Name ____________________________

**EM406**

Examination III

November 4, 2005

| Problem | Score |
|---|---|
| 1 | /20 |
| 2 | /40 |
| 3 | /40 |
| Total | /100 |

Show all work for credit

AND

Stay in your seat until the end of class

AND

Turn in your signed help sheet

Name ___________________________________ 20 pts

EM406 Examination III **Problem 1** November 4, 2005

**Problem 1.1** (3 pts)

What does it mean if the modes of a system are "mass normalized"?

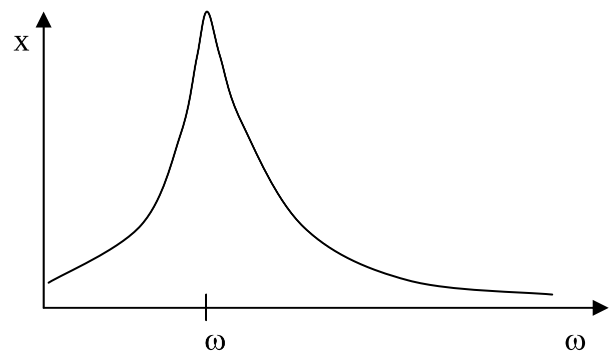
**Problem 1.2** (3 pts)

An undamped vibration absorber should be designed, as nearly as possible, so that: (3 pts)

a) the absorber natural frequency is the same as the primary system natural frequency
b) the primary system natural frequency is the same as the applied frequency
c) the absorber natural frequency is the same as the applied frequency
d) all of a, b, and c above
e) none of a, b, and c above

**Problem 1.3** (3 pts)

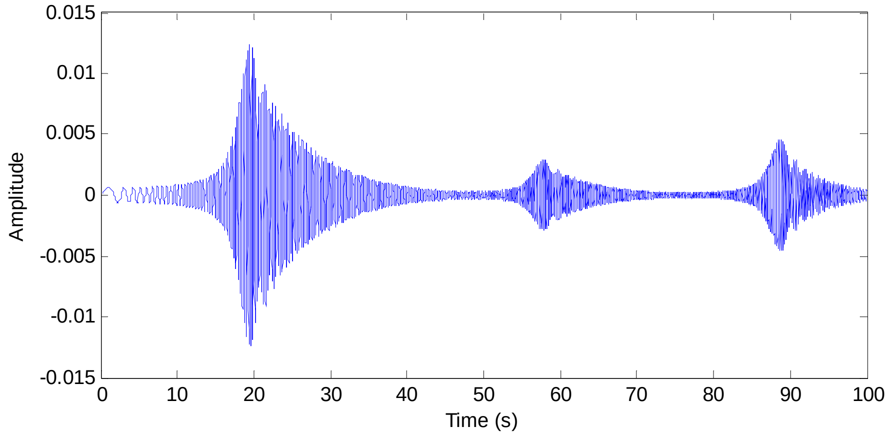
A frequency response plot is shown for a single degree of freedom system. Sketch what you would expect it to look like if you add an absorber to the system that is designed for $\omega = \omega_1$.




**Problem 1.4** (3 pts)

A coworker brings the results of a finite element analysis and he has found the first six natural frequencies are zero and he doesn't know what that means. What do you tell him?

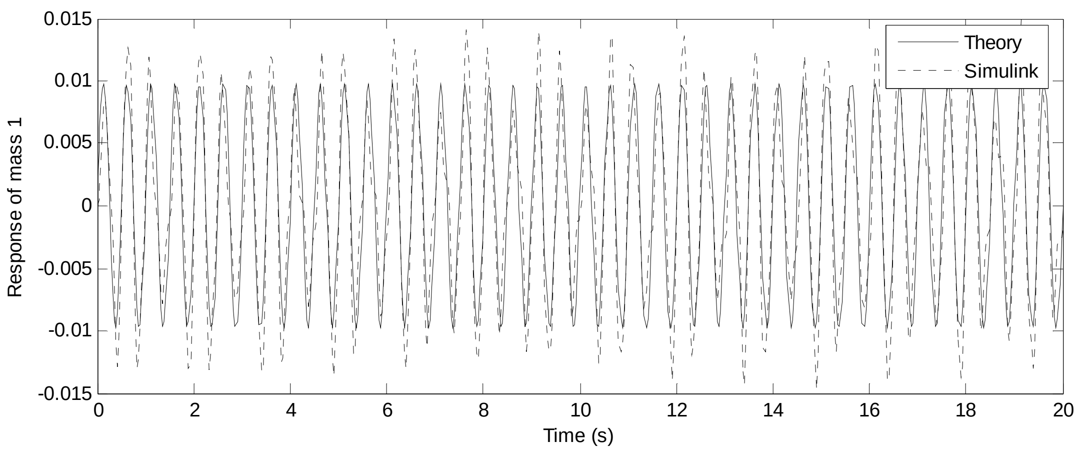
**Problem 1.5** (3 pts)
A chirp is used a forcing function to a system (similar to what we did in lab) resulting in the time response shown below. The chirp when from 0 Hz to 20 Hz in 100 seconds. Estimate the 3rd natural frequency of the system.




**Problem 1.6** (5 pts)
A coworker is trying to compare his theoretical steady-state solution to the results he gets from using Simulink for the equations of motion shown below.

$$\begin{bmatrix} 10 & 0 \\ 0 & 5 \end{bmatrix} \begin{Bmatrix} \ddot{x}_1 \\ \ddot{x}_2 \end{Bmatrix} + \begin{bmatrix} 10000 & -2000 \\ -2000 & 2000 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} = \begin{Bmatrix} F_0 \sin \omega t \\ 0 \end{Bmatrix}$$

What do you think his problem is? What advice can you give him?



Name ___________________________________ 40 pts
EM406 Examination III **Problem 2** November 4, 2005

A reciprocating engine is installed on the first floor of a building, which can be modeled as a rigid rectangular plate resting on four elastic columns. The equivalent weight of the engine and the floor is 2000 lb. At the rated speed of the engine, which is 600 rpm (62.83 rad/s), the operators experience large vibration of the floor. It has been decided to reduce these vibrations by suspending a spring-mass system from the bottom surface of the floor. Assuming that the spring stiffness is $k_2$ = 5000 lb/in.

a) Find the weight of the mass to be attached to absorb the vibrations.
b) What will be the natural frequencies of the system after the absorber is added?

Name ___________________________________ 40 pts

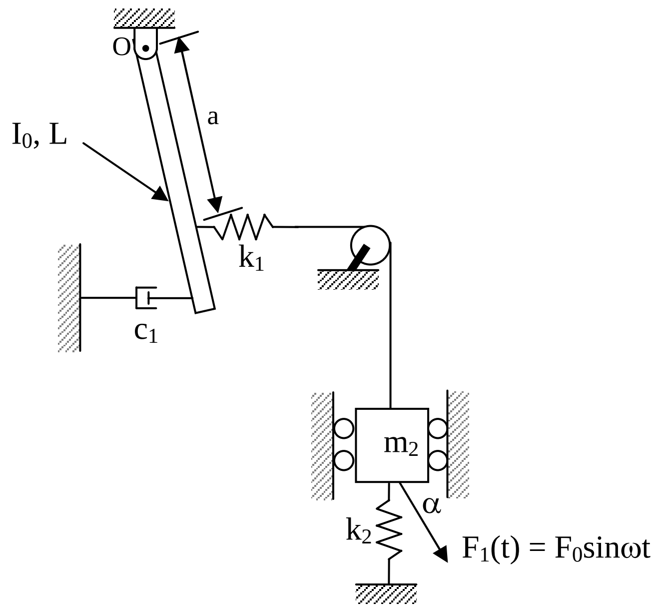
EM406 Examination III **Problem 3** November 4, 2005

The uniform bar shown has a mass moment of inertia about O, $I_0$ and length, L.

a) Using Lagrange's equations determine the equations of motion for the bar and block assuming small angles.

b) Assuming zero damping and $\alpha = 90°$, determine the steady state response of mass 2.

c) What value of $k_1$ will result in the bar acting like a vibration absorber for mass 2?




Note: If you cannot find the equations of motion assume they are

$$A_1\ddot{x} + A_2\ddot{\theta} + A_3 x + A_4\theta = A_5 \sin\omega t$$

$$B_1\ddot{x} + B_2\ddot{\theta} + B_3 x + B_4\theta = 0$$