ME 460/660, Mechanical Vibration — Exam 2, Fall 2009

Closed book, closed notes. Use $8\frac{1}{2} \times 11$ formula sheet from web and turn in with exam (nothing else may be written on the formula sheet). Test books will be provided. Calculators allowed. Knowing how to use them well is highly recommended.

Problems are 10 points each. Problem 4 is required for graduate students, bonus for undergraduates.

1. The pressure on a valve is given by $p(t) = 34,083 - 26996\cos(52.36t) + 8307.7\sin(52.36t) + 1416.7\cos(104.72t) + 3608.3\sin(104.72t) - 5833.3\cos(157.08t) + 2333.3\sin(157.08t) + \ldots$. Find the steady state solution of the governing equation, given by

$$0.25\ddot{x} + 10\dot{x} + 2500x = 6.25 \times 10^{-4} p(t)$$

2. An undamped system is excited by a brief excitation defined by

$$f(t) = \begin{cases} 300t & t < .01 \\ -300t + 6 & .01 < t < .02 \\ 0 & .02 < t \end{cases} \tag{1}$$

   Set up the integral/s to find $x(t)$ during and after the pulse presuming $10\ddot{x} + 1x = f(t)$.

3. Sketch the FRF X/Y of the system with the governing equation $100\ddot{x} + 1\dot{x} + 100x = 100y + 1\dot{y}$, including both magnitude and phase. Evaluate and label the values of the magnitude and phase at: $0.1\omega_n$, ω_n, and $10\omega_n$.

4. *Grad student/bonus* (20% of other points) Determine the first natural frequency and mode shape for a clamped-free (cantilevered) beam. The equation of motion of a bar is $\left(\frac{EI}{\rho A}\right)\frac{\partial^4 w(x,t)}{\partial x^4} + \frac{\partial^2 w(x,t)}{\partial t^2} = 0$. Yes, you have to obtain all constants that you can.