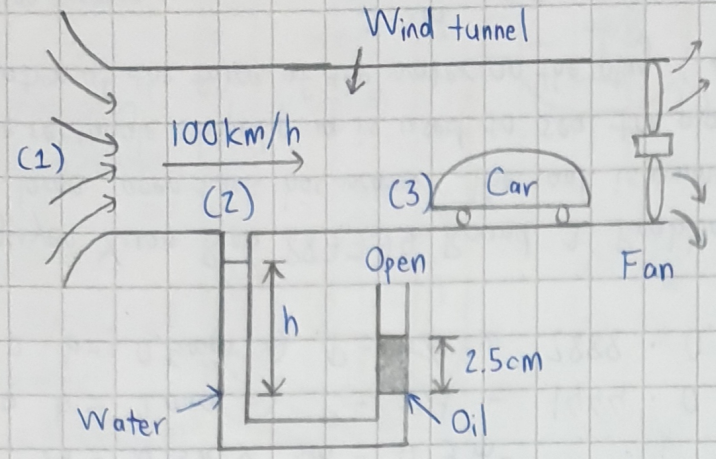
Nguyen Xuan Binh 887799 Round 2 Problem 2



Air is drawn into a wind tunnel used for testing automobiles.

a) Determine "h" when $V = 100\,km/h$ and $h_{oil} = 2.5\,cm$

b) Determine difference between the stagnation pressure on front of car and pressure in the test section

Specific gravity of oil is 0.9

Density of air is $1.2\,kg/m^3$

a) Hydrostatic pressure of the manometer : $p_2 + \rho_w = p_0$

$\Rightarrow p_2 + \rho_w hg = p_0 (0.025m) g$. We have $\rho_w = 1000\,kg/m^3 \Rightarrow p_0 = 0.9\rho_w = 900\,\frac{kg}{m^3}$

$\Rightarrow p_2 + 1000 \cdot h \cdot 9,81 = 900 \cdot 0,025 \cdot 9,81$

$\Rightarrow p_2 + 9810h = 220,725$ (1)

$V_2 = V = 100\,km/h = 250/9\,m/s$

Bernoulli equation : $h_{p_1} + h_{v_1} + z_1 = h_{p_2} + h_{v_2} + z_2$. We have $z_1 = z_2$

$\Rightarrow \frac{p_1}{\rho g} + \frac{v_1^2}{2g} = \frac{p_2}{\rho g} + \frac{v_2^2}{2g}$. P_1 is atmospheric pressure, affecting both outside and inside tunnel $\Rightarrow p_1 = 0$. Assume v_1 is not affected by the fan

$\Rightarrow v_1 = 0 \Rightarrow \frac{p_2}{\rho g} + \frac{v_2^2}{2g} = 0$

$\Rightarrow p_2 + \frac{1}{2}\rho_{air} v_2^2 = 0 \Rightarrow p_2 = -\frac{1}{2}(1,2\ kg/m^3)\left(\frac{250}{9}\right)^2 m/s = -\frac{12500}{27}\ Pa$

From (1): $p_2 + 9810h = 220,725 \Rightarrow h = \frac{220,725 - p_2}{9810} = \frac{220,725 + 12500/27}{9810}$

$\Rightarrow h \approx 0.06969\ m \Rightarrow h \approx 6.969\ (cm)$

b) Bernoulli equation: $hp_2 + hv_2 + z_2 = hp_3 + hv_3 + z_3$. We have $z_2 = z_3$

$\Rightarrow hp_2 + hv_2 = hp_3 + hv_3$ ((2) is the test section and (3) is in front of the car)

$\Rightarrow p_2 + \frac{1}{2}\rho_{air} v_2^2 = p_3 + \frac{1}{2}\rho_{air} v_3^2$. The air flows stop before the car $\Rightarrow v_3 = 0$

↑ Test pressure ↑ Stagnant pressure

$\Rightarrow p_2 + \frac{1}{2}\rho_{air} v_2^2 = p_3 \Rightarrow$ Stagnant pressure difference from test section's pressure is:

$p_3 - p_2 = \frac{1}{2}\rho_{air} v_2^2 = \frac{1}{2} \cdot 1,2\ kg/m^3 \cdot \left(\frac{250}{9}\right)^2 m/s = 462.96\ Pa$ (answer)