University of Kentucky
Department of Electrical and Computer Engineering

EE421G: Signals and Systems I – Fall 2007

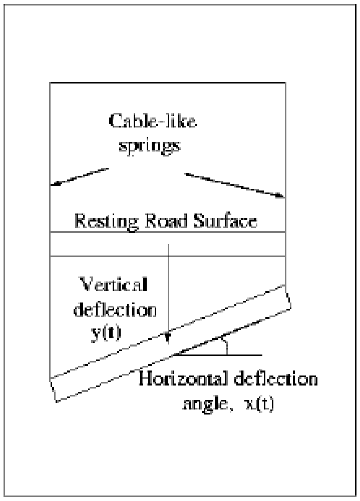
Problem Set 11

Issued: November 25, 2007 Due: November 30, 2007 (In class)

Reading Assignments:
Read Chapter 6.7-6.11 of Chen

Paper and Pencil Assignments:

1. Problem 6.15
2. Problem 6.17
3. Problem 6.20
4. Problem 6.22
5. Problem 6.23
6. Problem 6.24
7. Compute the inverse Laplace Transform of the followings:
   a. $X(s) = \dfrac{7s^2 + 15s + 10}{(s+1)^2(s+3)}$
   b. $X(s) = \dfrac{s^4 + 8s^2 + s + 17}{(s^2+4)^2(s+1)}$
8. You have seen the dramatic collapse of Tacoma Narrows Bridge during lecture. In this problem, we will analyze the cause of the collapse. The left figure below schematically shows the vertical deflection y(t) and the horizontal deflection angle x(t) of the bridge. Of particular importance is the horizontal deflection angle x(t) which is governed by the following differential equation:
   $$\frac{d^2}{dt^2}x(t) + c\frac{d}{dt}x(t) + kx(t) = f(t)$$
   where c > 0 is the coefficient of viscous damping divided by the mass, k = 1 is the Hooke's law spring constant of the cables divided by the mass, and f(t) is the acceleration of the bridge due to the wind.
   a. In the original design of the bridge (the middle figure), the parameter c is found to be very close to 0. Assuming c = 0 and modeling the bridge as H(s) = X(s)/F(s), does it exhibit BIBO stability? Justify your answer.
   b. The bridge was later rebuilt with a new design in which engineers replaced the stiffening-plate girders with web trusses as shown in the right figure. This increases the value of c to around two. Comment on the stability of this new design.


Cable-like springs
Resting Road Surface
Vertical deflection y(t)
Horizontal deflection angle, x(t)