ME 460/660, Mechanical Vibration — Test 1, Fall 2010

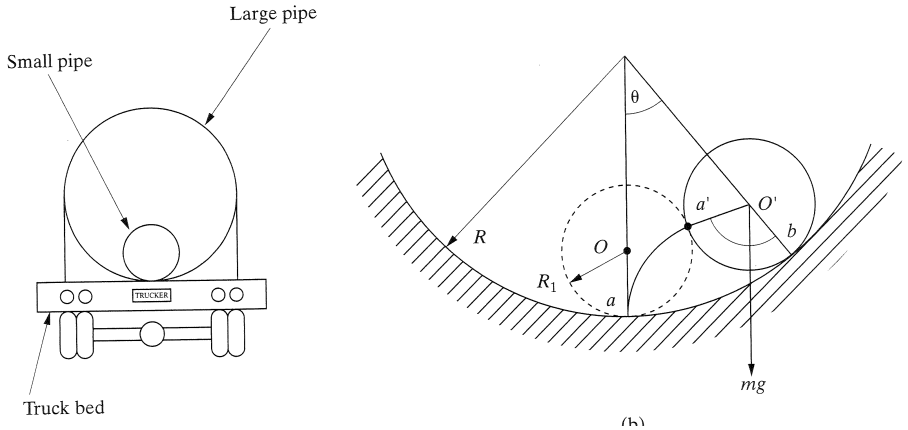
Closed book, closed notes. Test booklets will be provided. Formula sheet must be turned in with the exam. Formula sheet must be exactly the same as that posted on the web site. Calculators allowed. Problem 4 is required for graduate students.

1. (a) Find the forced response ($x(t)$, particular solution) of $\ddot{x} + 0.1\dot{x} + 100x = 100y(t) + 0.1\dot{y}(t)$ if $y(t) = Y \sin \omega t$ for

Y	f (Hz)
10	1
0.1	10
0.001	100

   (b) Sketch the magnitude (*using 1/2 of a page for scale!*) of $X(i\omega)/Y(i\omega)$ for the system above for $0 < \omega < 10\omega$ on a dB scale ($20 * \log_{10}(\frac{x}{y})$) labeling values (not in dB) at $f = (0, f_n, 10f_n)$ where f_n is the natural frequency in Hz.

2. To save space, two large pipes are shipped on stacked inside the other as indicated in Figure P1.56. Calculate the natural frequency of vibration of the smaller pipe rolling back and forth inside the larger pipe. Assume rolling without slipping.



3. Exposure to 18 g (18 times gravity) acceleration causes permanent brain damage. At 10 Hz, what is the maximum allowable velocity amplitude to ensure a safety factor of 1.1? What is the maximum allowable displacement? What is your sense of the ramifications of submitting a human to these conditions (what do you think you would observe in people subjected to vibration just below this threshold?)?

4. *Grad student/bonus:* Determine the natural frequencies and mode shapes for a clamped-clamped (fixed on the right end) circular cross section extension rod. The equation of motion of a rod is $\left(\frac{E}{\rho}\right) \frac{\partial^2 w(x,t)}{\partial x^2} = \frac{\partial^2 w(x,t)}{\partial t^2}$. (20% of other points)