Problem 1. (10 pts) Consider the first example from the notes we discussed beginning on September 28 (the example with the moving cart). Redo this example using a fixed control volume, by evaluating each of the relevant terms in the momentum equation.

Problem 2. (10 pts) A high-speed water jet is directed into a large basin, as shown. The jet has velocity $V = 5 \text{ m/s}$ and diameter $d = 2 \text{ cm}$, and the water is at a temperature of $20^\circ C$. The basin has circular cross-section with diameter $D = 1.2 \text{ m}$, sits on a scale (which measures vertical force), and is held to prevent it from moving horizontally. You can assume that the water inside the basin that isn’t in the jet is stationary. At the instant when the water in the basin has depth $h = 0.3 \text{ m}$, use the momentum equation to determine the horizontal force necessary to hold the basin still. What force will be read out by the scale at that instant? You may ignore the effect of gravity on the water jet itself.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{prob2.png}
\caption{Problem 2}
\end{figure}

Problem 3. (10 pts) A snowplow is clearing a $w = 5$-foot-wide swath of fresh snow that has a depth of $h = 6 \text{ in}$. The snow has specific gravity 0.30. What power is required just to clear the snow if the snowplow moves at $V = 20 \text{ mph}$ (i.e. you can ignore the power that would be required to propel the snowplow if there were no snow)? Ignore frictional effects.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{prob3.png}
\caption{Problem 3}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{topview.png}
\caption{Top view}
\end{figure}

**Problem 5.** (10 pts) Consider a rocket sled on a plane inclined at $\theta = 30^\circ$ from the horizontal. The empty sled has mass $m_0 = 100$ kg; initially the sled holds $m_f = 900$ kg of fuel, which it consumes at a rate $\dot{m} = 3$ kg/s. The rocket’s exhaust gases have velocity $v'_e = 2500$ m/s relative to the rocket. The sled’s bottom is flat, with area $A = 8$ m$^2$, and the sled slides on an $h = 10$ mm thick layer of SAE 10W oil that coats the plane. Write the differential equation that describes the velocity of the sled, $V_s(t)$, if the rocket is at rest at $t = 0$. What’s the maximum velocity of the sled in this case? What’s the maximum velocity if you ignore the viscous forces? You can ignore air resistance throughout this problem.