MAE598/494 Applied CFD, Fall 2019, Project 1 discussion

Task 1

See reference solutions for detailed contour plots and line plots. The contour plots and outlet temperature as shown in the solutions are robust (see statistics below), and a significant outlier with respect to those solutions is a strong indication of errors in the setup.

With a stronger gravity in Task 1a, the "cool waterfall" drops much sooner (closer to the left wall) compared to its counterpart in Task 1b. The outlet temperature for Task 1a is typically around 291°K ± 1.5°K, and that for Task 1b is at a lower value of around 287.5°K ± 1.5°K.

Task 1a

Outlet temperature, # of answers from the class
(287.x indicates answers within the range of 287-287.99 K)
287.x * 1
288.x *** 3
289.x ********* 9
290.x ******************************** 32
291.x ****************************** 30
292.x **** 4
293.x 0
294.x * 1
Significant outlier (outside the range of [287, 295]) or no answer: 17

Task 1b

Outlet temperature, # of answers from the class
284.x 0
285.x 0
286.x ******* 7
287.x ** 44
288.x *************** 15
289.x ****** 6
290.x **** 4
291.x ** 2
Significant outlier (outside the range of [284, 292]) or no answer: 20

Task 2

Reference solution #2 includes a back-of-the-envelope calculation of heat budget using the theoretical argument given in class. The values of ΔT obtained are slightly lower than those from numerical simulation using Ansys Fluent. Nevertheless, both show that ΔT is approximately proportional to 1/u where u is the inlet velocity.

Task 3

For this task, it is important to refine time step size to an appropriate value when the result becomes robust. A choice of $\Delta t = 0.1$ s is good enough. (For example, choosing $\Delta t = 0.05$ s would only alter the result slightly.) As previously explained, lowering Δt is more important than adding an excessively large number of iterations within each time step. For example, for a first-order scheme, the inherent numerical error (due to truncation) is proportional to Δt. This error cannot be further reduced no matter how many iterations are performed within a time step.

Task 4

The result of running the simulation with a quarter of the system and declaring two planes of symmetry is generally very close to that obtained by using the full system.