5.2 Information and assumptions

provided in problem statement

Find

pressure gradient required to accelerate flow

Euler’s equation

\[
\begin{align*}
\frac{\partial (p + \gamma z)}{\partial z} &= -\rho a_z = -\left(\frac{\gamma}{g}\right) \times 0.20g \\
\frac{\partial p}{\partial z} + \gamma &= -0.20\gamma \\
\frac{\partial p}{\partial z} &= \gamma(-1 - 0.20) = 0.81 \times 62.4(-1.20) = -60.7 \text{ lbf/ft}^3
\end{align*}
\]
5.20 Information and assumptions

provided in problem statement

Find

\( p_C - p_A \) and \( p_B - p_A \)

Euler’s equation

\[
\frac{dp}{dz} = -1.3 \times 1,000(9.81 - 6.54) = -4,251 \text{ N/m}^3
\]

\[
p_B - p_A = 4,251 \times 3 = 12,753 \text{ Pa} = 12.75 \text{ kPa}
\]

\[
p_C - p_B = \rho \alpha_x L = 1.3 \times 1,000 \times 9.81 \times 2 = 22,506 \text{ Pa}
\]

\[
p_C - p_A = 22,506 + 12,753 = 38,259 \text{ Pa} = 38.26 \text{ kPa}
\]

NOTE: This solution is incorrect. The error is in the third line, \( p_C - p_B \) should equal 25,506. Additionally, line 4 should reflect this change.
5.47 Information and assumptions

provided in problem statement

Find

pressure at point A

Bernoulli equation

\[ p_2 = \gamma(z_1 - \frac{V_2^2}{2g}) = 9.810(15 - \frac{36}{(2 \times 9.81)}) = 129,150 \text{ Pa} \]

\[ = 129.15 \text{ kPa} \]
5.52 Information and assumptions

provided in problem statement

Find

force required to drive piston

Continuity equation

\[ V_1 A_1 = V_2 A_2 \]
\[ V_2 = V_1 (D/d)^2 = 4 \times (4/2)^2 = 16 \text{ ft/s} \]

Bernoulli equation

\[ p_1 / \gamma + V_1^2 / 2g = V_2^2 / 2g \]
\[ p_1 = \gamma(V_2^2 / 2g - V_1^2 / 2g) = 233 \text{ psf} \]

Then \( F_{\text{piston}} = p_1 A_1 = 233(\pi/4) \times (4/12)^2 = 20.3 \text{ lbf} \)
5.88 Information and assumptions

provided in problem statement

Find
free-stream velocity

Let point 1 be at the stagnation point and point 2 be at the 90° position. At the 90° position \( U = 1.5U \sin \Theta = 1.5U \).

Bernoulli equation between points 1 and 2.

\[
\begin{align*}
\frac{\rho V_1^2}{2} & = p_1 + \rho V_1^2 / 2 \\
\rho V_2^2 / 2 & = p_2 - \rho V_2^2 / 2 \\
(\gamma_{Hg} - \gamma_{H2O}) \Delta h & = (\rho/2)(1.5U)^2 \\
((\gamma_{Hg} / \gamma_{H2O}) - 1) \Delta h & = (1/2g)(1.5U)^2 \\
(13.6 - 1) \Delta h & = (1/2g)(2.25)U^2 \\
U & = 2.34 \text{ m/s}
\end{align*}
\]
5.91 Information and assumptions

provided in problem statement

Find
true airspeed

Pitot tube equation

\[ V = K \sqrt{2 \Delta p / \rho} \]

then

\[
\begin{align*}
V_{\text{calibr.}} &= \left( K / \sqrt{\rho_{\text{calibr.}}} \right) \sqrt{2 \Delta p} \\
V_{\text{true}} &= \left( K / \sqrt{\rho_{\text{true}}} \right) \sqrt{2 \Delta p} \\
V_{\text{indic.}} &= \left( K / \sqrt{\rho_{\text{calibr.}}} \right) \sqrt{2 \Delta p}
\end{align*}
\]

Divide Eq. (1) by Eq. (2):

\[
\frac{V_{\text{true}}}{V_{\text{indic.}}} = \sqrt{\frac{\rho_{\text{calibr.}}}{\rho_{\text{true}}}} = \sqrt{\frac{101}{70}} \times \frac{(273 - 6.3)/(273 + 17)}{1/2} = 1.15
\]

\[
V_{\text{true}} = 60 \times 1.15 = 69.3 \text{ m/s}
\]