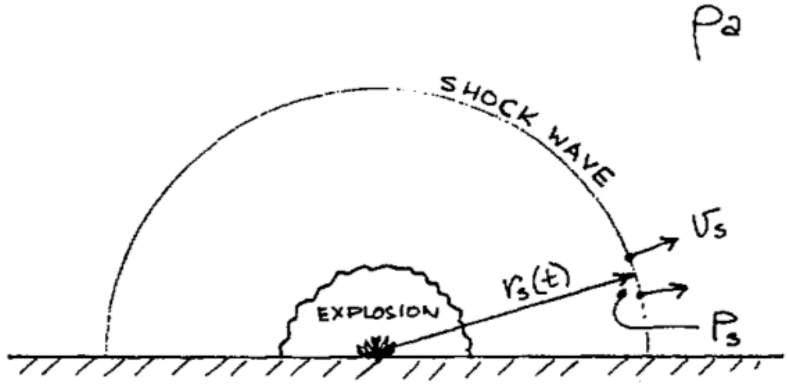
MIT Department of Mechanical Engineering

2.25 Advanced Fluid Mechanics

Problem 7.09

This problem is from "Advanced Fluid Mechanics Problems" by A.H. Shapiro and A.A. Sonin



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 the 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 total distance r_s of the shock wave from the origin, and the total energy E released by the explosion.

(a) Show that:

$$v_s = \text{const.} \left(\frac{E}{\rho_a} \right)^{\frac{1}{2}} \cdot r_s^{-\frac{3}{2}} \tag{7.09a}$$

$$p_s = \text{const.}\ E \cdot r_s^{-3} \tag{7.09b}$$

(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 a function of time.

