Solutions

2.1

- $Re_L = UL/\nu = 3 \times 0.8/(1.516 \times 10^{-5}) = \mathbf{1.58 \times 10^5}$, below 5×10^5: **laminar**.
- $\delta = 5L/\sqrt{Re_L} = 5 \times 0.8/\sqrt{1.58 \times 10^5} = \mathbf{10.1}$ mm.

2.2

- $C_f = 1.328/\sqrt{Re_L} = 1.328/\sqrt{1.583 \times 10^5} = 0.00334$.
- One side: $F = C_f \frac{1}{2}\rho U^2 A = 0.00334 \times 0.5 \times 1.204 \times 3^2 \times 0.4 = 0.00723$ N.
- Both sides: $F = 2 \times 0.00723 = \mathbf{0.0145}$ N.

2.3

- $Re = UD/\nu = 20 \times 0.08/(1.516 \times 10^{-5}) = 1.06 \times 10^5$, below the drag crisis, so $C_D = 1.2$ holds.
- $F_D = C_D \frac{1}{2}\rho U^2 A = 1.2 \times 0.5 \times 1.204 \times 20^2 \times (0.08 \times 6) = \mathbf{138.7}$ N.
- Uniform wind acts at mid-height: $M = F_D \times 3 = \mathbf{416}$ N $\cdot$ m.

3.1

- $F_D = C_D \frac{1}{2}\rho U^2 A = 0.30 \times 0.5 \times 1.204 \times 30^2 \times 2.2 = \mathbf{358}$ N.
- $P = F_D U = 357.6 \times 30 = \mathbf{10.7}$ kW.
- $P \propto U^3$: factor $(35/30)^3 = \mathbf{1.59}$, so $P = 1.59 \times 10.7 = \mathbf{17.0}$ kW.

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