Final Exam

The Rules:

1) By way of the honor code, absolutely no collaboration, discussion or communication with another human being regarding this exam is allowed. Not being human, you can ask me questions, but I prefer that you email these to me so that I may email the question and the answer to everyone in the class (removing your name of course).
2) The finished product should look very nice and be very easy for me to read. Thus, I am expecting a document that is complete in its explanations, answers all questions clearly and is backed up by good solid engineering calculations. All codes used to determine solutions should be put in an appendix. While your grade will be largely determined by the accuracy and completeness of your solutions, *you will also be graded on presentation*.
3) You may use any "published" resource (anything on the web, other texts, journals etc., are all fair game). It may be possible for instance to find a solution to a problem as an example in another text. This is fair to "copy" as long as you paraphrase enough so that you understand the solution and reference the source properly.

The Purpose:

The purpose of the final exam (besides evaluating what you learned in this class) is to wrap up and summarize the course material in such away as to bring together all the important ideas in presented in class. While this lofty goal is hardly ever achieved this test at least is in the mold of a summary. Hence the test focuses on one very simple device, a cantilevered beam (Euler-Bernoulli) with a tip mass. You will measure this device in our lab during the last week of class, and model the beam five different ways, using the material from the text plus that material presented in class. This exercise is not unlike working as a vibrations engineer. In such positions one is often asked to model a device and then do an experiment to verify the model. Please organize your "lab report" and exam document as answers to the following questions.

The Exam Questions:

1) Briefly describe the lab experiment. List all the important data regarding the experimental apparatus and test (tip mass, modulus, density, geometry etc.). List the **first four natural frequencies** of the system as you measured them in the lab. Every physical constant needed in the following problems will come from this test article so make sure you get everything you need out of the lab. Here you may ask Hooman anything you like about doing the experiment. He will organize the experiments. This portion of the exam will consist of a simple modal analysis

that will provide a rough idea of what modes each natural frequency corresponds to. (20 pts)

2) Model the experiment as a single-degree-of-freedom system and compute the natural frequency. Compare your answer to the test data and write a one-sentence (or brief) conclusion. (10 pts)

3) Model the experimental test article (beam with tip mass) by deriving the equation of motion and boundary conditions using the Energy Method (i.e. use Hamilton's principle) for distributed parameter systems. Use Euler Beam assumptions for the appropriate energies. Do this in terms of symbols (i.e. do not use any numbers for the physical constants). (20 pts)

4) Use your model developed in Problem 3 with numbers inserted for the parameters and compute the analytical values of the first four natural frequencies and the mode shapes. Note that this is not done in the text. Compare the frequencies you get with those measured in the lab and write a brief conclusion. (15 pts)

5) Create a finite-element model of the lab system large enough to compute six natural frequencies. Use this FEM to compute the first six natural frequencies and compare the first *three* of these frequencies with those measured in the lab. (15 pts)

6) Referring to the text and lectures on Timoshenko beam models determine if either shear deformation or rotatory inertia effects are needed to model the test device. (10 pts)

7) Compute the longitudinal and torsional frequencies and comment on whether or not it is possible that these frequencies show up in the frequencies measured in 1. (10 pts)

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8) Alternate/Extra Credit: Compute the first three natural frequencies of this system using the Rayliegh- Ritz- Galerkin Method and compare your answers to the frequencies measured in the lab. Read the text book to learn more about these methods.(15 pts)
9) Alternate/Extra Credit: Write a paragraph or so comparing the analytical results of your exam (problems 2 through 5) with the test data. Make sure you justify your answer, based on your solutions to the above problems. (10 pts)