

8.47 A circular cylinder is fitted with two pressure sensors, to measure pressure at “a” (180°) and “b” (105°), as shown. The intent is to use this cylinder as a stream velocity velocimeter. Using inviscid theory, derive a formula for calculating U_∞ from p_a , p_b , ρ , and radius a .

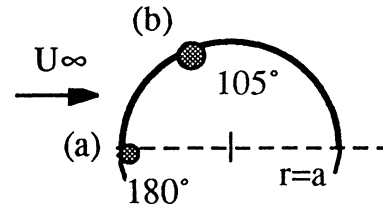


Fig. P8.47

Solution: We relate the pressures to surface velocities from Bernoulli's equation:

$$p_\infty + \frac{\rho}{2} U_\infty^2 = p_a + \frac{\rho}{2} (0)^2 = p_b + \frac{\rho}{2} (2U_\infty \sin 105^\circ)^2, \quad \text{or:} \quad U_\infty = \frac{1}{\sin 105^\circ} \sqrt{\frac{p_a - p_b}{2\rho}} \quad \text{Ans.}$$

This is not a bad idea for a velocimeter, except that (1) it should be calibrated; and (2) it must be carefully aligned so that sensor “a” exactly faces the oncoming stream.

8.48 Wind at U_∞ and p_∞ flows past a Quonset hut which is a half-cylinder of radius a and length L (Fig. P8.48). The internal pressure is p_i . Using inviscid theory, derive an expression for the upward force on the hut due to the difference between p_i and p_s .

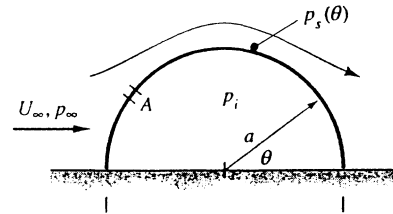


Fig. P8.48

Solution: The analysis is similar to Prob. 8.46 on the previous page. If p_o is the stagnation pressure at the nose ($\theta = 180^\circ$), the surface pressure distribution is

$$p_s = p_o - \frac{\rho}{2} U_s^2 = p_o - \frac{\rho}{2} (2U_\infty \sin \theta)^2 = p_o - 2\rho U_\infty^2 \sin^2 \theta$$

Then the net upward force on the half-cylinder is found by integration:

$$F_{\text{up}} = \int_0^\pi (p_i - p_s) \sin \theta ab \, d\theta = \int_0^\pi (p_i - p_o + 2\rho U_\infty^2 \sin^2 \theta) \sin \theta ab \, d\theta,$$

$$\text{or:} \quad \mathbf{F_{up}} = (\mathbf{p_i} - \mathbf{p_o})\mathbf{2ab} + \frac{\mathbf{8}}{\mathbf{3}}\rho\mathbf{U_\infty^2} \mathbf{ab} \quad \text{Ans.} \quad \left(\text{where } p_o = p_\infty + \frac{\rho}{2} U_\infty^2 \right)$$

8.49 In strong winds, the force in Prob. 8.48 above can be quite large. Suppose that a hole is introduced in the hut roof at point A (see Fig. P8.48) to make p_i equal to the surface pressure p_A . At what angle θ should hole A be placed to make the net force zero?