ECE-382: Homework 5

Due: Feb. 16, 2006

1. For the mechanical system shown in Figure 3-80 of textbook, where u_1 and u_2 are the two inputs, and y_1 and y_2 are the two outputs, derive the transfer functions for the four input-output pairs.

2. Problems B-3-19 and B-3-24 from the textbook.

3. A car suspension system (Fig. 1) is very similar to the mechanical system in Problem 1. We can model the wheels and tires as a pair of spring (with constant k_2) and damper (with constant b_2). Additional pair of spring (with constant k_1) and damper (with constant b_1) are provided by the suspension coils and shock absorber (see Fig. 2). Since the wheels and tires cannot be compressed much, we will use the distance $y = x_1 - x_2$ to denote the displacement (i.e., vibration) experienced by the body of the car. The purpose of this problem is to provide some experience of dealing with real systems, and to familiarize with the use of Matlab.

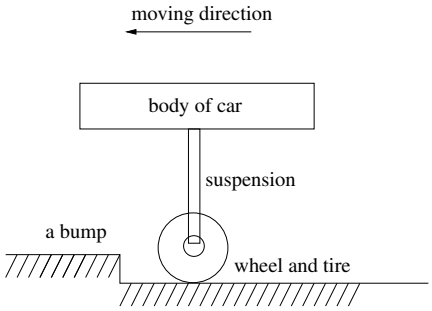

Figure 1: A car suspension system.

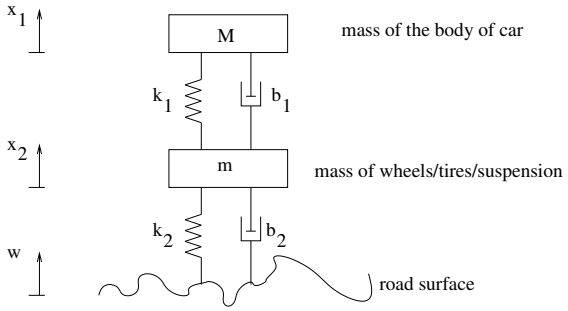

Figure 2: One-dimensional mechanical model

- Take the disturbance w from the surface of the road as the input, and take $y = x_1 - x_2$ as the output. Derive the transfer function from w to y. (Hint: When the car stands still, the springs should already be compressed to compensate for gravity. Hence, you can assume that the origins for x_1 and x_2 already account for such compression.)
- Assume the following values: $M = 2500kg$, $m = 320kg$, $k_1 = 80000N/m$, $k_2 = 500000N/m$, $b_1 = 350Ns/m$, $b_2 = 15020Ns/m$. Program this transfer function in Matlab.

- Assume that the car goes through a bump with height $5cm$. Use Matlab to plot the output response $y(t)$. What can you say about the performance of this suspension system?

You should provide your Matlab code and the generated plots with the homework. (Hint: this problem is adapted from the website http://www.engin.umich.edu/group/ctm/. I would strongly encourage you to work on the problem independently before you look at the website.)