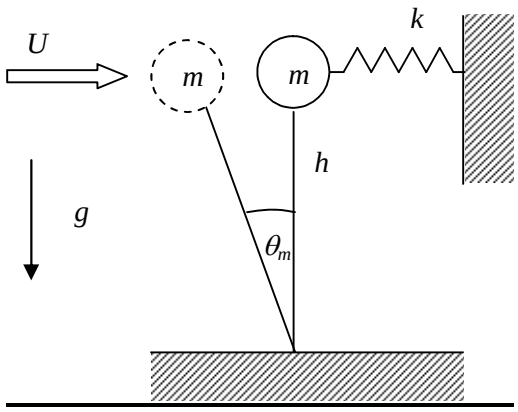
Problem Set 3b

Assigned: Tuesday 09/27/11 Due: Tuesday 10/04/11

Exercise 3.7:

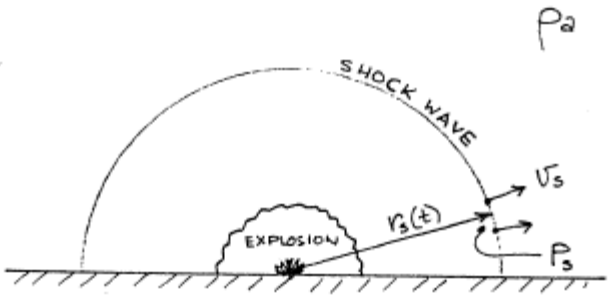
The John Hancock tower in Boston suffers from wind-induced structural swaying. You are asked to develop an experimental model-scale test matrix to determine the dependence of the maximum sway angle θ_m and sway period T on the building height h, mass m, and effective stiffness k, as well as the wind speed U. For modeling simplicity, we will represent this system as an inverted pendulum. Note that g, the gravitational acceleration, is also a key parameter in this system.

1. Before performing dimensional analysis, how many experiments are required to determine the outputs' (T, θ_m) dependence using five experiments per independent parameter (on Earth)?
2. Determine a set of governing non-dimensional parameters for this system using the Buckingham π-theorem.
3. What is the size of the test matrix using these dimensionless parameters?



Exercise 3.8: From Sonin - Shapiro

Problem 7.9



A strong explosion (like an atomic bomb) causes a spherically symmetric shock wave to move through the air radially out from the origin. As the shock sweeps by, it causes a sudden rise in pressure and sets the initially static air into radially outward motion.

It can be argued from strong shock wave theory that if the undisturbed atmosphere is homogeneous at a density ρ_a, the velocity v_s of the shock, as well as the pressure p_s and the wind speed just behind the shock wave, should depend only on the density ρ_a, the distance r_s of the shock wave from the origin, and the total energy E released by the explosion.

(a) Show that:

$$v_s = \text{const.}(E/\rho_a)^{\frac{1}{2}} \cdot r_s^{-\frac{3}{2}}$$

$$p_s = \text{const.}\ E \cdot r_s^{-3}$$

(b) Obtain an expression for the shock's radial position as a function of time (the expression may involve one unknown dimensionless constant). Show how the strengths of two different bomb explosions, as measured by their energy releases, can be compared based on film information about their shock wave positions as functions of time.