2.06J-13.80J-1.058J HOMEWORK NO. 7

Due at recitation April 3, 2002

This homework is intended to give you practice in:

a. finding equations of motion, natural frequencies and mode shapes of two degree of freedom systems. Read Chapter 5 through section 5.7. By the weekend we will put a solution to the previous homework up on the web page if you need to check up on results from the last problem set.

b. You may download a program fn.m from the matlab directory in the course locker. It will compute the natural frequencies and mode shapes of an n-DOF system. You must define M, K and R matrices and save them with the 'save'command, as follows.

'save mkr M K R' The data will be stored in a file called 'mkr.mat'. Just make up values for the R values. A very good way to do this is to define M and then let R=a*M, where 'a' is a constant such as 0.01 .

The fn.m program gives an error message right now which does not affect the result, so ignore it. The program will be updated soon to fix it.

1. Check your previous results for problem 5.4 using fn.m. Show your equations of motion in matrix form.

2. Find the equations of motion in matrix form for the system in problem 5.44. Use fn.m to find the undamped natural frequencies and mode shapes.

3. Read over the break about the musical instrument that you have chosen. Write up a one page report on the general nature of the resonances that occur in your selected instrument. Describe the typical important mode shapes and explain how the musician controls pitch. Then be more specific about a particular feature of your instrument that you intend to learn about by the end of the term. This might be 'wolf tones' in violins or the difference in prompt sound and the delayed sound quality of a piano.

   The following is required by the end of the term. I want each of you to have the experience of making a simple measurement of a spectrum. I have provided a piece of software that will do this. You need a PC with a sound card and a microphone. By turning on the peak detect function you will be able to measure the frequency of the peak harmonic. You will also be able to see the higher harmonics. They are important in the sound quality of most instruments. At least identify the strongest ones and make comparisons under various conditions. For example "can you see any difference in the spectrum of a plastic versus a wire string on a guitar? " I will ask Wes to write up a step by step how-to-use the program to get you started.

   A short paper of 3-4 pages including spectra will be required on the last allowable day for assignments for subjects with final exams. At the last recitation, you will have about 5 minutes each to present your findings to one another. This presentation is meant to be informative and interesting and not a major assignment.

4. In problem 5.4 you found potential and Kinetic energy expressions. These may be used to derive equations of motion. One way is an extension of Castigliano's first theorem to find the stiffness matrix directly from the strain energy when expressed in terms of deflections.

   For2x2 matrices the K matrix has the form $[K]=\begin{bmatrix} k_{11} & k_{12} \\ k_{21} & k_{22} \end{bmatrix}$. When the potential energy is

due to stored strain energy such as in springs, rods and beams etc then you can find each element, k_{ij} of the stiffness matrix from the following expression, where U is the strain energy.

$k_{ij} = \dfrac{\partial^2 U}{\partial x_i \partial x_j}$. Try this out for problem 5.4. That is find the [K] matrix by this method.

5. Do problem 5.29. Write down the expressions for the total potential and total kinetic energy of this 2-DOF system. To get some real numbers at the end, let $m_1 = m_2 = .5$ Kg and let $L_1 = 1.1L_2 = 1.0$ m. The stiffness k then can be strong or weak. Try both extremes to see what happens. Use the fn.m program to compute the natural frequencies and mode shapes. Assume that the motions are small enough that the spring stays horizontal and that the displacement of the ends of the spring are approximately given by $L_1\theta_1 \ or \ L_2\theta_2$.

5. Read carefully section 5.6. This is about frequency response functions applied to multi-dof systems.