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1. The canal shown in cross section in Fig. 1 runs 40 m into the paper. Determine (a) the horizontal F_H and vertical F_V components of the hydrostatic force against the quarter-circle wall (section A-B) and (b) the magnitude of resultant force F_R and the angle θ that the resultant force strikes the center of pressure (*c.p.*) on the wall. Use the specific weight γ = 9.79 kN/m^3 for the water.

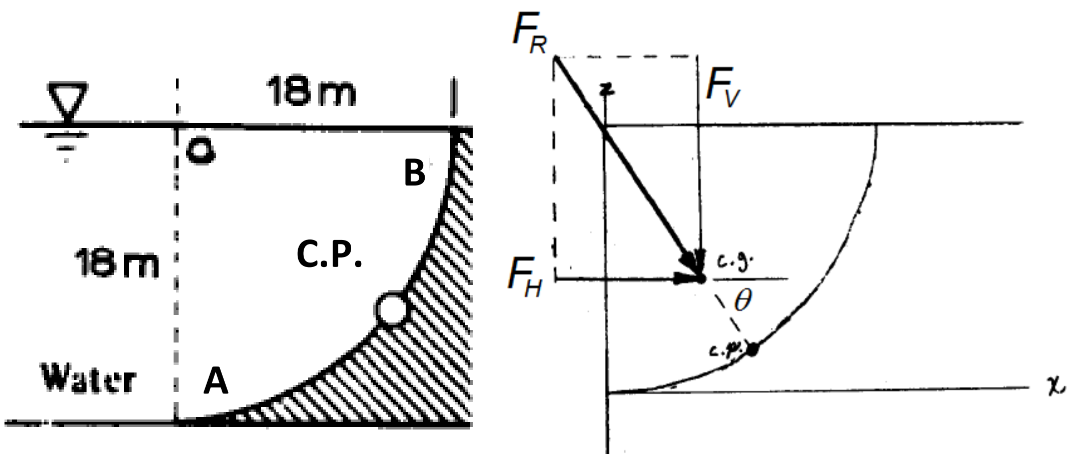

Figure 1

2. On the right end of a 9-in diameter pipe is a nozzle which discharges a 3-in-diameter water jet into the air (Fig. 2). At section 1, the water pressure p_1 = 60 psi (i.e., 8,640 lb/ft^2) and the water velocity V_1 = 9.9 ft/s. Compute (a) the jet velocity V_2, (b) the axial force on the nozzle F_x, and (c) the head loss h_L in the nozzle. Use ρ = 1.94 slugs/ft^3 for the water.

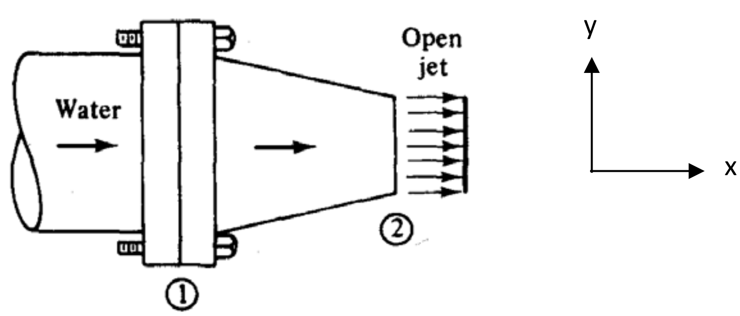

Figure 2

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3. The designers of a large tethered pollution-sampling balloon (Fig. 3) wish to know what the drag D will be on the balloon for the maximum anticipated wind speed V = 5 m/s (the air is assumed to be at 20°C). From a dimensional analysis, it is known that the non-dimensional drag is a function of Reynolds number when the prototype and a model are geometrically similar each other, i.e.,

$$\frac{D}{\rho d^2 V^2} = \phi\left(\frac{\rho V d}{\mu}\right)$$

where, d is the diameter of the balloon and ρ and μ are the density and viscosity of the fluid, respectively. A 1/20-scale model is built for testing in water at 20°C. What water speed is required to model the prototype? At this speed the model drag is measured to be D_m = 2 kN. What will be the corresponding drag on the prototype? Use ρ = 1.24 kg/m^3 and $\mu = 1.8 \times 10^{-5}$ N·s/m^2 for the air and ρ_m = 999 kg/m^3 and $\mu_m = 10^{-3}$ N·s/m^2 for the water used for the model testing.

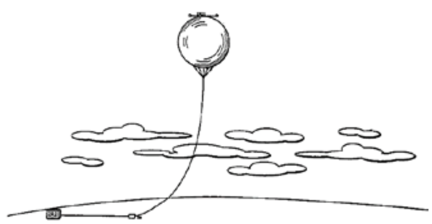
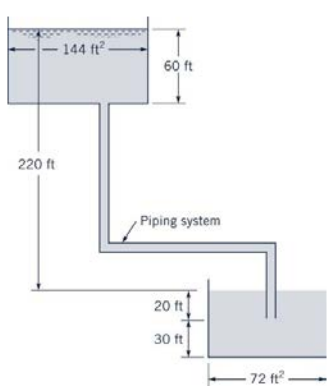


Figure 3

4. Calculate the water flow rate in the system shown in Fig. 4. The piping system includes four gate valves, two half-open globe valves, fourteen 90° regular elbows, and 250 ft of 2-in. diameter commercial steel pipe (roughness ε = 0.00015 ft). Assume a square-edged pipe entrance and kinematic viscosity $\nu = 1.21 \times 10^{-5}$ for water. Use trial and error method by using f = 0.019 as your initial guess then the following equation

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



Component	K_L
Gate valve	0.15
Half-open globe valve	20.0
90° regular elbow	1.5
Square-edged pipe entrance	0.5
Pipe exit	1.0

Figure 3

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5. The United States at one time in the thirties had three large dirigibles – the Los Angeles, the Graf Zeppelin, and the Akron. The largest was the Akron, having a length of 785 ft and a maximum diameter of 132 ft. Its maximum speed was 84 mph (i.e., 123.2 ft/s). Moving at top speed, estimate the horse power (550 lb ft/s = 1 hp) needed to overcome skin friction, which is a significant part of the drag. You can estimate the skin drag D_f by "unwrapping" the outer surface of the Akron to form a flat plate of 785 ft long and 132π ft wide (See Apendix A for the skin friction coefficient C_f). Disregard effects of protrusion from engine cowlings, cabin region, etc. Assume that the surface is smooth. Consider the Akron at 10,000-ft standard atmosphere (ρ = 0.001756 slugs/ft^3, $\mu = 3.7 \times 10^{-7}$ lb-s/ft^2).

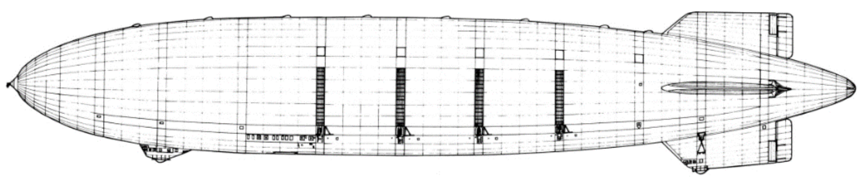

Figure 5

6. Hail is produced by the repeated rising and falling of ice particle in the updraft of a thunderstorm, as is indicated in Fig. 6. When the hail comes large enough, the aerodynamic drag from the updraft can no longer support the weight of the hail, and it falls from the storm cloud. (a) Estimate the velocity U of the updraft needed to make D = 1.5-in.-diameter (i.e., "golf ball-sized") hail, by assuming C_D = 0.5 and ignoring the buoyant force on the hail, and (b) show whether this assumed C_D value is reasonable or not by using the chart in Appendix B. Use density $\rho = 2.28 \times 10^{-3}$ slugs/ft^3 and viscosity $\nu = 1.57 \times 10^{-4}$ ft^2/s for the air and the density of the hail ρ_{ice} = 1.84 slugs/ft^3.

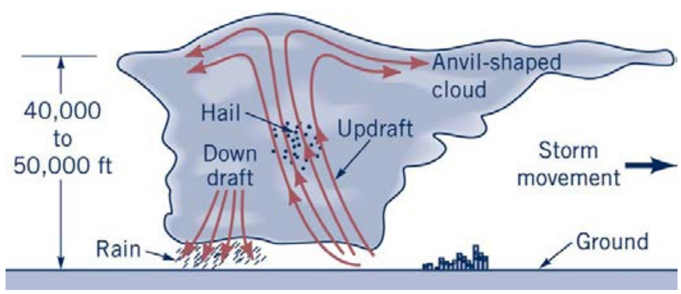

Figure 6

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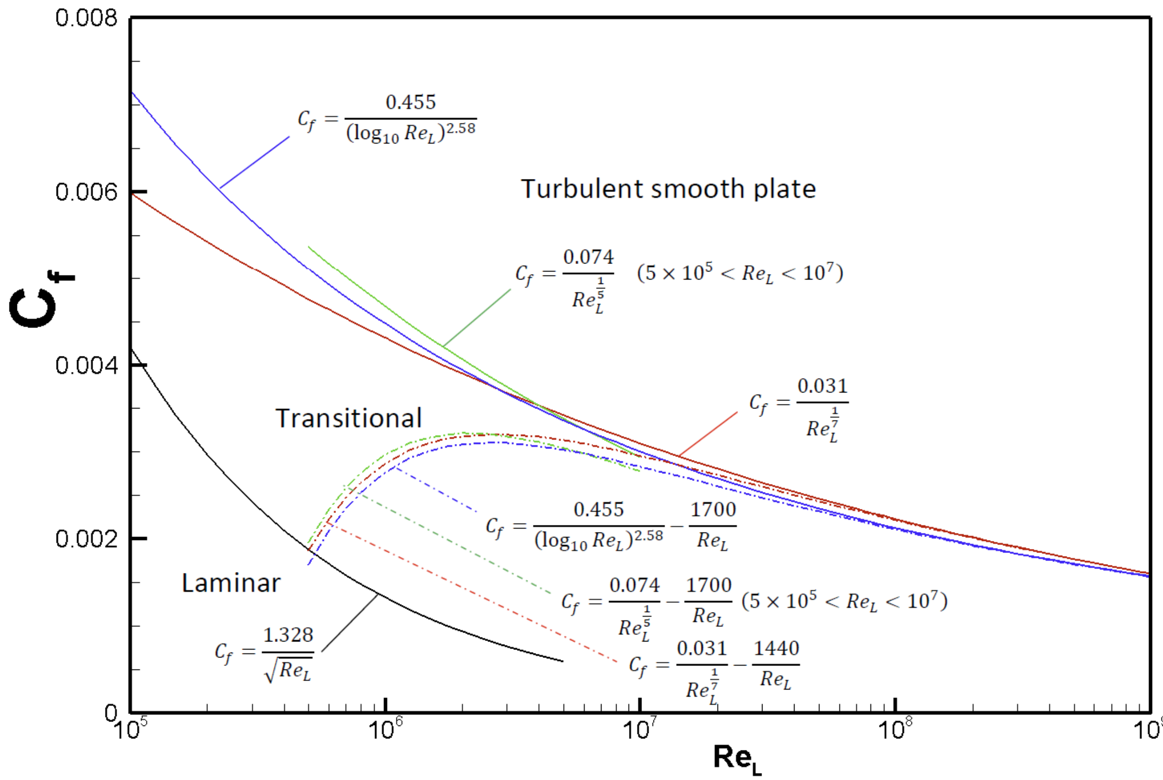
Appendix A. Friction drag coefficient for flat plate



Appendix B. Drag coefficient for a smooth sphere and a smooth cylinder