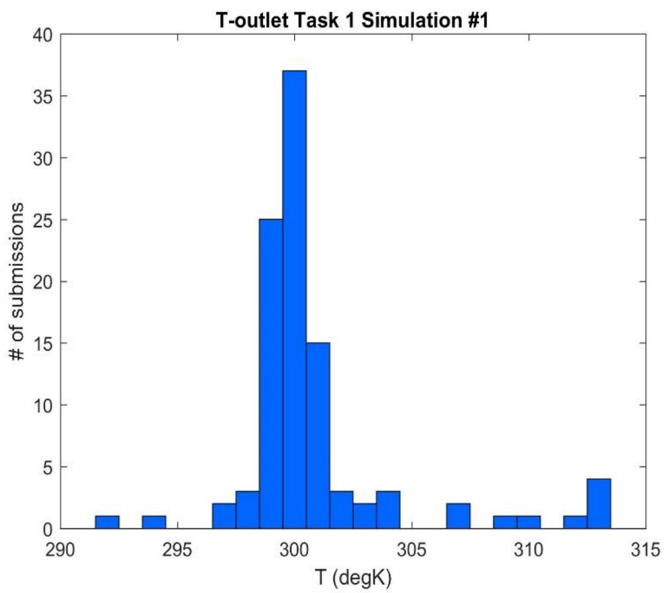
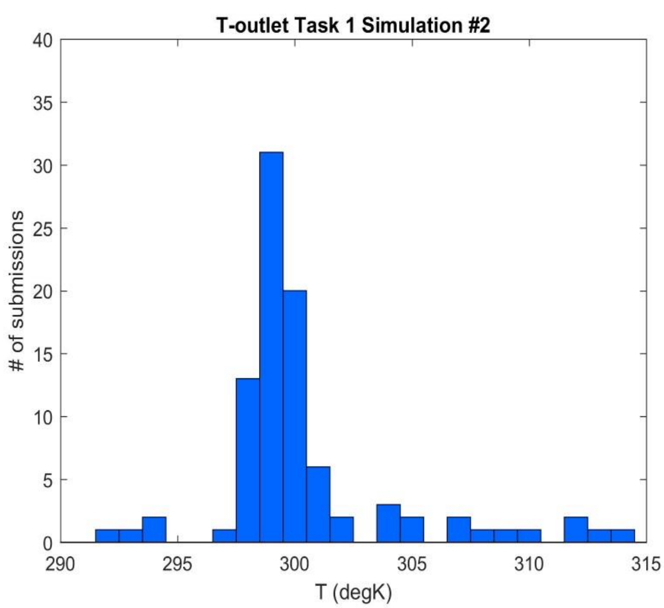
ACFD 2018 Project 1 discussion

Some statistics (from 102 submissions)

Task 1: Outlet temperature for Simulation #1

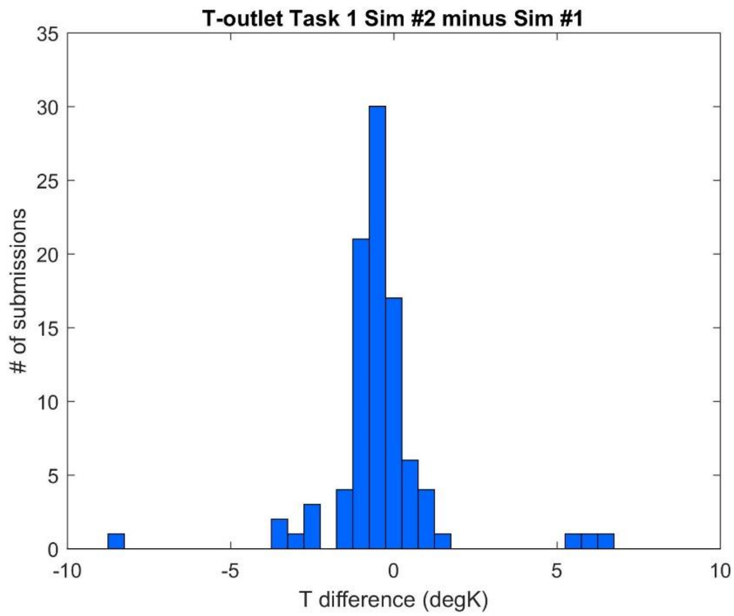


Task 1: Outlet temperature for Simulation #2

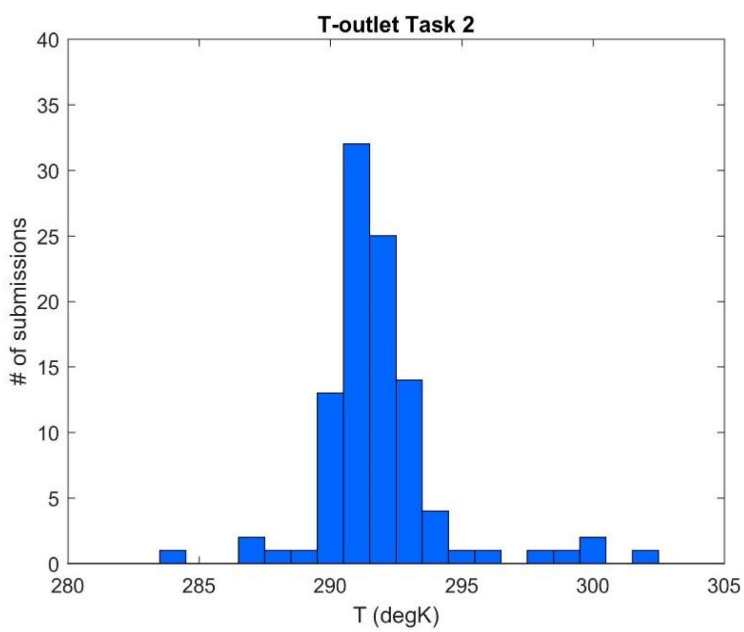


Difference in outlet temperature, Task 1: Sim #1 minus Sim #2

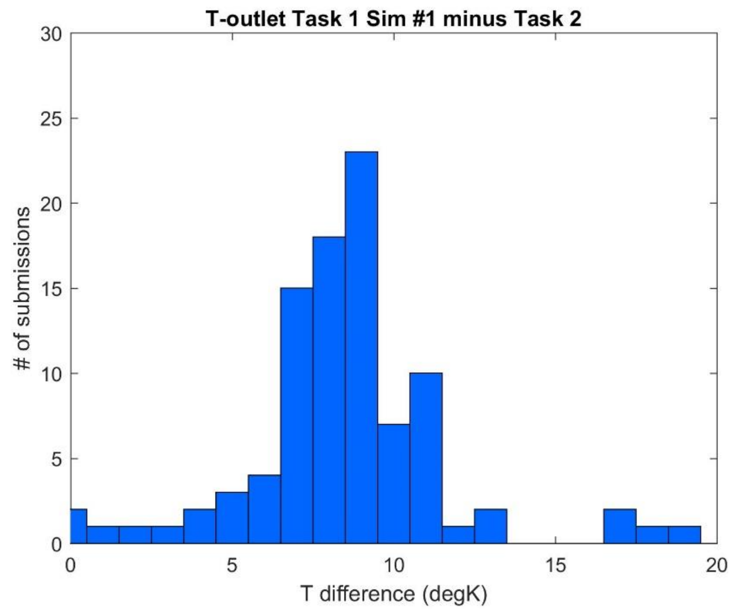
(Sim #2 is very slightly cooler, but the two are very close)



Task 2: Outlet temperature



Difference in outlet temperature: (Task 1 Sim #1) minus Task 2



Discussion

Task 1

Simulation #1: The outlet temperature is typically around 300°K. This result is robust and does not sensitively depend on mesh (unless the mesh is unreasonably coarse, missing the enhancement along the wall, etc.) An overwhelming majority in the class produced the value of T_{out} within ± 2°K of 300°K. The contour plot of temperature should show a "cool waterfall" associated with the stream coming through the inlet. The footprint of the cool waterfall is also present (as a narrow region of negative velocity) in the contour plot of y-velocity. See reference solutions.

Simulation #2: The outlet temperature for this case is very close to Simulation #1. On the average, the former is very slightly cooler (by less than 1°K) and is typically around 299°K ± 2°K. Despite the low location of inlet, a short "cool waterfall" still present in the contour plots of temperature and y-velocity. See reference solutions.

Task 2

With buoyancy effect turned off, the outlet temperature of this case is much lower than Simulation #1 of Task 1. The value of T_{out} typically falls within the range of 290°K-293°K. The contour plot of x-velocity should show a horizontal stream since the density of the cold water from inlet is the same as that of the warmer water in the main tank.

Task 3

The plot of y-velocity at the end of the transient simulation should exhibit a “cool waterfall” like that in the steady solution in Simulation #1 of Task 1. According to the specific requirement for initialization, $T_{out}(t)$ should be 288.16 K at t = 0, and S(t) should be zero at t = 0. At large time, S(t) should approach a value of around 0.01 m/s. See the 3 versions of reference solutions.

In the plots of $T_{out}(t)$ and S(t), the behavior of initial adjustment is somewhat sensitive to the choice of time step size. Since the initial condition is far from equilibrium, a quick adjustment occurs over a short period of time from t = 0. Afterward, a slower evolution gradually brings the system towards the steady state. When a larger time step size is chosen, the initial fluctuation is more dramatic. This is the case in reference solution #1 (with Δt = 60 s) and #3 (with Δt = 50 s). With a significantly smaller Δt, the initial adjustment is smoother, as is seen in reference solution #2 (with Δt = 2 s). Nevertheless, in all 3 versions of reference solutions the long-term behavior of $T_{out}(t)$ and S(t) are similar.

Task 4

The two runs with imposed temperature and imposed heat flux should produce nearly identical outlet temperature. The difference should be on the order of 0.1 °K. (For grading purpose, we deem a difference within 0.5 °K acceptable. But a difference of this magnitude already implies a non-trivial imbalance in the energy flow.) See reference solutions for typical values of the imposed heat flux.