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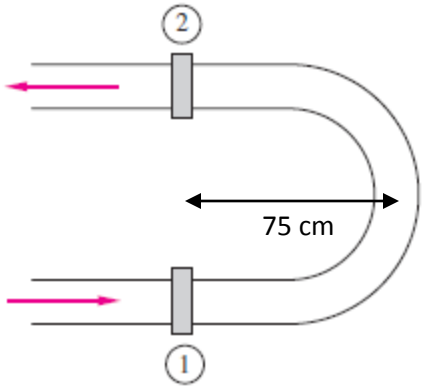
NAME

Fluids-ID

Quiz 7. Water at 20 °C flows through a 5 cm diameter pipe that has a 180 ° vertical bend, as in the figure. The total length of pipe between flanges 1 and 2 is 75 cm. When the weight flow rate is 230 N/s, gage pressure at section 1 and 2 is $p_1 = 64$ kPa and $p_2 = 33$ kPa. Neglecting pipe weight, determine the total force that the flanges must withstand for this flow.



Hint:

1) gravity, $g = 9.81\ m/s^2$
2) density, $\rho = 998\ kg/m^3$
3) mass flow rate, $\dot{m} = \rho Q =$ (weight flow rate)/(gravity)
4) volume flow rate, $Q =$ (mass flow rate)/(density)

Solution:

Mass flow rate, $\dot{m}$, is

$$\dot{m} = (230\frac{N}{s})/(9.81\frac{m}{s^2}) = 23.45\ kg/s$$

(+2.5 points)

Volume flow rate Q

$$Q = \frac{weight\ flow\ rate}{\gamma} = \frac{230}{9790} = 0.0235\ m^3/s$$

Or

$$Q = \frac{mass\ flow\ rate}{\rho} = \frac{23.45}{998} = 0.0235\ m^3/s$$

(+2.5 points)

$$V_1 = V_2 = V = \frac{Q}{A} = \frac{\left(0.0235\frac{m^3}{s}\right)}{\left(\frac{\pi}{4}\right)(0.05\ m)^2} = 12.0\frac{m}{s}$$

(+1 points)

$$\sum F_x = F_{x,flange} + p_1 A_1 + p_2 A_2 \ = \dot{m}_2 u_2 - \ \dot{m}_1 u_1$$

$$= F_{x,flange} + (64000)\frac{\pi}{4}(0.05)^2 + (33000)\frac{\pi}{4}(0.05)^2 = (23.45)(-12.0 - 12.0)$$

$$F_{x,flange} = \ -750\ N$$

(+2 point)

$$\sum F_y = F_{y,flange} = W_{pipe} + W_{fluid} = 0 + (9790)\frac{\pi}{4}(0.05)^2(0.75) = 14\ N$$

(+2 points)