5.14: Comparison of ballistic and non-ballistic MOSFETs.

If we calculate the $IV$ of a conventional MOSFET with a channel length in the ballistic regime, we obtain $IV$ curves that are qualitatively similar to the ballistic result. For example, the classical model of a MOSFET with a channel length of 40 nm is shown in Figure 5.13.6. It is qualitatively similar to Figure 5.13.1. Both possess a linear and a saturation regime, and both exhibit identical subthreshold behavior. But the magnitude of the current differs quite substantially. The ballistic device exhibits larger channel currents due to the absence of scattering.

Another way to compare ballistic and non-ballistic MOSFETs is to return to the water flow analogy. As before, the source and drain are modeled by reservoirs. The channel potential is modeled by a plunger. Gate-induced changes in the channel potential cause the plunger to move up and down in the channel. The most important difference between the ballistic and non-ballistic MOSFETs is the profile of the water in the channel. The height of the water changes in the non-ballistic device, whereas water in the ballistic channel does not relax to lower energies during its passage across the channel.
Figure \(\PageIndex{1}\): The water flow analogy for the operation of ballistic and classical MOSFETs. Conduction in the channel is controlled by a plunger that models the channel potential. The transistors are turned ON by lowering the gate potential. Then, as the height of the drain reservoir decreases (corresponding to increased \(V_{\text{DS}}\)), the channel first enters the linear regime (where current flow is limited by \(V_{\text{DS}}\)) and then the saturation regime where the current is controlled only by the gate potential.