Due Feb. 5, Thursday

All problems must be solved symbolically first. Then, any numerical answer, when required, can be computed by substituting numbers into the symbolic expression at/near the very end. Solving problems symbolically means deriving the answer in terms of symbols, instead of numerical values. All problem numbers refer to those in the textbook. (Not all problems may be graded in detail, due to limited man power; however, you must do all problems.)

For each problem, you are required to use sensible symbols, by defining or adopting them yourself, for your symbolic solution. If you are unsure how to do this, feel free to ask!

Problem 1 (10 points) Problem 15.17 (circular wave).

Problem 2 (10 points) Problem 15.40 (wave reflection, transmission).

Problem 3 (10 points) Problem 15.52 (standing wave).

Problem 4 (10 points) Problem 16.19 (dB).

Problem 5 (10 points) Problem 16.58 (interference).

Problem 6 (10 points) Problem 16.59 (beats).

Problem 7 (10 points) Problem 16.90 (tuning fork and pipe).

Problem 8 (10 points) Problem 16.97 (Doppler effect).

Problem 9 (10 points) Problem 16.104 (Doppler effect).

Problem 10 (10 points) Problem 16.108 (sound wave).

Problem 11 (10 points + 20 extra credit points) Consider a long spring ("slinky") with natural length L_0, total mass M, and spring constant k.

(a) You and your friend hold the spring horizontally. The spring is stretched to length $L > L_0$. You generate a longitudinal wave along the spring by giving a quick short push (or pull) at your end. Find the speed of the wave as a function of the parameters defined so far. [Hint: you may make use of the formula for the longitudinal wave in solid, if you can express Young's modulus and the volume density of mass in terms of the parameters defined here.]

(b) The same spring is now held vertically by your friend. The bottom end is free. Due to its own mass, the spring will extend from its natural length L_0. Find the new length L_V. [Hint: you must think similarly for problem 11 of the previous homework, while noting that the spring constant of an infinitesimal part of a spring is very different from the spring constant of the whole spring.]

(c) Continuing the previous part, find the speed of the longitudinal wave at the top of the spring and at the bottom of the spring.