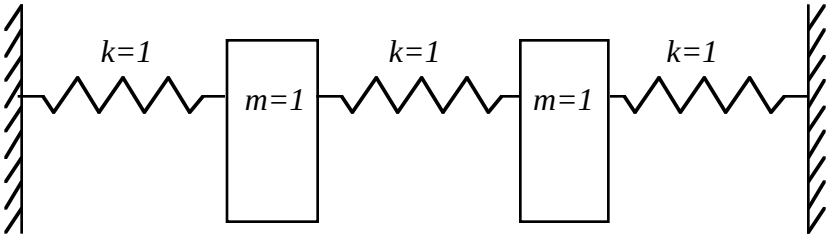
ME 460/660 Final Exam, Up 94

Please **read** the problems very carefully.

1) A crane has natural frequencies of 7.03, 44.00, 123.24, and 242.00 Hz and weighs 9070 kg. The engine runs at about 1100 rpm. Design a vibration absorber (i.e. choose m and k) that will reduce engine induced vibrations in the crane.

2) A three degree of freedom system is shown below. The natural frequencies are known to be .5176, 1.4142, and 1.9319 rad/sec. It is desired to have at least 20% critical damping but no more than 30% critical damping in each mode. Design a set of dampers to meet this criteria and sketch them in the figure below. Assume proportional damping and use α and β as your design variables. Demonstrate that the dampers provide the required damping by finding all of the damping ratios once the values of α and β have been found. (Hint: The first and third modes will have the highest damping regardless of your choices of α and β. This is design, and there is no single correct answer.)



3) Recall the definitions of settling time and time to peak. Design a control law for the following single degree of freedom system that will cause a settling time of 10 sec and a time to peak of 1 sec. The single degree of freedom system has m = 2 kg, c = 2 kg/sec, and k = 2 N/m. Write the controlled equation of motion (with the control on the right hand side).

4) A harmonic force of maximum value 25 N and frequency 180 rpm acts on a machine with mass 25 kg. Design a support system for the machine so that only about 10% of the force applied to the machine is transmitted to the base supporting the machine.

5) Use Lagrange's equation to find the equation of motion for the following system. Include the pendulum effect on mass 2. (Stiffness due to gravity).