Fluid Mechanics and Rate Processes: Tutorial 10

P1. A small low-speed wind tunnel (Fig. P1) is being designed for calibration of hot wires. The air is at 19°C. The test section of the wind tunnel is 30cm×30cm×30cm. The flow through the test section must be as uniform as possible. The wind tunnel speed ranges from 1 to 8 m/s, and the design is to be optimized for an air speed of V = 4.0 m/s through the test section. (*a*) For the case of nearly uniform flow at 4.0 m/s at the test section inlet, by how much will the centerline air speed accelerate by the end of the test section? (*b*) Recommend a design that will lead to a more uniform test section flow.

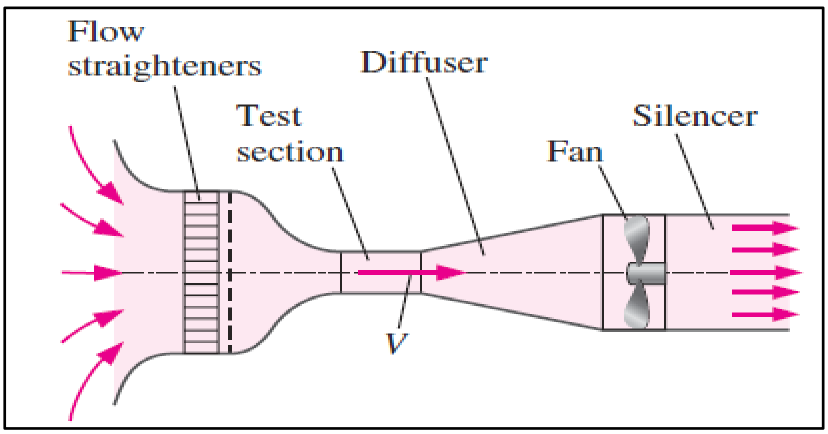


Fig.P1

P2. Advertisement signs are commonly carried by taxicabs for additional income, but they also increase the fuel cost. Consider a sign that consists of a 0.30-m-high, 0.9-m-wide, and 0.9-m-long rectangular block mounted on top of a taxicab such that the sign has a frontal area of 0.3 m by 0.9 m from all four sides. Determine the increase in the annual fuel cost of this taxicab due to this sign. Assume the taxicab is driven 60,000 km a year at an average speed of 50 km/h and the overall efficiency of the engine is 28 percent. Take the density, unit price, and heating value of gasoline to be 0.75 kg/L, Rs65/L, and 42,000 kJ/kg, respectively, and the density of air to be 1.25 kg/m^3.

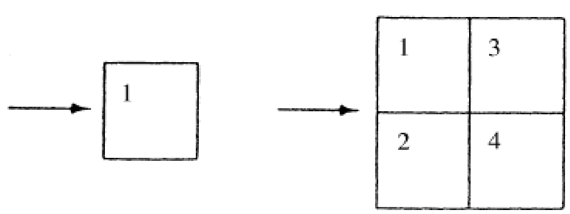
Fig.P2

P3. Perform a flat-plate momentum analysis on given sinusoidal profile:

$$\frac{u}{U} \approx \sin\left(\frac{\pi y}{2\delta}\right)$$

Compute momentum-integral estimates of C_f, δ/x, δ^*/x, and δ^{**}/x.

P4. Consider laminar flow past the square-plate arrangements in the figure below. Compared to the drag of a single plate (1), how much larger is the drag of four plates together as in configurations (a) and (b)? Explain your results.



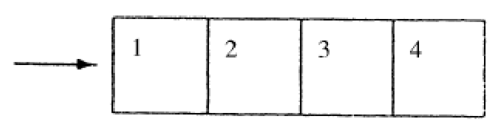


Fig.P4(a)

Fig.P4(b)