70 POINTS **HOMEWORK 2** **DUE: 1/28/15**

1. (30 pts.) A car weighing 1000 lbs. empty and 3000 lbs. fully loaded vibrates in a vertical direction while traveling at 55 mph on a bumpy road. The road can be modeled by a sinusoid with amplitude 4 in. and period (wavelength) of 12 ft. Assume the car can be modeled as a spring-mass-damper system with $k = 30{,}000$ lbs./ft. and $\zeta = 0.2$.

a. (10 pts.) Determine the amplitude of vibration of the car when it is empty and fully loaded.

b. (10 pts.) Determine the speed of the car in mph at which the fully loaded vehicle would vibrate with the greatest amplitude.

c. (10 pts.) On the same graph, plot the amplitude of the car's vibration vs. driving speed in mph for the empty and fully loaded cases. Verify your answer to part (b) on the graph.

2. (10 pts.) The equation of motion of a spring-mass-damper system is given by

$$5\ddot{x} + c\dot{x} + 10x = f(t)$$

Find the smallest permissible value of the damping constant c if the steady-state amplitude of $x(t)$ must remain below 3 for $f(t) = 22\sin(\omega t)$ for all values of ω.

3. (30 pts.) A machine with a rotating imbalance is run at different RPM, and its vibration amplitude is recorded in the table below. The machine's mass is 100 kg, but the damping and stiffness of its support are unknown.

a. (10 pts.) Estimate the damping and stiffness of the support.

b. (10 pts.) Estimate what percentage of the vertical force generated by the rotating imbalance is transmitted to the floor under the machine when running at 6 Hz.

c. (10 pts.) Is there any way to redesign the support such that less than 10% of the imbalanced force is transmitted to the floor over the range of speeds listed in the table? If so, show how you would redesign it; if not, explain why it is impossible.

ω (Hz)	x (mm)	ω (Hz)	x (mm)
0.2	1	3.8	13
1	2	4	11
2	4	5	8
2.6	12	6	7
2.8	18	7	6
3	25	8	6
3.4	18	9	6
3.6	15	10	5