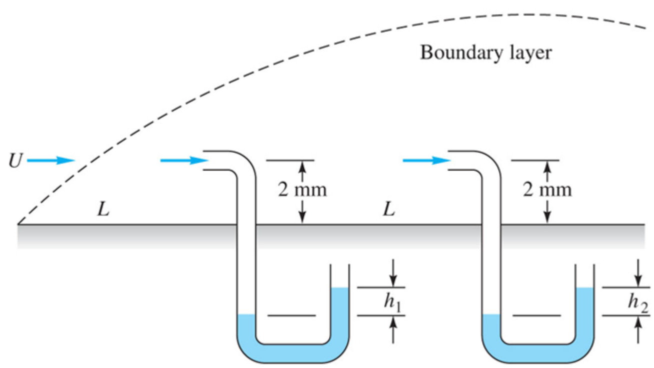
Name: ------------------ **Quiz 11** **Time: 20 minutes**

ME:5160 **Fall 2024**

The exam is closed book and closed notes.

Air at 20°C and 1 atm flows past the flat plate in below figure. The two pitot tubes are each 2 mm from the wall. The manometer fluid is water at 20°C. If U = 15 m/s and L = 50 cm, determine the values of the manometer readings h_1 and h_2 in cm. Assume laminar boundary-layer flow.

For air at 20°C: $\rho = 1.2$ kg/m³ and $\mu = 1.8 \times 10^{-5}$ kg/m·s
Distance from inlet to 1st Pitot tube: L=0.5m
Distance from inlet to 2nd Pitot tube: 2L=1m



$y[U/(\nu x)]^{1/2}$	u/U	$y[U/(\nu x)]^{1/2}$	u/U
0.0	0.0	2.8	0.81152
0.2	0.06641	3.0	0.84605
0.4	0.13277	3.2	0.87609
0.6	0.19894	3.4	0.90177
0.8	0.26471	3.6	0.92333
1.0	0.32979	3.8	0.94112
1.2	0.39378	4.0	0.95552
1.4	0.45627	4.2	0.96696
1.6	0.51676	4.4	0.97587
1.8	0.57477	4.6	0.98269
2.0	0.62977	4.8	0.98779
2.2	0.68132	5.0	0.99155
2.4	0.72899	∞	1.00000
2.6	0.77246		

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Solution

Calculate $\nu = \frac{\mu}{\rho} = \frac{1.8\times10^{-5}}{1.2} = 1.2 \times 10^{-5} m^2/s$

(1) Derive velocity

$$\eta_1 = y\sqrt{\frac{U}{\nu x_1}} = 0.002\sqrt{\frac{15}{1.2 \times 10^{-5} \times 0.5}} = 2.83 \qquad \textbf{(2)}$$

From table f'=0.816

$$u_1 = Uf' = 15 \times 0.816 = 12.25\text{m/s} \qquad \textbf{(1)}$$

$$\eta_2 = y\sqrt{\frac{U}{\nu x_2}} = 0.002\sqrt{\frac{15}{1.2 \times 10^{-5} \times 1}} = 2.00 \qquad \textbf{(2)}$$

From table f'=0.630

$$u_2 = Uf' = 15 \times 0.630 = 9.45\text{m/s} \qquad \textbf{(1)}$$

(2) Calculate pressure difference

Assume constant stream pressure, then the manometers are a measure of the local velocity *u* at each position of the pitot inlet, so we can find Δp across each manometer:

$$\Delta p_1 = \frac{\rho}{2}u_1^2 = \frac{1.2}{2}(12.25)^2 = 90 \text{ Pa} = \Delta\rho g h_1 = (998-1.2)(9.81)h_1, \quad \mathbf{h_1 \approx 9.2\ mm} \qquad \textbf{(2)}$$

$$\Delta p_2 = \frac{\rho}{2}u_2^2 = \frac{1.2}{2}(9.45)^2 = 54 \text{ Pa} = (998-1.2)(9.81)h_2, \quad \text{or:} \quad \mathbf{h_2 \approx 5.5\ mm} \quad \textit{Ans.} \qquad \textbf{(2)}$$