Due Jan. 29, Thursday

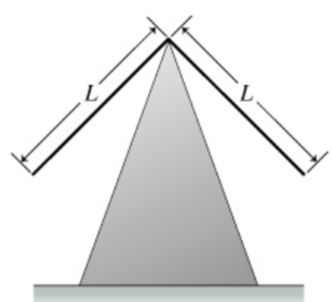
All problems must be solved symbolically first. Then, any numerical answer, when required, can be computed by substituting numbers into the symbolic expression at/near the very end. Solving problems symbolically means deriving the answer in terms of symbols, instead of numerical values. All problem numbers 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 so, feel free to ask (or look back at homework 1)!

Problem 1 (10 points) Problem 14.43 (simple pendulum).

Problem 2 (10 points; Problem 14.53 (torsion pendulum).

Problem 3 (10 points) Two identical thin rods, each of mass m and length L, are joined at right angles to form an L-shaped object. This object is balanced on top of a sharp object. If the object is displaced slightly, it oscillates. Assume that the magnitude of the acceleration due to gravity is g. Find the angular frequency ω.



Problem 4 (10 points) Problem 15.12 (string wave)

Problem 5 (10 points) Problem 15.26 (wave; dealing with multi-variable function)

Problem 6 (10 points) Problem 15.29 (wave; basics)

Problem 7 (10 points; extra credit) Problem 15.31 (wave equation)

Problem 8 (10 points) Problem 15.34 (wave equation; linearity and superposition)

Problem 9 (10 points) Problem 15.37 (wave propagating in inhomogeneous media)

Problem 10 (10 points) Problem 15.75 (wave; energy)

Problem 11 (30 points + 10 extra credit points) A string with mass M and length L is hanging from the ceiling. The mass of the string is uniformly distributed along its length.

(a) The string is at rest. Let us define the coordinate from top to bottom as x ($x = 0$ at top and $x = L$ at bottom). Find the tension in the string as a function of x, M, L, and g.

(b) Consider a transverse string wave generated on this string. Show that the speed of the wave, v, is x dependent and find v as a function of x, M, L, and g (some of these symbols may not appear in the answer).

(c) You disturb the string near the very top, by pushing the near top part horizontally. How long will it take for this disturbance to reach the bottom of the string? Your answer must be expressed as a function of L, g, and M (some of these symbols may not appear in the answer). Assume that there is no damping of the wave as it propagates.

(d) (extra credit) You push the bottom end of the string (gently) in the horizontal direction. Again we assume that there is no damping. Will the disturbance propagate be able to travel as a wave from the bottom to all the way to the top? Answer this question from the point of view of (1) your common sense and (2) your answer for part (b). These two answers might conflict each other, presenting a paradox. Resolve the paradox by pointing out which one of them is actually incorrect and why (discussion after Eq. 4.19 would be helpful).