ME 460/660 Final Exam, Fall '96

One equation sheet. Front and back. No examples. No derivations. It must be turned in with the exam.

1) Solve/answer the following short problems. (4 points each)

   a) A linear system with natural frequencies ω_1, ω_2, ω_3, and ω_4 is excited by a force with a frequency ω_{dr}. What is the frequency of the resulting motion?

   b) If a vibration absorber with frequency ω_a is attached to the system of question 1a, what is the frequency of the resulting motion?

   c) Define ω_r.

   d) What is the fundamental principle the Energy Method is based on?

   e) Check to see if the vectors $[\ 1\ 2\ ]^T$ and $[\ -2\ 1\ ]^T$ are orthogonal.

   f) What is the name of the formula that can be used to solve for the forced response of a system to any arbitrary forcing function?

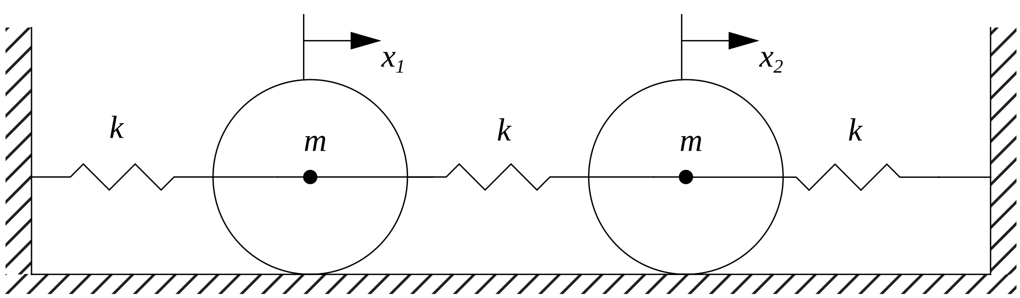
2) A machine weighing 2000 N rests on the floor. The floor deflects about 5 cm as a result of the weight of the machine. The floor is somewhat flexible and moves, because of the motion of a nearby machine, harmonically near resonance ($r = 1$) with an amplitude of 0.2 cm. Assume a damping ratio of 0.01 and calculate the transmitted force and the amplitude of the amplitude of the transmitted displacement. (25 points)

3) Find the free response of the system defined by $M = I$. and

$$K = \begin{bmatrix} 2 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 2 \end{bmatrix}$$

to initial conditions of $\mathbf{x}(0) = \begin{bmatrix} \frac{1}{2} & \frac{1}{\sqrt{2}} & \frac{1}{2} \end{bmatrix}^T$ and $\dot{\mathbf{x}}(0) = \begin{bmatrix} 0 & 0 & 0 \end{bmatrix}^T$ given that the natural frequencies and eigenvectors are $\sqrt{0.5858}$, $\sqrt{2}$, $\sqrt{3.414}$ rad/sec and $\begin{bmatrix} \frac{1}{2} \\ \frac{1}{\sqrt{2}} \\ \frac{1}{2} \end{bmatrix}$, $\begin{bmatrix} \frac{1}{\sqrt{2}} \\ 0 \\ \frac{1}{\sqrt{2}} \end{bmatrix}$, and $\begin{bmatrix} \frac{1}{2} \\ \frac{-1}{\sqrt{2}} \\ \frac{1}{2} \end{bmatrix}$ respectively. Note that the mode shapes and eigenvectors are the same. (25 points)

4) Derive the equation of motion for the following system in terms of the coordinates labelled and the variables k and m. The disks are solid with mass m. The mass moments of inertia **about their centers** are $1/2\ m\ r^2$. The mass moment of inertias about any other point can be found using the parallel axis theorem, $J = J_0 + m\ r^2$. (20 points)



5) What are the mode shapes of the system of problem 4? (6 points).