MAE 560 – Project #1
Mitchell Durbin

Statement of Collaboration

No collaboration

Task 1

(a) The required deliverables are below in sequential order

D1.

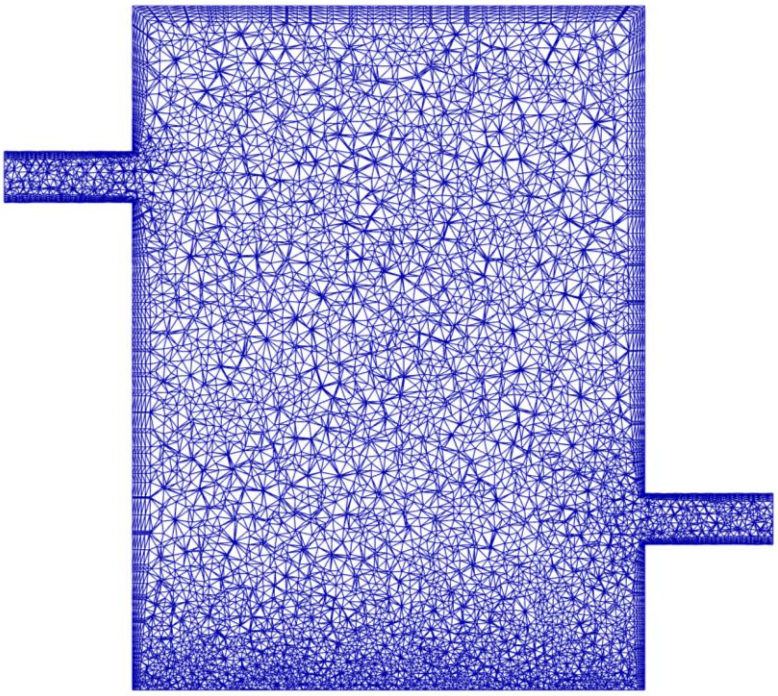

Figure D1 – Plot of Mesh Along Plane of Symmetry

Operating temperature	30 °C
Operating density	995.65 kg/m^3
Thermal expansion coefficient	0.00030326 K^{-1}

D2.

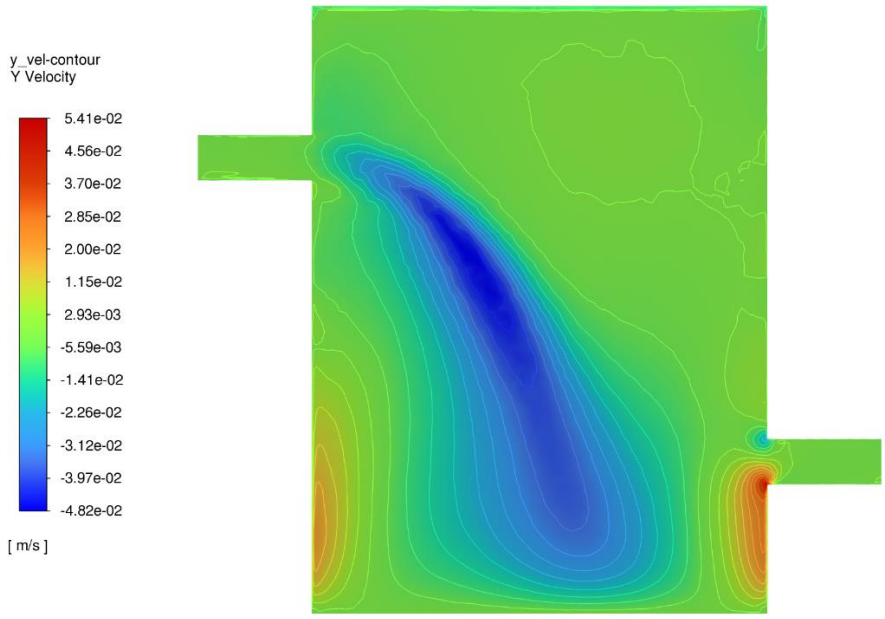

Figure D2 Y-Velocity contour plot in the Plane of Symmetry

D3.

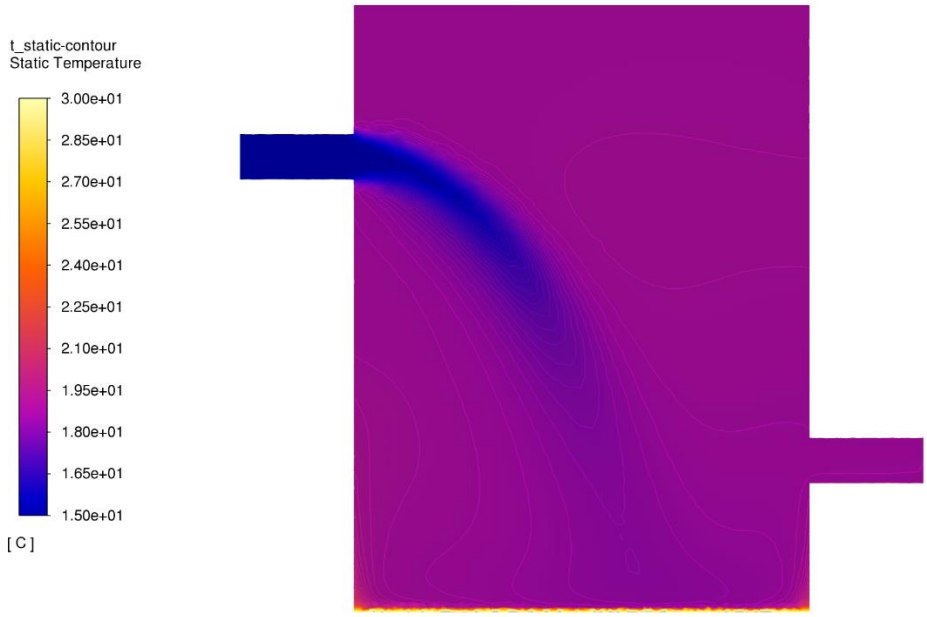

Figure D3 Temperature Contour Plot in the Plane of Symmetry

Note that in the temperature contour plot, the range was adjusted from 15-45 °C to 15-30 °C to show the greater detail at low-to-mid temperatures.

D4.

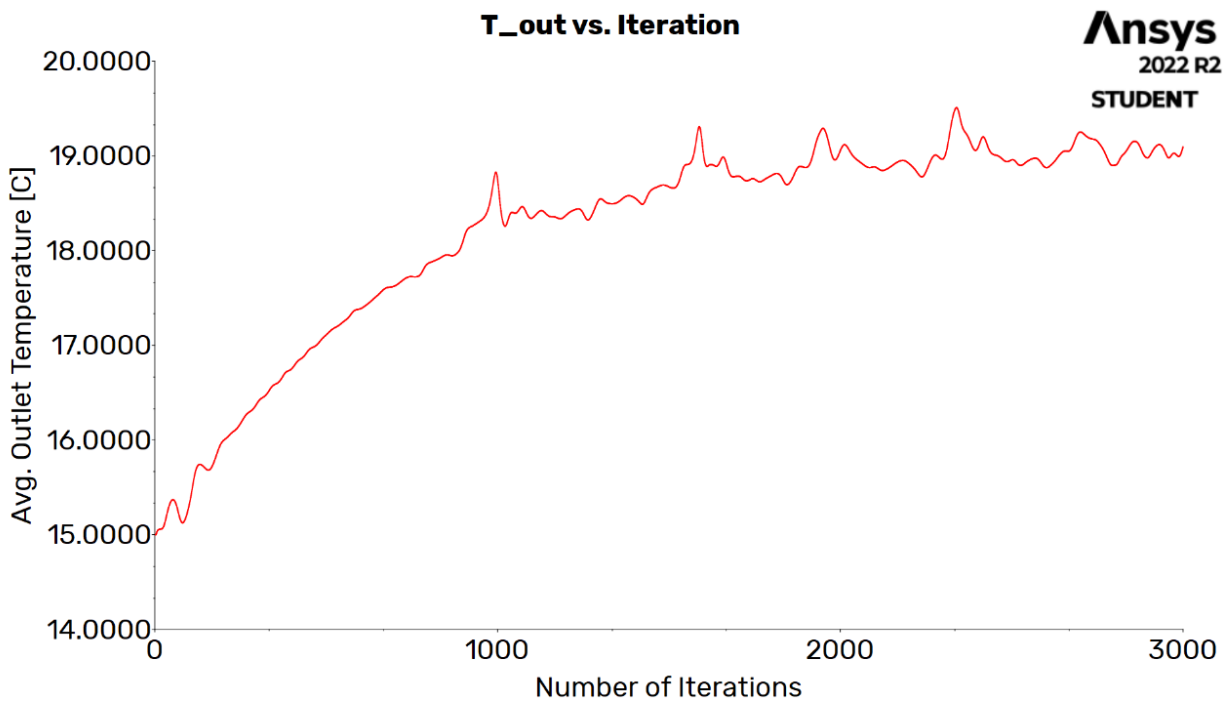

Figure D4 Line Plot of Outlet Temperature vs. Number of Iterations

Outlet temperature: 19.069 °C

Note: The "steady state" value of outlet temperature seems to fluctuate, however the required convergence condition was met for these deliverables: The difference between the outlet temperature at 2900 and 2800 iterations was indeed less than 0.1°C.

(b) The requested deliverables can be found below.

D5.

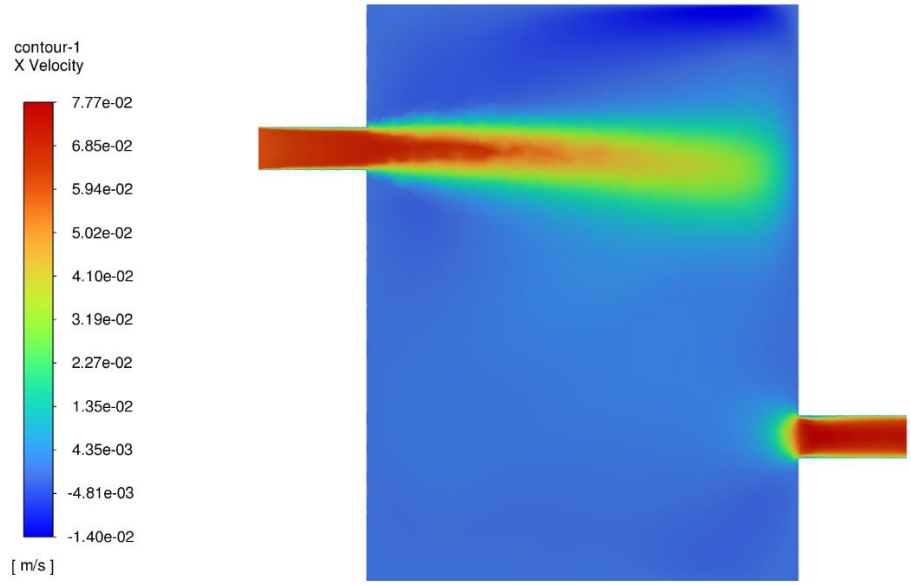

Figure D5 X-Velocity Contour Plot in the Plane of Symmetry

D6.

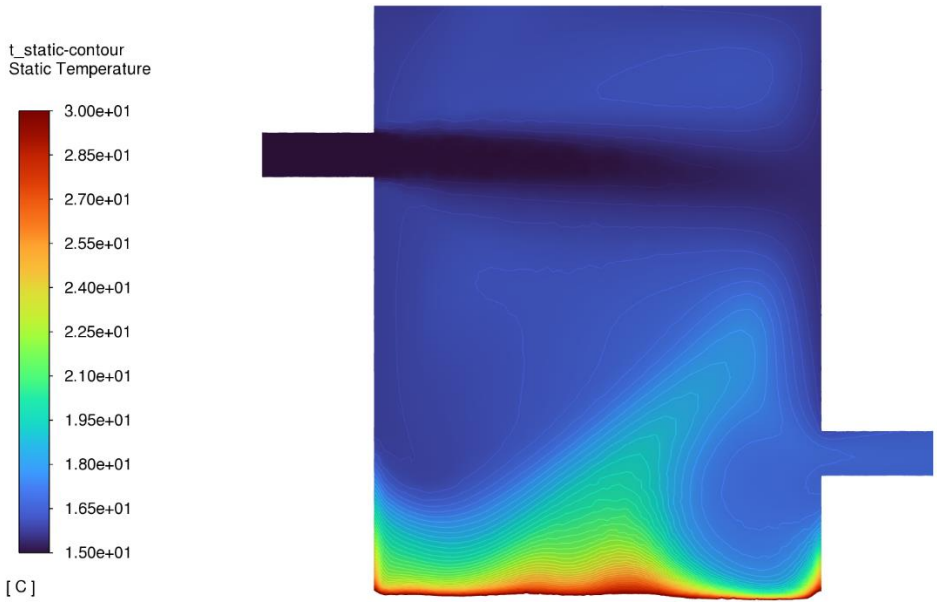

Figure D6 Temperature Contour Plot in the Plane of Symmetry

Note that the range of temperatures has been shortened to 15-30°C to show greater detail at lower temperatures.

D7.

Outlet Temperature: 17.016 °C

Note: Similar to Task 1a, the outlet temperature starts settle at around 2000 iterations, at which point it will fluctuate ± 0.25 °C. However, the required convergence condition was satisfied. The difference between the temperature at iteration 3000 and iteration 2900 was 0.067 °C.

(c)

D8.

Time step size: 5 s

Maximum number of iterations per time step: 20

Maximum number of total iterations: ≈ 14,400

Note: the initial time resolution was initially much more coarse. The time step size was lowered and the max iterations per step was raised until the results did not change between settings. It is acknowledged that the above settings are much more computationally intense than necessary, but time was abundant.

D9.

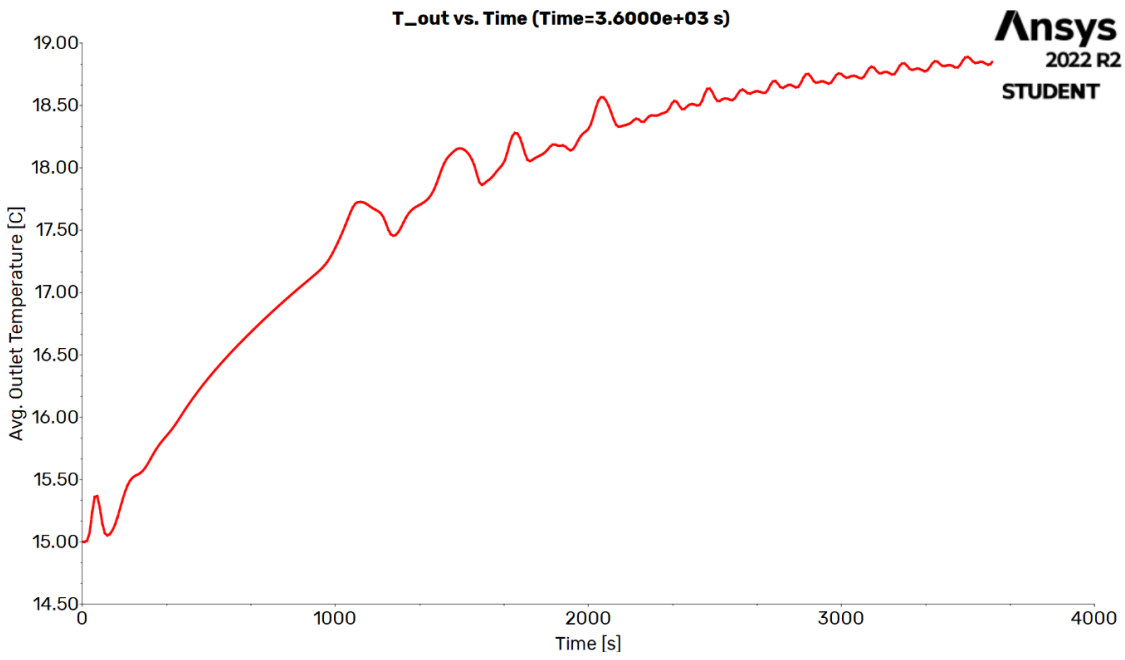

Figure D9 Outlet Temperature Line Plot over Time

D10.

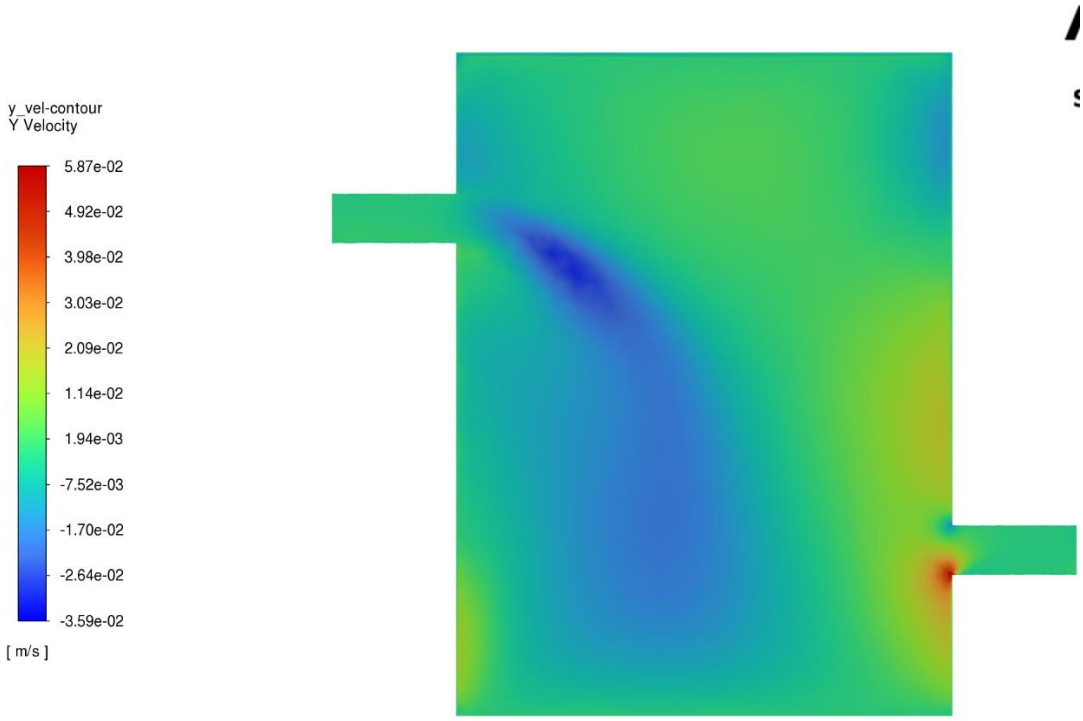

Figure D10a Y-Velocity Contour Plot on Plane of Symmetry at t = 15 minutes

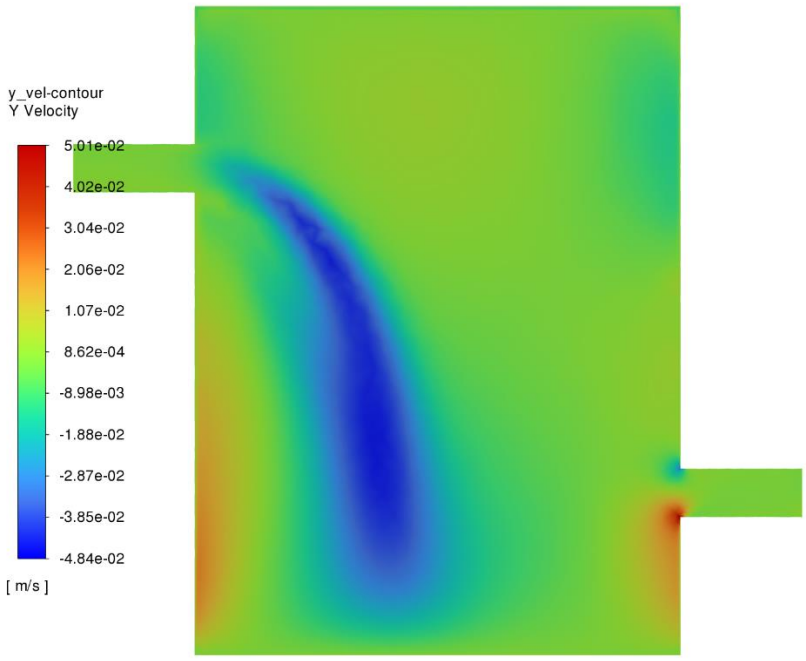

Figure D10b Y-Velocity Contour Plot on Plane of Symmetry at t = 60 minutes

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Task 2a

D11.

Inlet Velocity (m/s)	Temperature Difference (K)
0.008	12.70
0.016	6.47
0.032	3.32
0.064	1.70

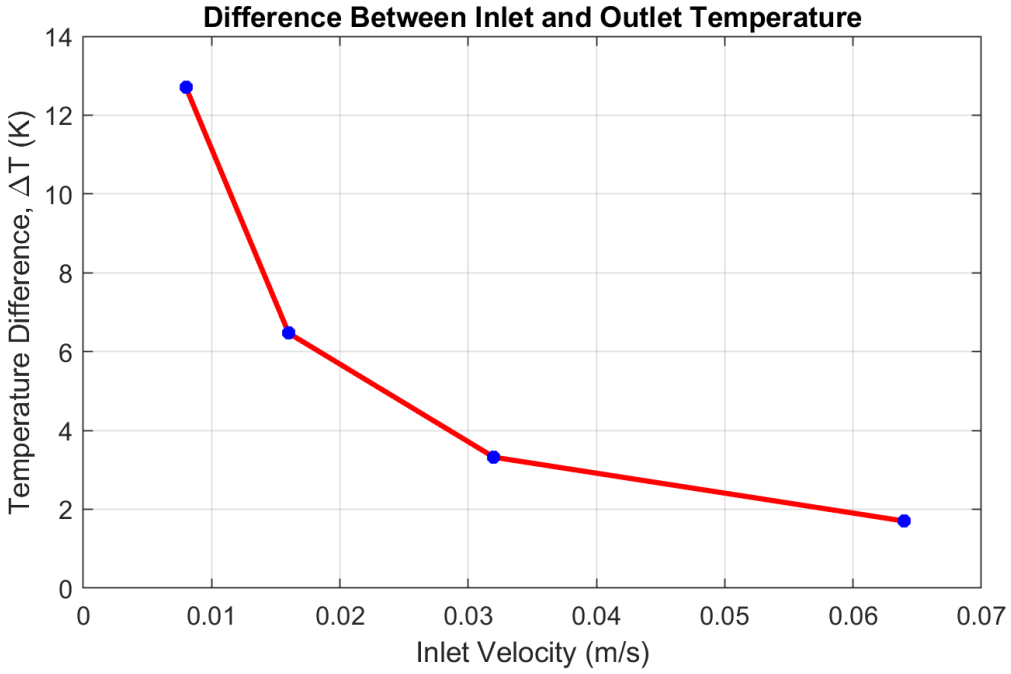

Figure D11 Line Plot of Temperature Difference vs. Inlet Velocity

This plot demonstrates that the temperature difference between inlet and outlet is inversely proportional to the inlet velocity. If you were to continue to increase the inlet velocity towards infinity, the temperature difference would approach zero.

D12. The required figures are shown below.

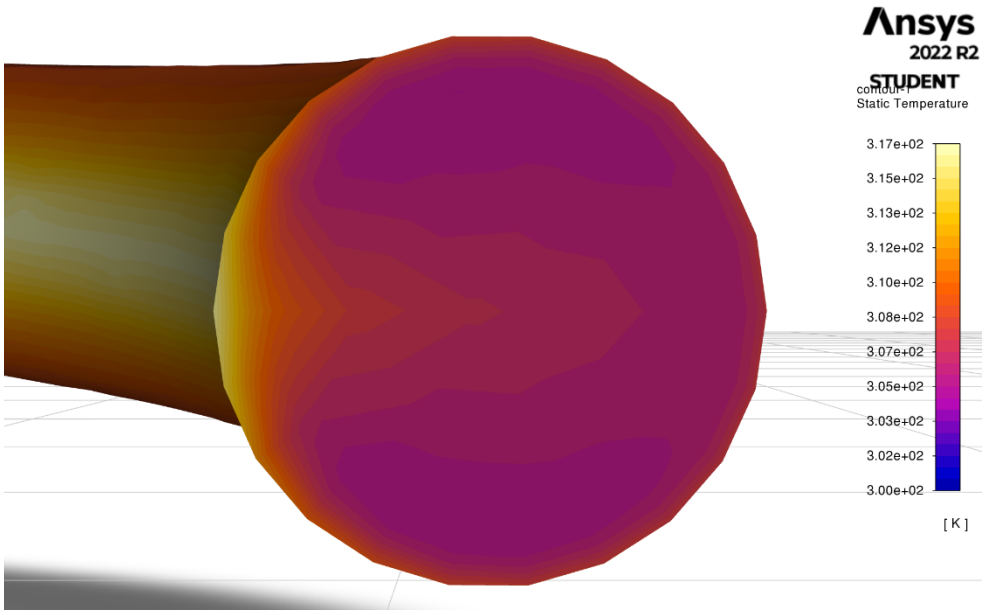

Figure D12a Temperature Contour Plot along Outlet

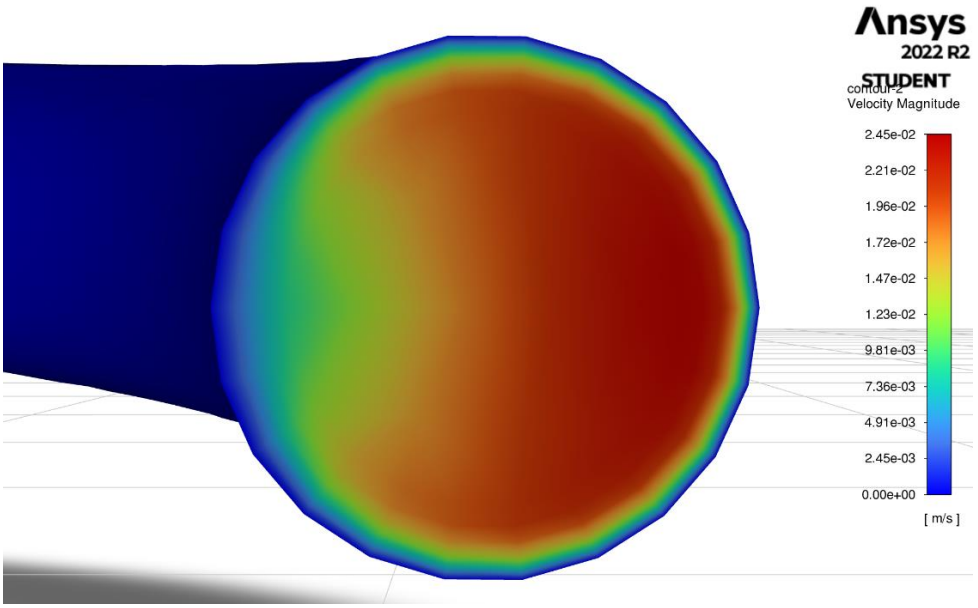

Figure D12b Velocity Magnitude Contour Plot along Outlet

Note that in both of the above figures, the left side of the outlet plane is the inner side of the pipe, as made obvious from the curving pipe wall.

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Task 2b

D13.

Inlet Velocity (m/s)	Temperature Difference (K)
1	0.04
2	0.10
4	0.24

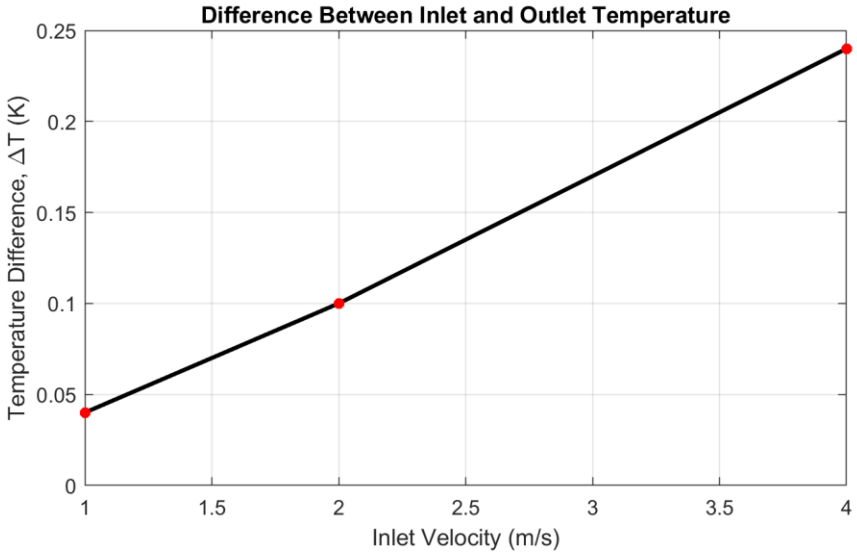

Figure D13 Line Plot of Temperature Difference vs. Inlet Velocity

Based on three data points (which is probably not enough data to make this conclusion), the relationship between viscous heating (temperature difference) and the inlet velocity appears to be linearly positive.

D14.

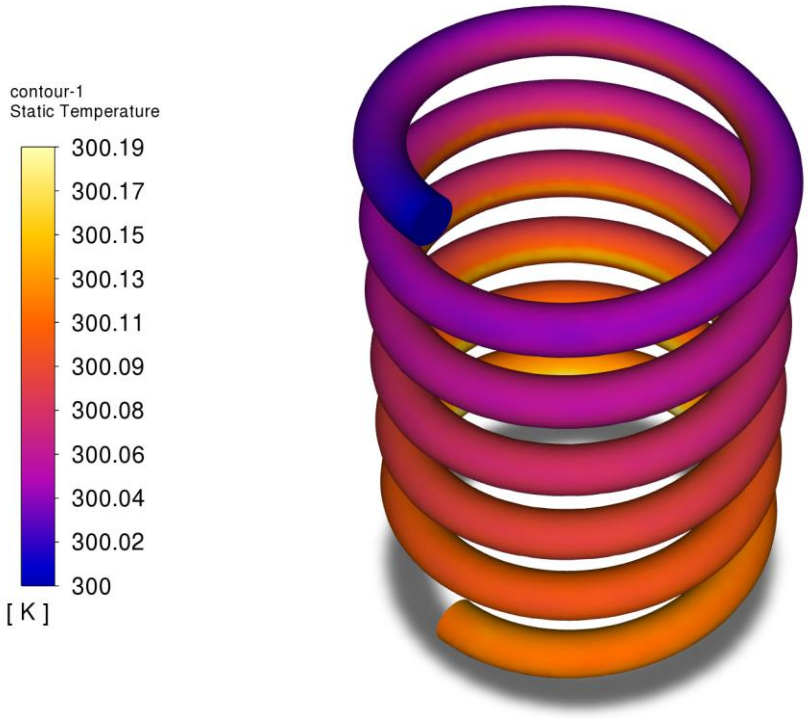

Figure D14a Isometric View of Temperature Contour Plot

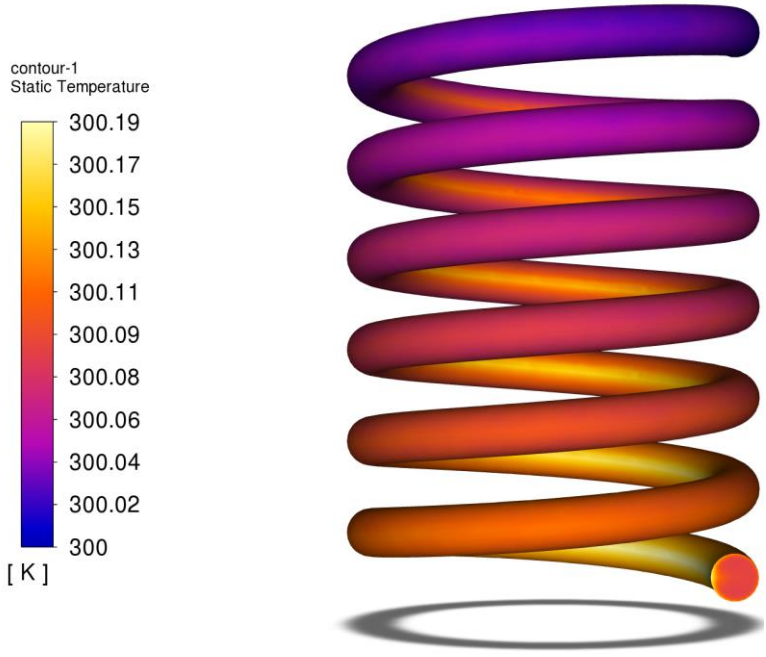

Figure D14b Side View of Temperature Contour Plot

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Task 3

D15.

Time step size: 0.0005

Max iterations per time step: 20

D16.

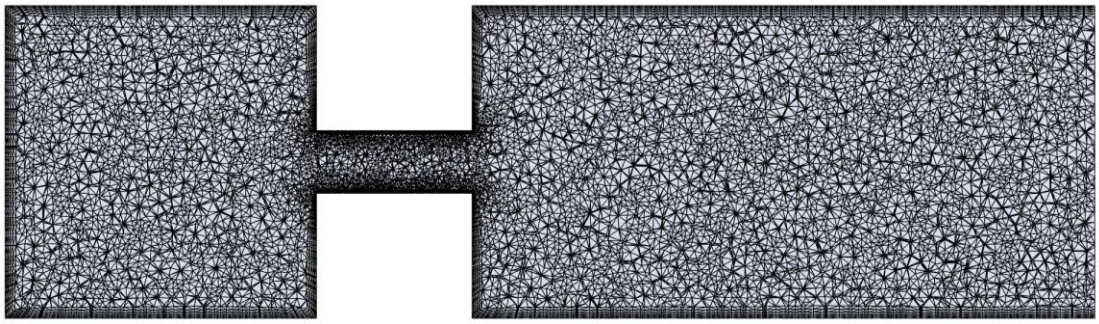

Figure D16a Mesh on Plane of Symmetry

D17.

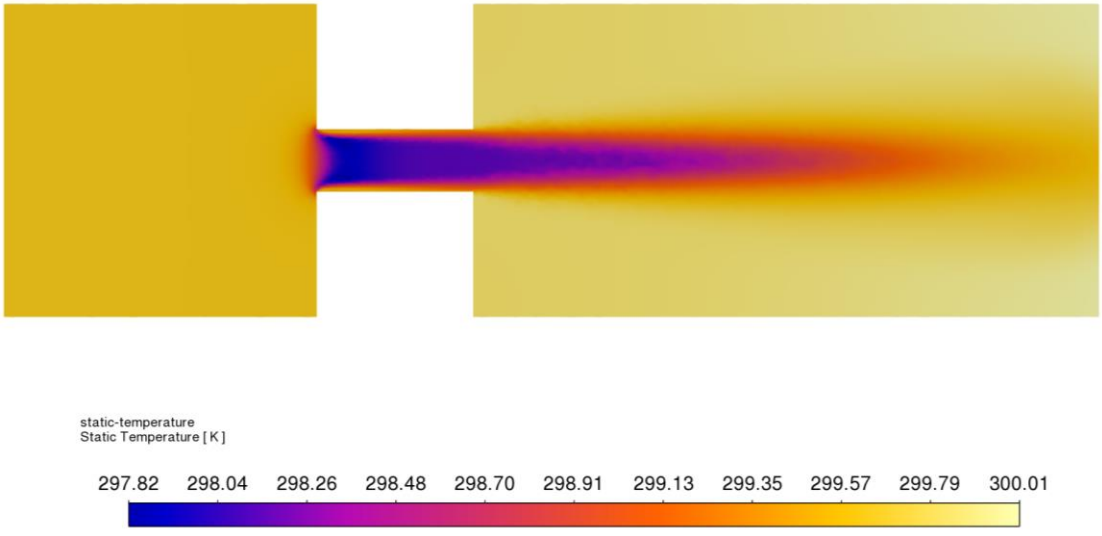

Figure D17(T1) Static Temperature Contour Plot at t = 0.025

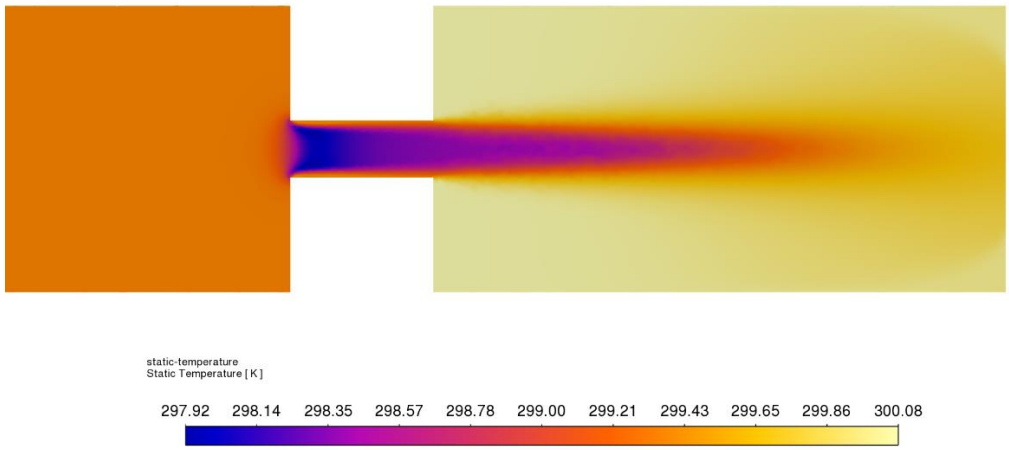

Figure D17(T2) Static Temperature Contour Plot at t = 0.05

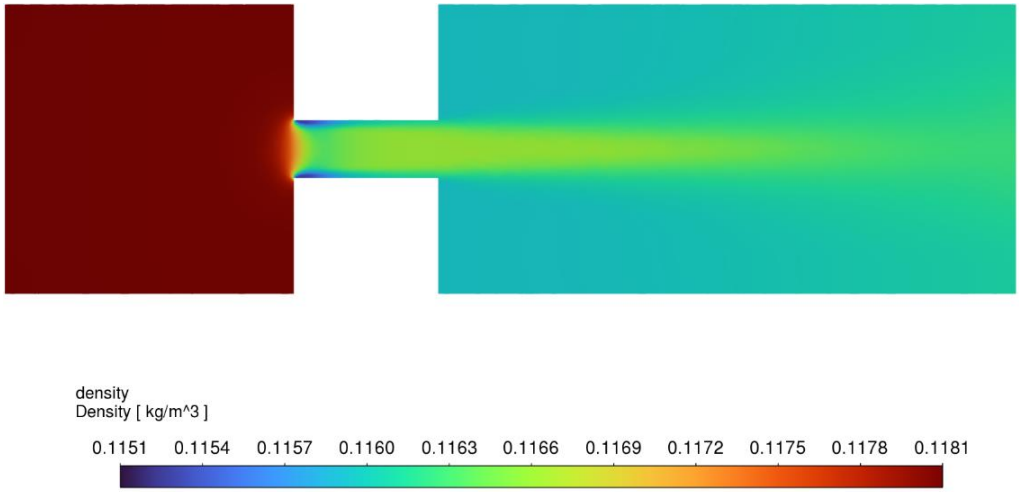

Figure D17(D1) Density Contour Plot at t = 0.025

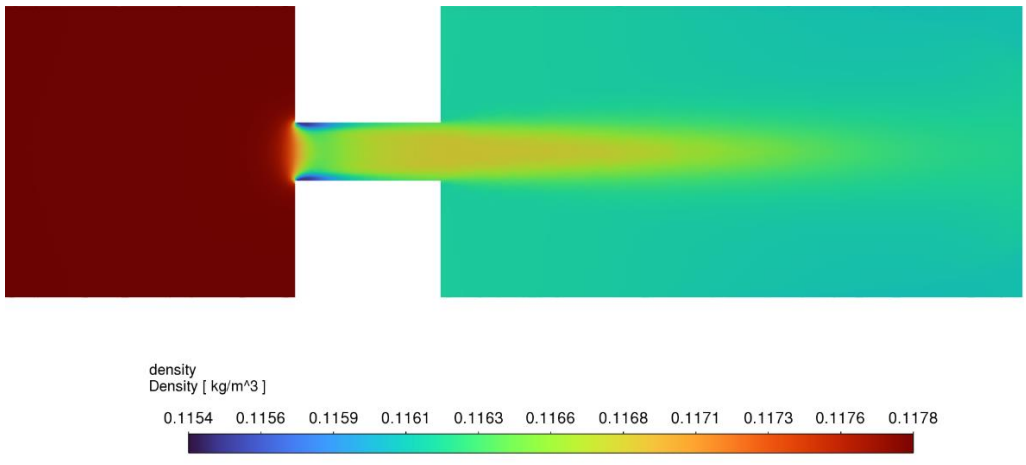

Figure D17(D2) Density Contour Plot at t = 0.05

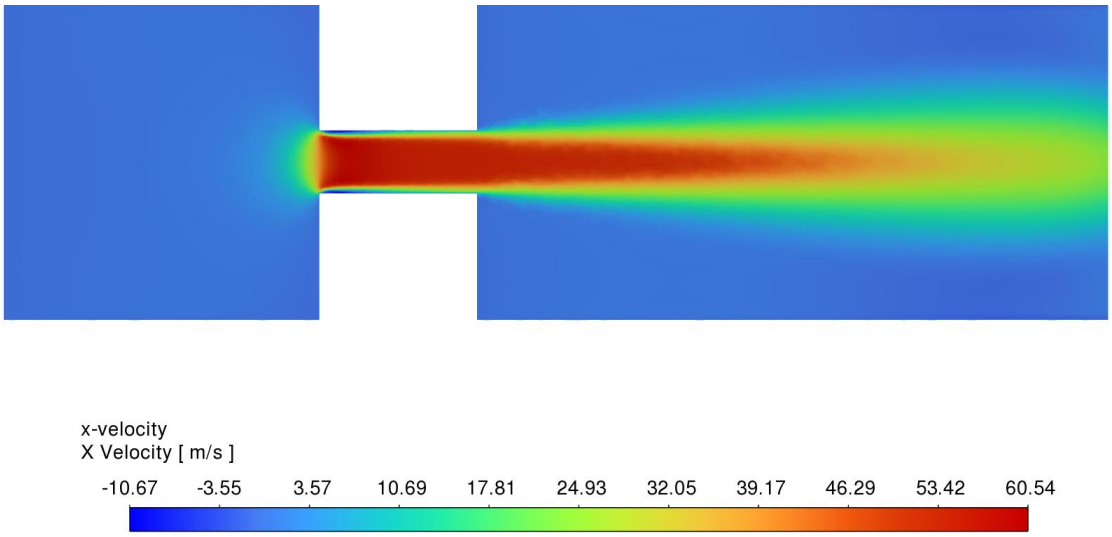

Figure D17(V1) Axial Velocity Contour Plot at t = 0.025

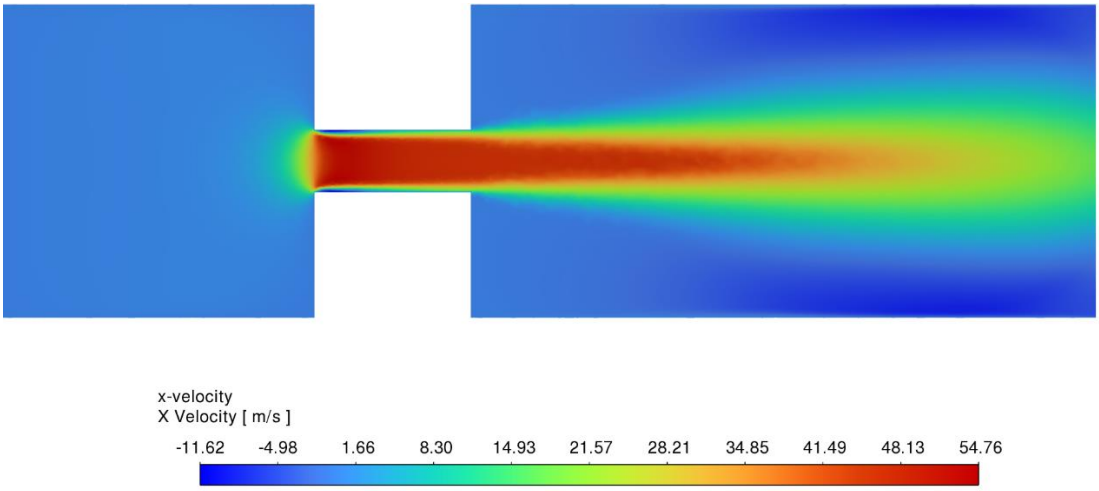

Figure D17(V2) Axial Velocity Contour Plot at t = 0.05

Note that in the above velocity plots, the positive-x direction is defined as pointing to the right side of the page.