CALIFORNIA INSTITUTE OF TECHNOLOGY
Control and Dynamical Systems

CDS 101/110
Homework Set #1

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Due: 6 Oct 03

Note: In the upper left hand corner of the first page of your homework set, please put the class you are taking (CDS 101, CDS 110) and the number of hours that you spent on this homework set (including reading).

All students should complete the following problems:

1. Identify 5 feedback systems that you encounter in your everyday environment. For each system, identify the sensing mechanism, actuation mechanism, and control law. Describe the uncertainty that the feedback system provides robustness with respect to and/or the dynamics that are changed through the use of feedback. At least one example should correspond to a system that comes from your own discipline or research activities.

   (Hint: If you can't think of any examples, look in the index of *Control in an Information Rich World*, available on the course homepage.)

2. (MATLAB/SIMULINK) Download the file "hw1cruise.mdl" from the course web page, which contains a SIMULINK model of a simple cruise controller, similar to the one described in class (see documentation from web page for more details). Figure out how to run the example and plot the vehicles speed as a function of time.

   (a) Leaving the control gains at their default values, plot the response of the system to a step input and measure the time it takes for the system error to settle to within 95% of commanded change in speed (i.e., ± 0.5 miles/hour).

   (b) By manually tuning the control gains, design a controller that settles 50% faster than the default controller. Include the gains you used, a plot of the closed loop response, and describe any undesireable features in the solution you obtain.

   All plots should included a title, labeled axes (with units), and reasonable axis limits.

   Note: The purpose of this problem is to give you some familiarity with MATLAB and SIMULINK. Don't worry if you don't yet know how the control law works or why it does what it does. We'll go over this in class later in the term.

3. Complete the course survey attached to this homework set. Please turn this in at the same time as your homework, but do not attach to your homework set.

Only CDS 110a students need to complete the following additional problems:

4. Read the Jun 2002 New York Times article "For the Spy in the Sky, New Eyes" (available on the course homepage). The article discusses several generations of camera stabilization systems. Identify these different approaches to stabilization and indicate which of them correspond to the use of feedback control. For each of the feedback control systems, describe the sensor, actuator, and computational element. If the information is not available in the article, indicate this and take a guess at what might have been used.

5. (MATLAB/SIMULINK) Download the file "hw1ballbeam.mdl" from the course web page, which contains a SIMULINK model of a "ball and beam" experiment, in which you apply a torque to a beam and try to balance a ball that rolls along the beam (see course web page for more documentation).

   (a) Run the simulation with default parameters and create a plot of the ball position versus time. Note that the desired action of the system is to move the ball from its initial position at the center of the beam to a new resting point at $r = 0.25$ m.

   (b) While keeping the gain on $\dot{\alpha}$ fixed at its default value, vary the gain on α from 75% to three times the default value. Plot the "overshoot" (the maximum amount by which the ball goes past the desired resting point, expressed as a percentage of the commanded position) as a function of this gain for stable cases.

   (c) While keeping gain on α fixed at its default value, vary the gain on $\dot{\alpha}$ from zero to twice its default value. Give the numerical range of this gain for which the system is stable. Plot the "settling time" (amount of time required for the system to get within 5% of the desired resting point) as a function of this gain for the stable cases.

   All plots should included a title, labeled axes (with units), and reasonable axis limits.

   Note: It is not necessary for you to understand the dynamics of the system and control law at this point. This model makes use of some advanced features in MATLAB and SIMULINK, which you may need to spend some time learning.