

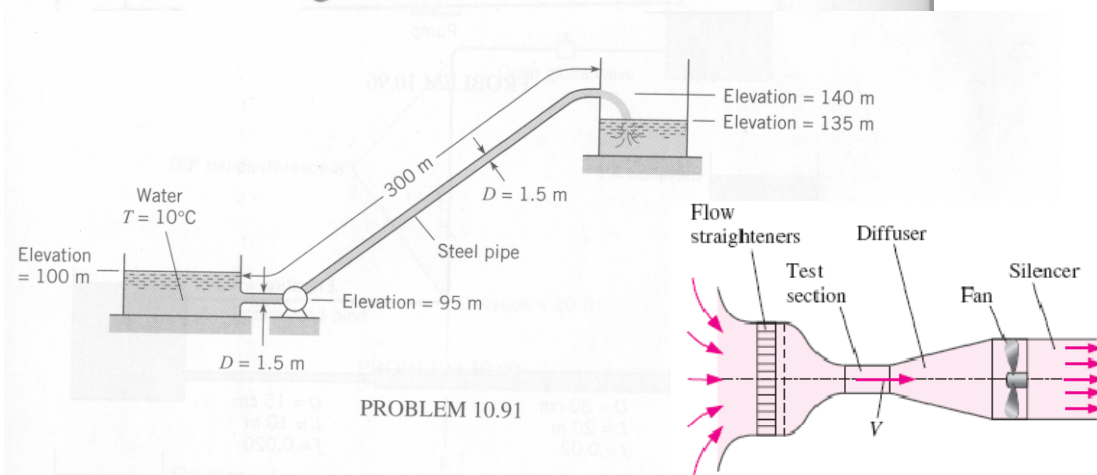
Review problems for Exam 3, 057:020-Fall 2007

Friction factor and head loss

Water at 40°F ($\rho = 62.42 \text{ lbm/ft}^3$ and $\mu = 1.038 \times 10^{-3} \text{ lbm/ft} \cdot \text{s}$) is flowing through a 0.12-in- (= 0.010 ft) diameter 30-ft-long horizontal pipe steadily at an average velocity of 3.0 ft/s (Fig. 8–18). Determine (a) the head loss, (b) the pressure drop, and (c) the pumping power requirement to overcome this pressure drop.

Minor loss

10.91 Water is pumped at a rate of $20 \text{ m}^3/\text{s}$ from the reservoir and out through the pipe, which has a diameter of 1.50 m. What power must be supplied to the water to effect this discharge?



Boundary layer

A small low-speed wind tunnel (Fig. 10–106) is being designed for calibration of hot wires. The air is at 19°C. The test section of the wind tunnel is 30 cm in diameter and 30 cm in length. 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 $V = 4.0 \text{ m/s}$ 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.

FIGURE 10–106

Drag force

A 2.2-cm-outer-diameter pipe is to span across a river at a 30-m-wide section while being completely immersed in water (Fig. 11–38). The average flow velocity of water is 4 m/s and the water temperature is 15°C. Determine the drag force exerted on the pipe by the river.

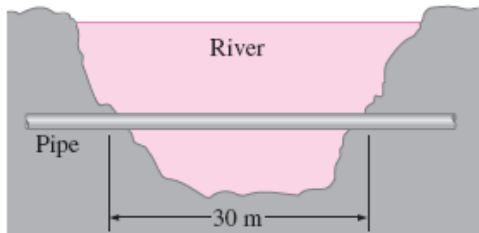


FIGURE 11–38

Dimensional Analysis

A one-sixteenth scale model tractor-trailer truck (18-wheeler) is tested in a wind tunnel as sketched in Fig. 7–38. The model truck is 0.991 m long, 0.257 m tall, and 0.159 m wide. During the tests, the moving ground belt speed is adjusted so as to always match the speed of the air moving through the test section. Aerodynamic drag force F_D is measured as a function of wind tunnel speed; the experimental results are listed in Table 7–7. Plot the drag coefficient C_D as a function of the Reynolds number Re , where the area used for the calculation of C_D is the frontal area of the model truck (the area you see when you look at the model from upstream), and the length scale used for calculation of Re is truck width W . Have we achieved dynamic similarity? Have we achieved Reynolds number independence in our wind tunnel test? Estimate the aerodynamic drag force on the prototype truck traveling on the highway at 26.8 m/s. Assume that both the wind tunnel air and the air flowing over the prototype car are at 25°C and standard atmospheric pressure.

TABLE 7–7

Wind tunnel data: aerodynamic drag force on a model truck as a function of wind tunnel speed

V , m/s	F_D , N
20	12.4
25	19.0
30	22.1
35	29.0
40	34.3
45	39.9
50	47.2
55	55.5
60	66.0
65	77.6
70	89.9

