

Example 8.4/8.6/8.7 (Blimp problem)

Assume $v_m = v_p$ and $\rho_m = \rho_p$
(air at the same temperature)

Prototype

$$L_p = 60 \text{ m}$$

$$D_p = 5 \text{ m}$$

$$\Delta p_p = p_A - p_B = ?$$

$$F_p = ?$$

$$V_p = 10 \text{ m/s}$$

Dynamic Similarity
(equal Re numbers)

$$Re_m = \frac{V_m L_m}{\nu_m} = \frac{V_p L_p}{\nu_p} = Re_p$$

Model (1/10 scale)

$$\Delta p_m = p_{A'} - p_{B'} = 17.8 \text{ kPa}$$

$$F_m = 1,530 \text{ N}$$

$$V_m = ?$$

$$D_m = 0.5 \text{ m}$$

$$L_m = 6 \text{ m}$$

$$\frac{V_m}{V_p} = \frac{L_p}{L_m} = \frac{D_p}{D_m} = 10$$

Final Answer: $V_m = 100 \text{ m/s}$

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$$V_p = 10 \text{ m/s}$$

Model (1/10 scale)

$$\Delta p_m = p_{A'} - p_{B'} = 17.8 \text{ kPa}$$

Pressure similarity
(equal pressure coefficients)

$$V_m = ?$$

$$D_m = 0.5 \text{ m}$$

$$L_m = 6 \text{ m}$$

$$F_m = 1,530 \text{ N}$$

$$C_{Pm} = \frac{\Delta p_m}{\frac{1}{2} \rho_m V_m^2} = \frac{\Delta p_p}{\frac{1}{2} \rho_p V_p^2} = C_{Pp}$$

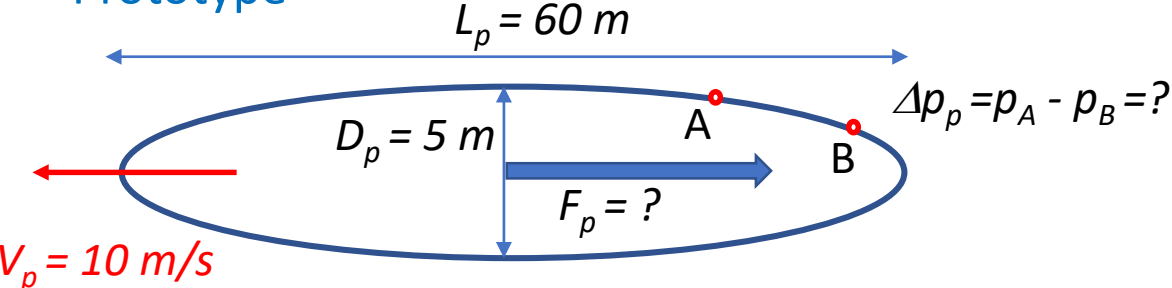
$$\frac{\Delta p_p}{\Delta p_m} = \left(\frac{V_p}{V_m} \right)^2 = \frac{1}{100}$$

Final Answer: $\Delta p_p = 178 \text{ Pa}$

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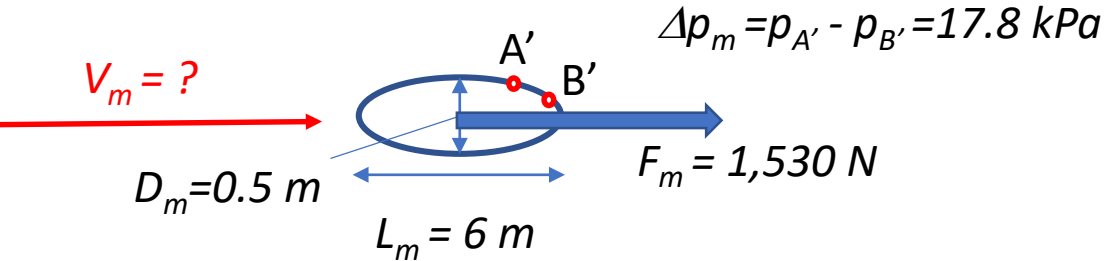


$$\frac{V_m}{V_p} = \frac{L_p}{L_m} = \frac{D_p}{D_m} = 10$$

Force Similarity

$$\frac{\bar{F}_p^u}{\bar{F}_m^u} = \frac{\bar{F}_p^p}{\bar{F}_m^p} = \frac{\bar{F}_p^g}{\bar{F}_m^g} = \frac{\bar{F}_p^i}{\bar{F}_m^i}$$

Model (1/10 scale)



$$\frac{F_p}{F_m} = \frac{\rho_p L_p^2 V_p^2}{\rho_m L_m^2 V_m^2}$$

...or equal Drag Coefficients

Projected object areas on planes normal to inflow direction:

$$A_p = \frac{\pi D_p^2}{4} \quad \& \quad A_m = \frac{\pi D_m^2}{4}$$

$$C_{Dm} = \frac{F_m}{\frac{1}{2} \rho_m V_m^2 A_m} = \frac{F_p}{\frac{1}{2} \rho_p V_p^2 A_p} = C_{Dp}$$

Final Answer: $F_p = F_m = 1,530 \text{ N}$