Problem 4.1

Water flows through a divergent duct. The inlet velocity and area are 5 ft/sec and 10 ft\(^2\), respectively. If the exit area is 4 times the inlet area, calculate the water flow velocity at the exit.

\[ A_1 V_1 = A_2 V_2 \]

Let points 1 and 2 denote the inlet and exit conditions

\[ V_2 = V_1 \left( \frac{A_1}{A_2} \right) = (5) \left( \frac{1}{4} \right) = 1.25 \text{ ft/sec} \]
Problem 4.2

Water flows through a divergent duct. The inlet velocity and area are 5 ft/sec and 10 ft², respectively. If the exit area is 4 times the inlet area, calculate the pressure difference between the exit and inlet. The density of water is 62.4 lb/ft³.

From Bernoulli’s equation,

\[ p_1 + \rho \frac{V_1^2}{2} = p_2 + \rho \frac{V_2^2}{2} \]

\[ p_2 - p_1 = \frac{\rho}{2} (V_1^2 - V_2^2) \]

In consistent units,

\[ \rho = \frac{62.4}{32.2} = 1.94 \text{ slug/ft}^3 \]

Hence,

\[ p_2 - p_1 = \frac{1.94 \text{ slugs/ft}^3}{2} (5^2 - 1.25^2) \text{ ft}^2/\text{sec}^2 = 22.7 \text{ lb/ft}^2 \]
Problem 4.3

An airplane is flying at a standard altitude of 3 km with a velocity of 60 m/sec. At a point on the wing, the airflow velocity is 70 m/sec. Assume incompressible flow and calculate the pressure at this point.

From Appendix A; at 3000m altitude,

\[ p_1 = 7.01 \times 10^4 \text{ N/m}^2 \]

\[ \rho = 0.909 \text{ kg/m}^3 \]

From Bernoulli’s equation,

\[ p_2 = p_1 + \frac{\rho}{2} (V_1^2 - V_2^2) \]

\[ p_2 = 7.01 \times 10^4 \text{ N/m}^2 + \frac{0.909 \text{ kg/m}^3}{2} (60^2 - 70^2) \text{ m}^2/\text{sec}^2 \]

\[ = 6.95 \times 10^4 \text{ N/m}^2 \]
Problem 4.6

An airplane is flying at a standard altitude of 5000 ft with a velocity of 130 mi/hr. At a point on the wing, the pressure is 1750 lb/ft². Assume incompressible flow and calculate the velocity at this point.

\[ V_1 = 130 \text{ mph} = 130 \left( \frac{88}{60} \right) = 190.7 \text{ ft/sec} \]

\[ p_1 + \frac{1}{2} \rho V_1^2 = p_2 + \frac{1}{2} \rho V_2^2 \]

\[ V_2^2 = \frac{2}{\rho} (p_1 - p_2) + V_1^2 \]

\[ V_2^2 = \frac{2 (1761 - 1750) \text{ lb/ft}^2}{0.002048 \text{ slugs/ft}^3} + (190.7 \text{ ft/sec})^2 \]

\[ V_2 = 216.8 \text{ ft/sec} \]