CE 573 – Structural Dynamics
Homework #4
due 2 October 2009, Friday, 1:30pm

1) Harmonic excitation was used in forced-vibration tests on a building. During the tests, it was observed that when the building was excited at its natural frequency it displaced eight times that it did when excited at a frequency 30% higher than its natural frequency. Determine the damping ratio of the structure.

2) The mission of the space shuttle Discovery is extended to repair a malfunctioning satellite. Astronauts examine the 500-kg satellite and find an unbalanced mass rotating at 1500 revolutions/minute in it. They estimate that the unbalanced mass exerts a harmonic force of amplitude 20,000 N on the satellite. The astronauts also find out that the satellite cannot be powered down and has to be anchored to the cargo floor of the shuttle for repairs while the unbalanced mass is spinning. However, there is a safety issue: the specifications state that the load applied at the cargo floor anchor point shall not exceed 10,000 N. To reduce the force transmitted from the satellite astronauts want to build an isolator to place between the satellite and the anchor point. All they can find are three linear springs, each with a stiffness of 8×10^6 N/m. Do you think that using the springs the astronauts could build an isolator and reduce the transmitted force to a safe level? If you think they can, demonstrate how the isolator can be built using the springs. If you think they can not, demonstrate why they are out of luck.

3) Many of you missed it by a couple of years but during the construction of the Armstrong building next door, vibrations from the rotary-hammers driving the piles were too much to bear in the CIVL building. The level of disturbance was so high that certain experiments at the basement soil mechanics lab in CIVL building were to be affected. To help alleviate the problems, a vibration isolation block had to be installed (see figure below) in the soil mechanics lab. Let's reenact the consulting task we had to do. Assume that you were given the following information: the weight of the isolation block is 1,000 lb; measurements indicate that the floor and the foundation in the soils lab vibrate at 600 cycles per minute due to the Armstrong construction (you can assume purely vertical oscillations). Geotech folks are asking for your help to limit the motion of the isolation block to less than 10% of that of the basement floor. Can you find the limiting (the smallest? the largest?) stiffness for the isolation system so that it would meet their specification?