

CE 573 – Structural Dynamics

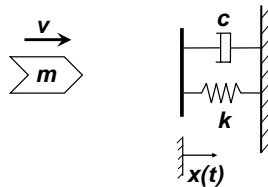
Homework #2

due 18 September 2009, Friday, 1:30 PM

- 1) Using the computer code you have developed for HW #1, carry out numerical experiments to find
 - a. a functional relationship, i.e. mathematical expression, between free vibration period and stiffness and mass for undamped, linear elastic single degree of freedom (SDOF) vibrating systems;
 - b. a functional relationship between critical damping amount and stiffness and mass for linear elastic SDOF vibrating systems. Recall that critical damping amount is the minimum amount of damping that makes a system not oscillate in otherwise free-vibration settings.

Note: Of course you know the answers analytically; the purpose here is to do numerical experiments.

- 2) A projectile of mass $m=20$ kg traveling with a velocity $v=100$ m/sec strikes and embeds itself in a massless board supported by a spring ($k=64,000$ N/m) in parallel with a viscous damper ($c=400$ N sec/m). Find the time required for the board to reach the maximum displacement from its initial at rest position. Calculate that maximum displacement. What are the values of all the various forces acting on the mass at that particular instant?



- 3) Using the free-vibration data given on the course website <http://cobweb.ecn.purdue.edu/~ce573>, find the fundamental period and the damping ratio of the three story flat-plate Bowen Lab test structure.
- 4) Find the fundamental period and damping ratio of the World Trade Center Tower 2. Use the graph given in Figure K-14, *Appendix K* of the NIST WTC investigation report. The relevant section of the report is on-line at NIST website: <http://wtc.nist.gov/pubs/NISTNCSTAR1-5Achap9-appdxsDraft.pdf>

NIST investigators talk about “decay rate” instead of “damping ratio”. What do they mean by “decay rate”? How is it related to damping ratio? Are your findings in agreement with theirs?

Note: A copy of the Appendix K is stored, temporarily, at the CE573 website for your perusal. (<http://cobweb.ecn.purdue.edu/~ce573>)

Aside: Assume a plausible weight for the tower (the 110-story tower has an approx. 200 ft x 200 ft footprint) and see if you could find an “equivalent” stiffness of the tower considering its fundamental (i.e. first) mode only?