ME 460/660, Mechanical Vibration   Final Exam, Spring 2002

Closed book, closed notes. Use one provided $8\frac{1}{2} \times 11$ (on the web) formula sheet and turn in with exam. Test books will be provided. **Do all work on the exam pages** with the exception of the full length problems. Full length problems are to be done in the test book. Problems must be in order in the blue books. 10% will be deducted from each problem done out of order.

Circle the letters of the correct answers. Each question may have multiple correct answers. Circle each correct answer for each problem *on the exam*. Answers fo multiple choice problems in the blue books **will not be counted**. *Read all questions very carefully.* One point for each correctly circled or not circled item. (20 points total)

1. What modeling method/s apply for determining the system equations of motion when viscous damping is present in a system?

   a. Lagrange's Equations

   b. Newton's Law

   c. The Energy Method

   d. The Fourier method

2. A linear, underdamped SDOF system is excited at 9 Hz ($F = 10\cos(18\pi t)$). It has a natural frequency of 10 Hz. Assuming zero initial conditions, its frequency of motion, after a significant period of time, will be:

   a. 9 Hz

   b. 10 Hz

   c. 9.5 Hz

   d. 19.5 Hz

3. The settling time of a system can be changed by modifying...

   a. m

   b. c

   c. k

   d. η

4. Gravity may **always (as in "for any system")** be neglected in determining

   a. ω

   b. ω_d

   c. ω_{dr}

   d. Stresses in a vibrating system

   e. m

5. Damping has the greatest impact on the response of most systems system

   a. near $r = 0$

   b. near $r = 1$

   c. near $r = \infty$

   d. When the forcing function is random

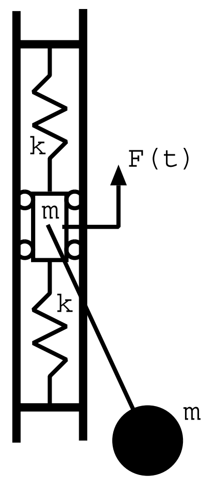
6. The convolution integral
   a. can be used to obtain the response to an excitation of any form
   b. will not give the correct answer for a harmonically excited system
   c. applies only for impulse excitations
   d. only applies to free response
7. Coulomb damping
   a. works best at resonance
   b. works worst at resonance
   c. is a precise model of friction damping
   d. is equivalent to (the same as) viscous damping

Circle the correct answers relating to units of vibration:

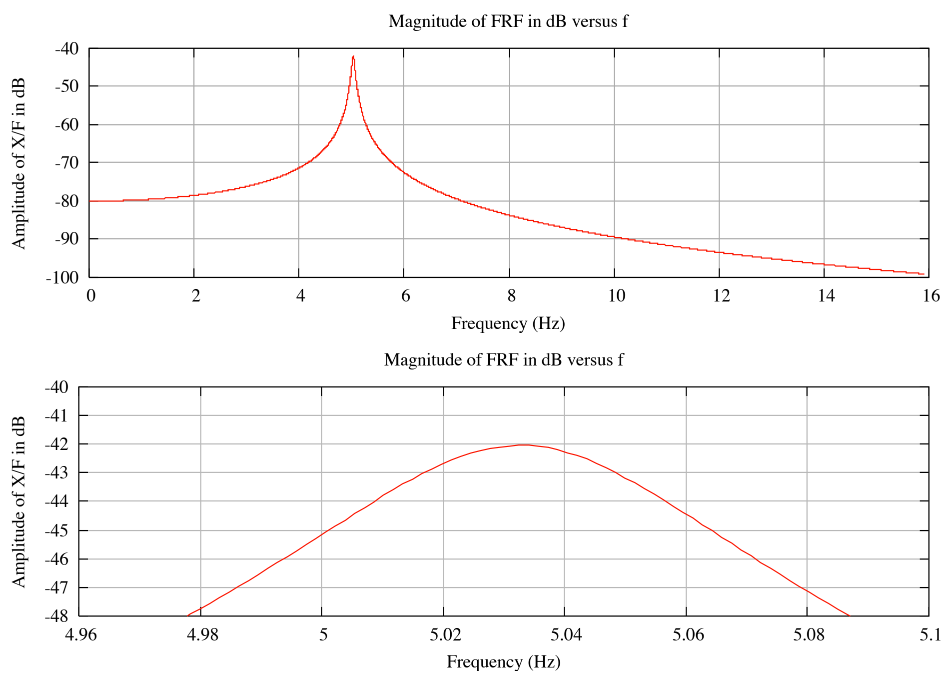
1. Correct units for the viscous damping coefficient are:
   (a) kg s
   (b) kg/s
   (c) N s/m
   (d) N m
2. The amplitude of acceleration of a vibrating system is given as 2 g. The units of g may then be
   (a) m/s
   (b) ft/s^2
   (c) grams
   (d) lbs/slug
3. If a person weighs 100 lbs, their mass is most closely
   (a) 100 slugs
   (b) 10.2 slugs
   (c) 3.1 slugs
   (d) 322 slugs

Full Length Problems (20 points each)

1. Find the natural frequencies of a system for which the mass normalized mode shapes and stiffness matrix are
$$S = \begin{bmatrix} 0.40825 & 0.70711 \\ 0.40825 & -0.70711 \end{bmatrix}, \qquad K = \begin{bmatrix} 65 & -35 \\ -35 & 65 \end{bmatrix}$$
2. Find the response of a SDOF undamped system to a force defined by $F(t) = 20$ N for $0 < t < 2$ sec and $F(t) = 10$ N for $2 < t < 4$ sec, and repeating itself again.
3. Derive the equation of motion of the following system shown using Lagrange's equation. Assume no damping, and don't forget to include gravity. Assume no damping or other energy loss mechanisms. Define $x = 0$ to be at the geometric center of the springs. Both springs are unstretched when $x = 0$. *Do not neglect gravity at any place in the problem.*



4. Obtain estimates of m, c and k for the SDOF system with the FRF as shown below. Units of the FRF are m/N. The damping ratio can be estimated by $\zeta = \frac{\omega_b - \omega_a}{2\omega_d}$.



5. Graduate Students/Undergraduate Bonus (25%): Solve the following equation for the steady state response $w(x,t)$ where $c = \sqrt{\tau/\rho}$.

$$w_{tt}(x,t) - c^2 w_{xx}(x,t) = 100 \sin(3t)\delta(x - l/3)$$

Recall that the integral of a Dirac delta function times another function is equal to the "another function" evaluated when the argument of the argument of the Dirac delta function is zero.

BONUS: For problem 1, what is the mass matrix? (5 points)