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1. A 1-m-diameter cylindrical mass is connected to a 2-m-wide rectangular gate as shown in Fig. 1. The gate is to open when the water level, h, drops below 2.5 meter. Determine (a) the hydrostatic pressure force F_R and the pressure center y_R acting on the gate and (b) the tension T acting on the cable and (c) the mass of the cylinder, M. Neglect friction at the gate hinge and the pulley. (Note: $\gamma = 9.8\times10^3$ N/m^3 for water)

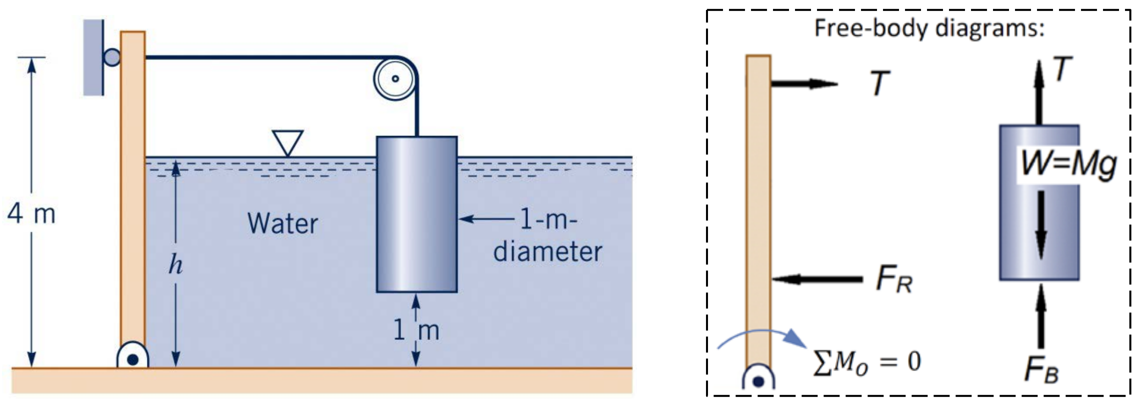

Figure 1

2. Water at 60°F ($\rho = 1.94$ slugs/ft^3 and $\gamma = 62.4$ lb/ft^3) flows through a *horizontal* elbow-nozzle combination as shown in Fig. 2. (a) By assuming a head loss of 1 ft associated with the elbow-nozzle combination flow, determine the horizontal anchoring force F_x needed to hold the elbow-nozzle combination in place. (b) Repeat part (a) by assuming no losses.

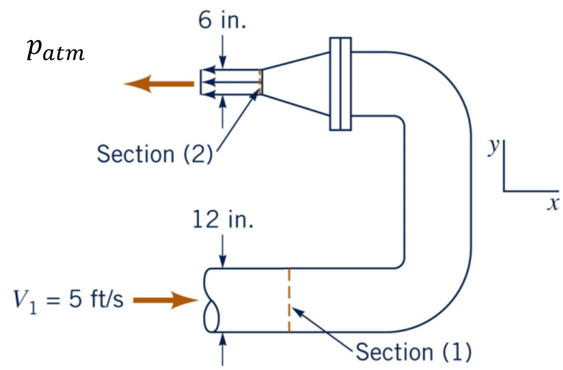

Figure 2

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3. A wide moving belt passes through a container of a viscous liquid. The belt moves vertically upward with a constant velocity, V_0, as shown in Fig. 3. Because of viscous forces the belt picks up a film of fluid of thickness h. Gravity tends to make the fluid drain down the belt. If the flow is assumed steady, laminar, and fully developed, the exact solution of the Navier-Stoke equation is given as

$$v(x) = \frac{\gamma}{2\mu}x^2 + c_1 x + c_2$$

where γ is the specific weight of the liquid and μ the viscosity. (a) Use appropriate boundary conditions (at $x = 0$ and h) to determine the coefficients c_1 and c_2 and complete the solution equation in terms of γ, μ, h, V_0 and x. Assume that the atmosphere offers no shear force to the film surface. (b) Find the shearing stress that the liquid exerts on the belt surface and the flow rate per unit width q of the fluid film if the liquid is Glycerin at 20°C ($\gamma = 1.24 \times 10^4$ N/m^3 and $\mu = 1.50$ N·s/m^2), $V_0 = 1.5$ cm/s, and $h = 2$ mm.

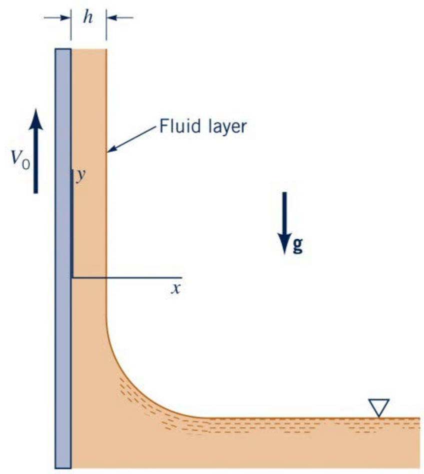

Figure 3

4. Water at 68°F ($\rho = 1.94$ slug/ft^3 and $\mu = 2.09 \times 10^{-5}$ lb·s/ft^2) is to be pumped through 2,000 ft of pipe from reservoir 1 to 2, as shown in Fig. 4. The pipe is cast iron ($\varepsilon = 0.00085$ ft) and its diameter is 7.5 inches. If the pump delivers a head of 250 ft to the water, determine the flow rate Q expected. Use the following formula for friction factor.

$$\frac{1}{\sqrt{f}} = -1.8\log\left[\left(\frac{\varepsilon/D}{3.7}\right)^{1.1} + \frac{6.9}{Re}\right]$$

Note: This problem requires an iteration process. You may use $f = 0.02$ as the initial guess.

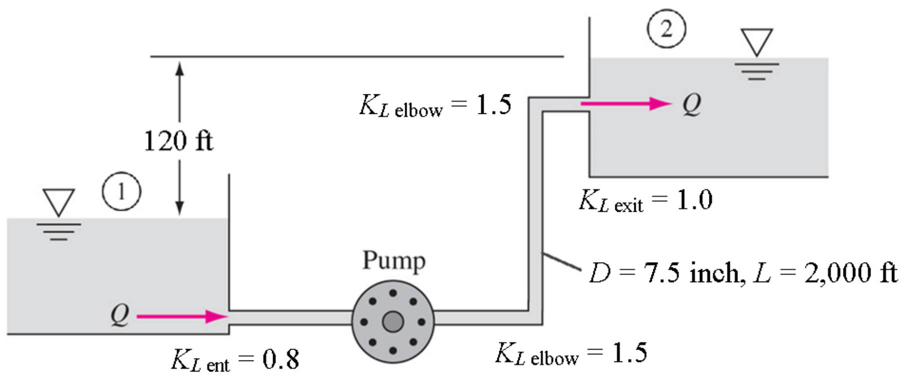

Figure 4

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5. The passenger compartment of a minivan traveling at 60 m/h in ambient air at 1 atm and 80°F (ρ = 2.28 slugs/ft^3 and ν = 1.697 × 10^{-4} ft^2/s) can be modeled as a 3.2-ft-high, 6-ft-wide, and 11-ft-long rectangular box (Fig. 5). The airflow over the exterior surfaces can be assumed to be turbulent from the beginning because of the intense vibrations involved. Determine the friction drag force acting on the top and the two side surfaces of the van. You may use Figures A1 and A2 in appendix to find formulas for local friction coefficient and friction drag coefficient, respectively. (Note: 1 m/h = 1.4667 ft/s)

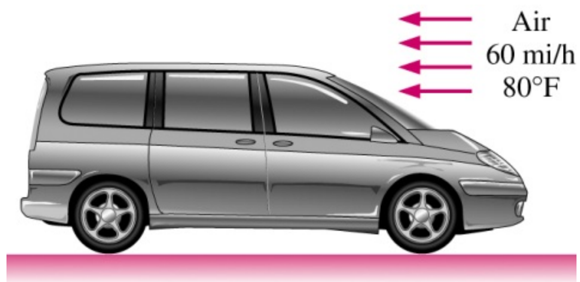

Figure 5

6. (a) The drag D on a moving sphere through a fluid is a function of the sphere diameter d, velocity U, and its surface roughness ε, and the fluid density ρ and kinematic viscosity ν, i.e., $D = f(d, U, \varepsilon, \rho, \nu)$. By using the Pi theorem, derive a suitable set of dimensionless variables for this problem. (b) Fig. 6 illustrates some experimental relationship between the dimensionless variables. Find the drag on a well-hit ball (d = 3 inch and ε = 3.75×10^{-2} inch) that is traveling at U = 51 ft/s through standard air (ρ = 2.38 × 10^{-3} slugs/ft^3 and ν = 1.57 × 10^{-4} ft^2/s).

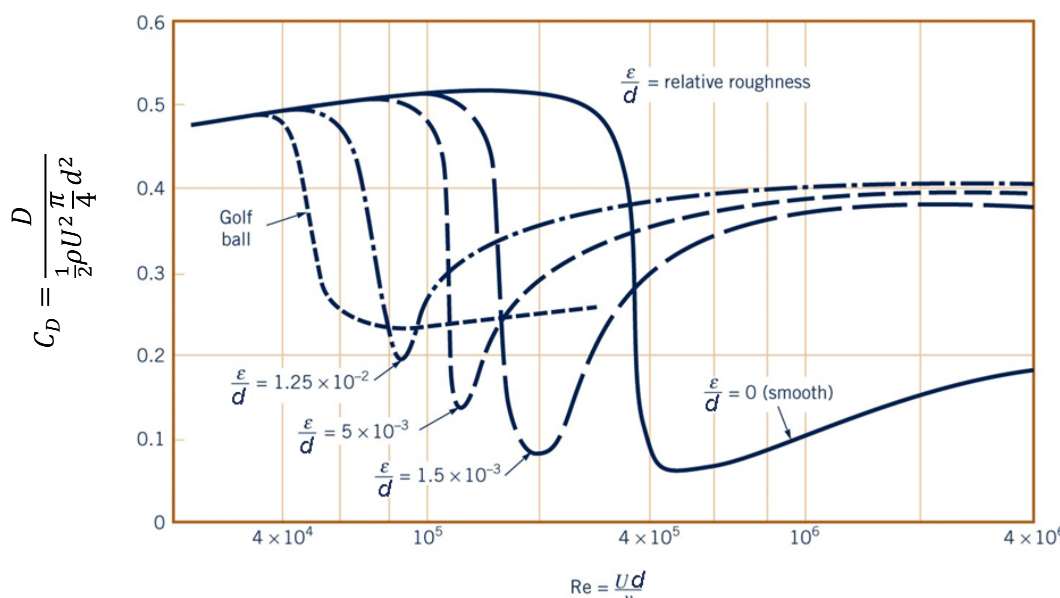

Figure 6

Appendix for Problem 5:

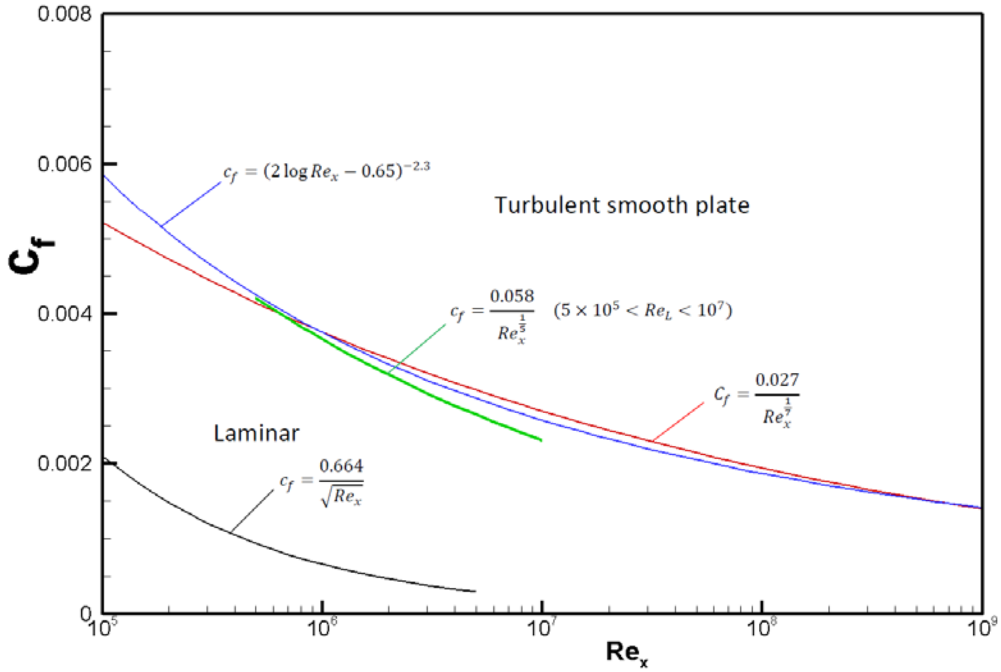

Figure A1: Local friction coefficient

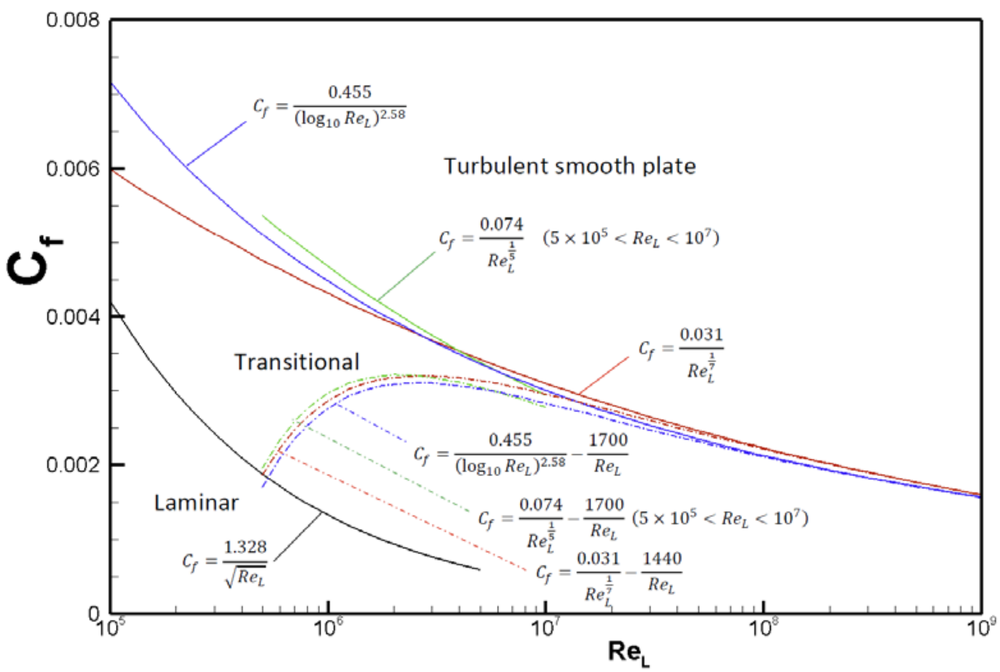

Figure A2: Friction drag coefficient