1. A jet of alcohol (ρ = 788.42 kg/m³) strikes the vertical plate in Fig. 1. The (absolute) pressure \( p_1 = 760 \text{ kPa} \) at section 1. Find (a) the alcohol jet velocity \( V_2 \) at section 2 and (b) the force \( F \) required to hold the plate stationary. For part (a), assume there are no losses in the nozzle flow.

2. Water flows through a vertical pipe, as is indicated in Fig. 2. The vertical distance \( H = 50 \text{ cm} \) between the two points marked with dots at the pipe and the mercury (\( SG = 13.6 \)) manometer height \( h = 5 \text{ cm} \) due to the pressure difference between the two points. (a) What is the head loss \( h_L \) between the two points? (b) Is the flow up or down in the pipe? Explain.

3. Consider a steady, incompressible, parallel, laminar flow of a viscous fluid falling between two infinite, vertical walls as shown in Fig. 3. The distance between the walls is \( h \), and gravity acts in the negative \( z \)-direction (\( g_z = -g \), downward in the figure). There is no forced pressure (\( \partial p / \partial z = 0 \)) driving the flow – the fluid falls by gravity alone. Starting from the following Navier-Stokes equation,

\[
\rho \left( \frac{\partial w}{\partial t} + u \frac{\partial w}{\partial x} + v \frac{\partial w}{\partial y} + w \frac{\partial w}{\partial z} \right) = - \frac{\partial p}{\partial z} + \rho g_z + \mu \left( \frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2} + \frac{\partial^2 w}{\partial z^2} \right)
\]

(a) drive an expression for \( w \) and (b) calculate the centerline velocity (\( w \) along the \( x = 0 \) line) if \( h = 2 \text{ mm} \) and the fluid is glycerin at 20°C (\( \rho = 1,260 \text{ kg/m}^3 \) and \( \mu = 1.49 \text{ N-s/m}^2 \)). Assume the flow is purely two-dimensional (\( v = 0 \) and \( \partial / \partial y = 0 \)) and parallel to the walls (\( u = 0 \)).

4. Liquid flows out of a hole in the bottom of a tank as in Fig. 4. Consider the case in which the hole is very small compared to the tank (\( d \ll D \)). Experiments reveal that average jet velocity \( V \) is nearly independent of \( d, D, \rho, \) or \( \mu \). In fact, for a wide range of these parameters, it turns out that \( V \) depends only on liquid surface height \( h \) and gravitational acceleration \( g \). (a) Using dimensional analysis, generate a dimensionless relationship for \( V \) as a function of \( g \) and \( h \). (b) If the liquid surface height \( h \) is doubled, all else being equal, by what factor will the average jet velocity \( V \) increase?