Exam 2, November 9, 2009

1. The water jet shown in Fig. 1 strikes a vane that is fixed on a frictionless cart. The cart is restrained by a horizontal force, F_x. If ρ = 999 kg/m^3, V_j = 30 m/s, A_j = 0.01 m^2, and θ = 30°, compute the force F_x. The jet velocity magnitude remains constant along the vane surface.

2. When the pump in Fig. 2 draws Q = 220 m^3/h of water at 20°C (ρ = 999 kg/m^3) from the reservoir, the total friction head loss h_L is 5 m. The flow discharges through a nozzle (D_e = 5 cm) to the atmosphere. Calculate the pump power in kW delivered to the water. Assume the kinetic energy correction factor α = 1 in the energy equation.

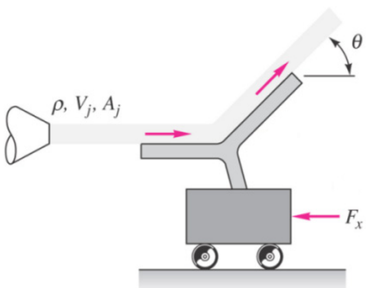

Fig. 1

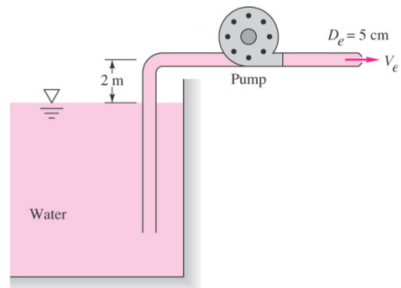

Fig. 2

3. Two horizontal, infinite, parallel plates are spaced a distance b = 5 mm apart, as shown in Fig. 3. A viscous liquid is contained between the plates. The bottom plate is fixed, and the upper plate moves parallel to the bottom plate with a velocity U = 0.2 m/s. The flow is steady and fully developed, and there is no pressure gradient in the direction of flow. (a) Start with the Navier-Stokes equations and determine the velocity distribution $u(y)$ across the plates. (b) Determine the flowrate q passing between the plates (for a unit width).

4. Flow characteristics for a 30-ft-diameter prototype parachute (Fig. 4) are to be determined by tests of a 1-ft-diameter model parachute in a water tunnel. (a) The drag, D, can be expressed as $D = f(\rho, V, d)$, where ρ is the fluid density, V is the parachute velocity, and d is the parachute diameter. Use the dimensional analysis and find a suitable pi parameter for this problem. (b) Some data collected with the model parachute indicate a drag of 17 lb when the water velocity is 4 ft/s. Use the model data to predict the drag on the prototype parachute falling through the air at 10 ft/s. (ρ_{water} = 1.94 slugs/ft^3 and ρ_{air} = 2.38 $\times 10^{-3}$ slugs/ft^3)

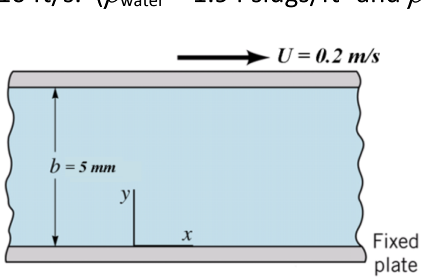

Fig. 3

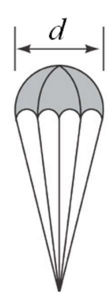

Fig. 4