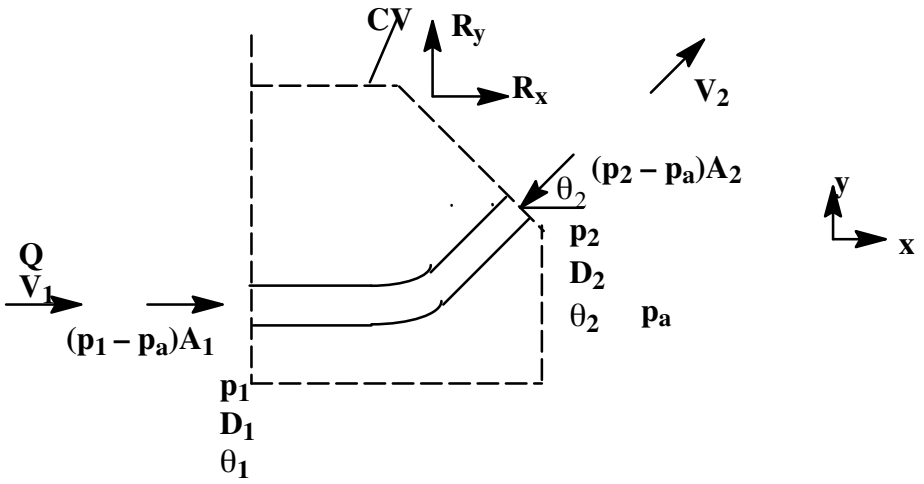
HOMEWORK #3A

Problem Statement

Water flows through a horizontal pipe which makes a 60 degree bend. The inside diameter of the pipe is constant at 4 inches and the flow rate is 240 cfm. The pressure at the bend entrance and exit is measured to be 30 psia and 24 psia respectively. What force (magnitude and direction relative to the flow inlet direction) is required to hold the bend in place? Assume the surroundings are at stp.



Given $D_1 = D_2 = 4$ in $\theta_1 = 0^o$ relative to V_1 direction

$p_1 = 30$ psia $= 30 \times 144$ psfa $\theta_2 = 60^o$ relative to V_2 direction

$p_2 = 24$ psia $= 24 \times 144$ psfa $Q = 240$ cfm $= 4$ ft^3/sec

$p_a = 14.7$ psia $= 14.7 \times 144$ psfa

Determine R_x, R_y

Assumptions 1D, incompressible, steady flow

Equations & Constants

$$\text{continuity}: V_1A_1 = \; = V_2A_2 \qquad \text{(i, s, 1D)}$$

$$x-\text{momentum}: (p_1 - p_{a)}A_1 \; - \; (p_2 - p_{a)}A_2\cos(\theta_2) + R_x \; = \; \dot{m}(V_2\cos(\theta_2) - V_1) \qquad \text{(s, 1D)}$$

$$y-\text{momentum}: \; - \; (p_2 - p_{a)}A_2\sin(\theta_2) + R_y \; = \; \dot{m}(V_2\sin(\theta_2)) \qquad \text{(s, 1D)}$$

$$\dot{m}_1 \; = \; \varrho V_1A_1 \; = \; \dot{m}_2 \; = \; \varrho V_2A_2$$

$$\varrho \; = \; 1.938 \text{slug/ft}^3$$

Solution $V_1 \; = \; \dfrac{Q}{A} = \dfrac{4(144)}{4\pi}$ ft/s

$$(30 - 14.7)\frac{4\pi(144)}{144} - (24 - 14.7)\frac{4\pi(144)}{144}(.5) + R_x = 1.938(4)\frac{(4)(144)}{4\pi}(.5 - 1)$$

$$R_x = -311.5 \text{ lb} \leftarrow$$

$$- (24 - 14.7)\frac{4\pi(144)}{144}(.866) + R_y = 1.938(4)\frac{(4)(144)}{4\pi}(.866 - 0)$$

$$R_y = 408.9 \text{ lb} \uparrow$$

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HOMEWORK #3B

Problem Statement

The pressure altimeter on a low–speed aircraft reads 5000 ft (i.e., it is flying at a pressure altitiude of 5000 ft). The outside air temperature is 45 degrees F. A pitot tube (measuring stagnation pressure) is mounted on the wingtip and it measures an absolute pressure of 12.5 psia.

Determine

1. the aircraft true airspeed
2. its equivalent airspeed
3. If a pitot–static probe had been used, connected to a water–filled manometer, what would be the measurement in inches of water

Given

$p = 1760.9$ psfa at 5000ft MSL (TABLES)
$T = 45$ F $= 505$ R
$p_o = 12.5$ psfa

Determine

1. TAS
2. EAS
3. q in in H_2O

Assumptions 1D, incompressible, inviscid, steady flow

Equations & Constants

$$p + \frac{\varrho}{2}V^2 = p_o \qquad \text{(inv, inc, s, 1D)}$$

$$\varrho = \frac{p}{RT}$$

$$\Delta p = w|\Delta h|$$

$\varrho_s = .002337 \text{slug/ft}^3$ (TABLES)

$w_{H_2O} = 62.4 \text{lbm/ft}^3$ (TABLES)

Solution

$$1.\ \varrho = \frac{p}{RT} = \frac{1760.9}{1716(505)} = .00203 \text{slug/ft}^3$$

$$\text{TAS} = \sqrt{\frac{2(p_o - p)}{\varrho}} = \sqrt{\frac{2(1800 - 1760.9)}{.00203}} = 196.2 \text{ft/s}$$

$$2.\ \text{EAS} = \sqrt{\frac{\varrho}{\varrho_s}}\ \text{TAS} = \sqrt{\frac{.00203}{.002377}}196.2 = 181 \text{ft/s}$$

$$3.\ \Delta h = \frac{\Delta p}{w_{H_2O}} = \frac{1800 - 1760.9}{62.4}12 = 7.52 \text{ in } H_2O$$