Project 2 discussion

Task 1

The result presented in both Reference Solutions is robust over a wide range of mesh resolution and time step size. If the time step size is too large, the edge of the “mushroom cloud” would become blurred. Inadequate choices of spatial resolution and time step size may also lead to formation of zigzag-like edge for the “mushroom”.

The volume of methane associated with the mushroom at t = 7s is slightly different between (a) and (b). This is not unexpected, since the imposed 75 Pa pressure at the small pressure inlet does not imply a constant mass flow rate for methane. (If it is a velocity inlet with an imposed constant velocity, the mass flow rate will be fixed, and the mushroom in (a) and (b) will have the same mass.) The mushroom is slightly smaller in (b), because the imposed mean flow increases the environmental pressure in the interior, and reduces the inward pressure gradient that pushes methane from the small inlet into the main domain.

Task 2

The result presented in both Reference Solutions is robust over a wide range of mesh resolution and time step size. A significant deviation from the reference solution is usually caused by a large time step size. The detail in the contour plot of velocity magnitude is somewhat sensitive to the spatial and temporal resolution. As shown in both Reference Solutions, “flapping” of water surface generates a pair of vortices in the air. The structure of the vortices depends on the detailed evolution of the water surface over a short period of time.

Task 3

The Reference Solutions present examples of reasonable choices of computational domain, mesh resolution, and time step size. Reference Solution #1 uses a slightly bigger domain, imposes a coarser global mesh resolution first, then locally refines a smaller sub-domain that covers the path of the blob of glycerin. Reference Solution #2 uses a smaller domain and a uniform mesh resolution through the whole domain. Both strategies work under the limit of 500K elements.

The key feature of this simulation is the sliding down of the blob of glycerin and detachment of its leading edge from the slope at t = 0.1s. Because the gap between the “hanging” leading edge and the slope is small, this feature would not be properly simulated if the mesh resolution is too coarse.

Task 4

The period of oscillation is around 1s. In the contour plot, the x-velocity at bottom should be positive (going from left to right) at t = t1, and negative at t = t2. (Note that in Reference Solution #2 the plot for t = t2 adopts a reverse color scale, with red being strongly negative.) An interesting feature is that, over the curved section, the maximum velocity is located closer to the inner edge of the pipe. This is different from the behavior observed in Task 2 (helical pipe) of Project 1. But note that the physical setup is different for the two systems. In this current task, the flow through the bottom of the pipe is driven by an internal exchange between potential energy and kinetic energy. There is no external source of kinetic energy or momentum. In contrast, in Task 2 of Project 1, momentum is constantly pumped into the system from the velocity inlet.