.

Course outline and schedule

Week	Topics
1	Lecture: Course administration, description of ducted fan dynamics Homework #1: classical control design using matlab
2	Lecture: System identification, real-time sensing, filtering Homework #2: classical control design on experiment
3	Lecture: Real-time control, continuous to discrete time conversion Homework #2: classical control design on experiment
4	Lecture: State feedback control methods Homework #3: state feedback and LQR design
5	Lecture: Linear quadratic regulators Homework #3: state feedback and LQR design
6	Lecture: Weighted sensitivity and loopshaping Project proposals due (Wed)
7	Lecture: Weighted sensitivity and loopshaping Work on course project
8	Lecture: Robust performance Work on course project
9	Lecture: Additional topics Work on course project
10	Finals week Final reports due Friday, 5 pm