Given: Air flow in open circuit wind tunnel as shown.

\[ P_{\text{in}} - P_1 = 45 \text{ mm Hg} \]
\[ T_0 = 25^\circ C \]
\[ P_0 = P_{\text{in}} \]

Consider air to be incompressible.

Find: Air speed in tunnel at section 0

Solution:

Basic equations:

\[ \frac{P}{\rho} + \frac{V^2}{2} + g \frac{z}{\rho} = \text{constant} \]

Assumptions:
1. steady flow
2. incompressible flow
3. frictionless flow
4. flow along a streamline
5. air behaves as an ideal gas
6. stagnation pressure = \( P_{\text{in}} \)

From the Bernoulli equation,

\[ \frac{P_0}{\rho} = \frac{P_1}{\rho} + \frac{V_1^2}{2} \]

\[ P_0 - P_1 = P_{\text{in}} - P_1 = \frac{1}{2} \rho V_1^2 \]

\[ V_1 = \left[ \frac{2(P_{\text{in}} - P_1)}{\rho} \right]^\frac{1}{2} \]

From the manometer reading,

\[ P_{\text{in}} - P_1 = P_{\text{Hg}} \text{ h} \]

\[ V_1 = \left[ \frac{2 \rho g P_{\text{Hg}} h}{\rho} \right]^\frac{1}{2} \]

From the ideal gas equation of state

\[ \rho = \frac{P}{RT} = \frac{100 \times 10^3}{287 \times 273} \times \frac{\frac{1}{2} \frac{1}{2}}{298} \times 1.17 \frac{\text{kg}}{\text{m}^3} = 1.17 \frac{\text{kg}}{\text{m}^3} \]

\[ V_1 = \left[ \frac{2 \rho P_{\text{Hg}} g h}{\rho} \right]^\frac{1}{2} = \left[ \frac{2 \times 10^3 \times 9.81 \times 0.05 \times 9.81}{1.17 \times 0.05 \times 9.81} \right]^\frac{1}{2} = 27.5 \text{ m/s} \]