Tufts University

EE105 Feedback Control Systems, Fall 2018  
Prof. Brian Aull

Homework #1 Due Monday, September 17

1. **Thermal management of a small satellite**. Finish the problem we started in class.

(a) Solve the differential equation pertaining to the “day” side of the orbit to get an equation for the elapsed time needed for the solar flux to heat the satellite from some initial temperature T0 to some warmer temperature T.

Helpful partial fraction expansion:

(In this expression, Tf is the steady state temperature where solar flux heating balances radiative cooling. The partial fraction expansion breaks down the integral over temperature into integrals that are found in tables of elementary integrals.)

(b) Solve the differential equation pertaining to the “night” side of the orbit to get an equation for the elapsed time needed for the solar flux to heat the satellite from some initial temperature T0 to some colder temperature T.

(c) Using Matlab or your favorite tool, generate parametric plots showing temperature vs time for each phase of the orbit over a temperature interval from 236.163 K to 243.388 K. If you use the parameters given on slide 21 from Session 2, you should get heat and cooling time intervals corresponding to a 45-minute half orbit, with a modest temperature excursion of about 7 degrees K. Think about why the temperature excursions on the moon are so much greater.

2. Complete the exercise at the end of Session 3 by getting an expression for the conversion efficiency of potential energy ½ kx2 to kinetic energy ½ mv2 in the mass-spring-damper system.

Using Matlab or your favorite tool, plot this as a function of the damping ratio .

3. A mass-spring-damper system with an undamped natural frequency wn = 1 can be described with the differential equation: F/m = x’’+ 2x’ + x. Suppose that the system is under steady state sinusoidal forcing, . Using Matlab or your favorite tool, generate overlaid log-log plots of the magnitude of the velocity oscillation as a function of excitation frequency w over the range 0.001<  < 1000, for values of the damping ratio  = 0.01, 0.2, 1.0, and 5.0.

In preparation for class, think about why a low-friction system, whose unforced oscillations last a long time, should be strongly frequency selective for forced oscillations.