Solutions

2.1

- Five variables (F, ρ, V, D, μ) in three dimensions (M, L, T): $5 - 3 = \mathbf{2}$ groups.
- $F/(\rho V^2 D^2)$, a drag coefficient, and $\rho V D/\mu = Re$.

2.2

- $Re = VD/\nu = 1.2 \times 0.05/(1.004 \times 10^{-6}) = \mathbf{59\,800}$.
- Far above 4000: **turbulent**.

2.3

- Equal Re: $V_m = V_p(L_p/L_m)(\nu_m/\nu_p) = 25 \times 5 \times (1.004 \times 10^{-6}/1.516 \times 10^{-5}) = \mathbf{8.28}$ m/s.

3.1

- Equal C_D: $F_p = F_m(\rho_p/\rho_m)(V_p/V_m)^2(L_p/L_m)^2 = 900 \times (1.204/998) \times (25/8.28)^2 \times 5^2 = \mathbf{248}$ N.
- $C_D = F/(\frac{1}{2}\rho V^2 A) = 248/(0.5 \times 1.204 \times 25^2 \times 2.2) = \mathbf{0.30}$.
- In air the model would need $25 \times 5 = 125$ m/s, a third of the speed of sound, so compressibility would spoil the similarity.

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