MAE 560 Project 2

Collaboration Statement:

Name of Collaborator	Task: Contribution
Justin Martia	Task 3: Brainstormed computational domain and timestep parameters

Task 1a:

This problem simulates the leaking of natural gas from an underground vault in a 2-D setting with no lateral velocity in the air above the ground. In this simulation, the boundaries A, B, and C were defined as pressure outlets with zero gauge pressure and the backflow was set to air. The mesh resolution parameters are detailed in Table 1, and a mesh contour plot is shown in Figure 1. The transient solution parameters are described in Table 2.

Table 1: Mesh Resolution Parameters

Element Size (m)	Number of Elements
0.3	67809

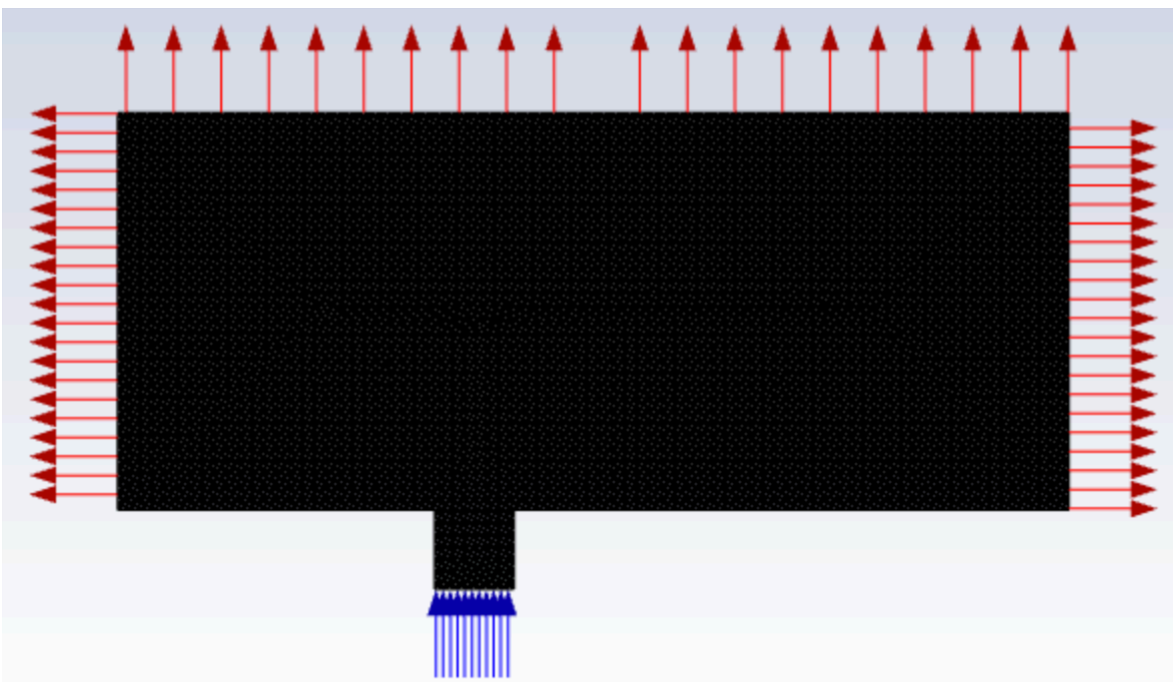

Figure 1: Task 1a Mesh

Table 2: Transient Solution Parameters

Time Step (s)	Number of Time Steps	Max Iterations/Time Step
0.02	350	15

The main deliverable for this problem is a contour plot of the methane volume fraction at t = 7s, and this is shown in Figure 2, below.

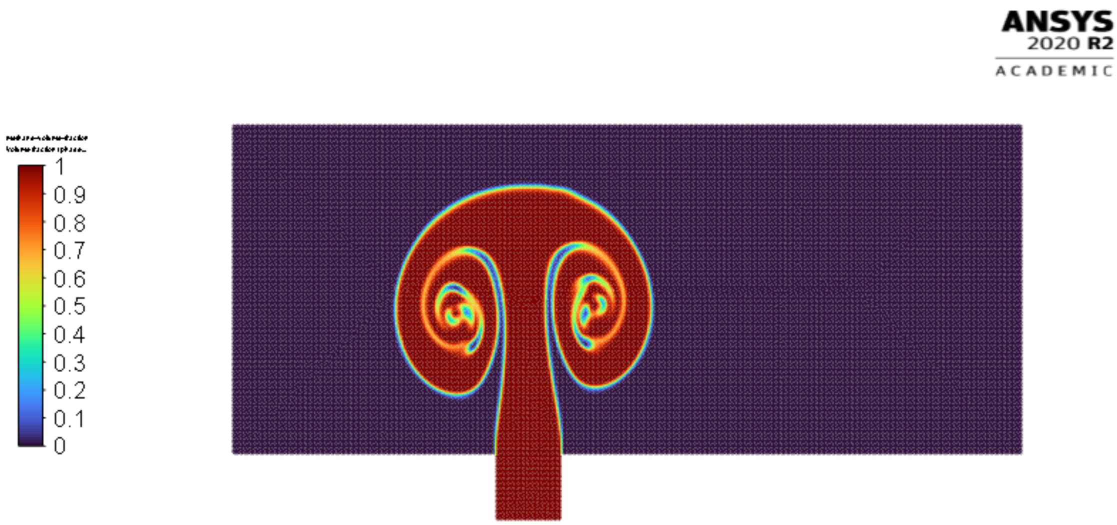

Figure 2: Task 1a Methane Volume Fraction Contour Plot

<u>Task 1b:</u>

This problem simulates the leaking of natural gas from an underground vault in a 2-D setting with no lateral velocity in the air above the ground. In this simulation, the boundaries B and C were defined as pressure outlets with zero gauge pressure and the backflow was set to air. Boundary A was set to a velocity inlet with a parabolic velocity profile defined using the equation $u = 0.4y - 0.008y^2$ where u is in m/s and y is in m. The mesh resolution parameters are detailed in Table 3, and the mesh contour plot is shown in Figure 3. The transient solution parameters are described in Table 4.

Table 3: Mesh Resolution Parameters

Element Size (m)	Number of Elements
0.3	67809

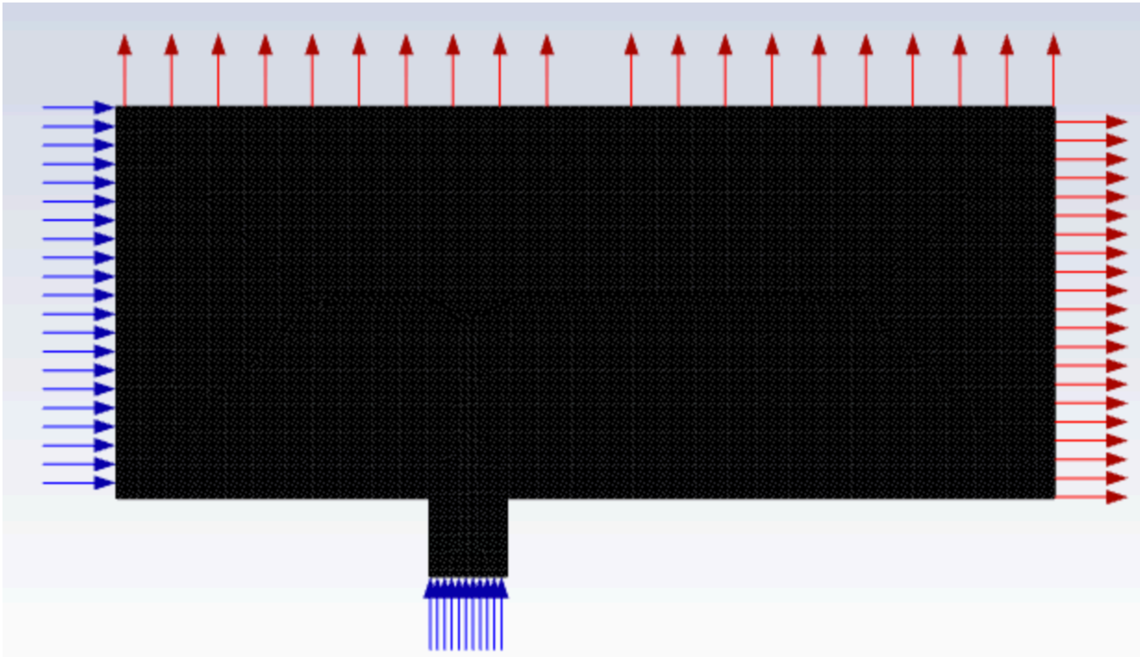

Figure 3: Task 1b Mesh

Table 4: Transient Solution Parameters

Time Step (s)	Number of Time Steps	Max Iterations/Time Step
0.01	700	15

The main deliverable for this problem is a contour plot of the methane volume fraction at t = 7s, and this is shown in Figure 4, below.

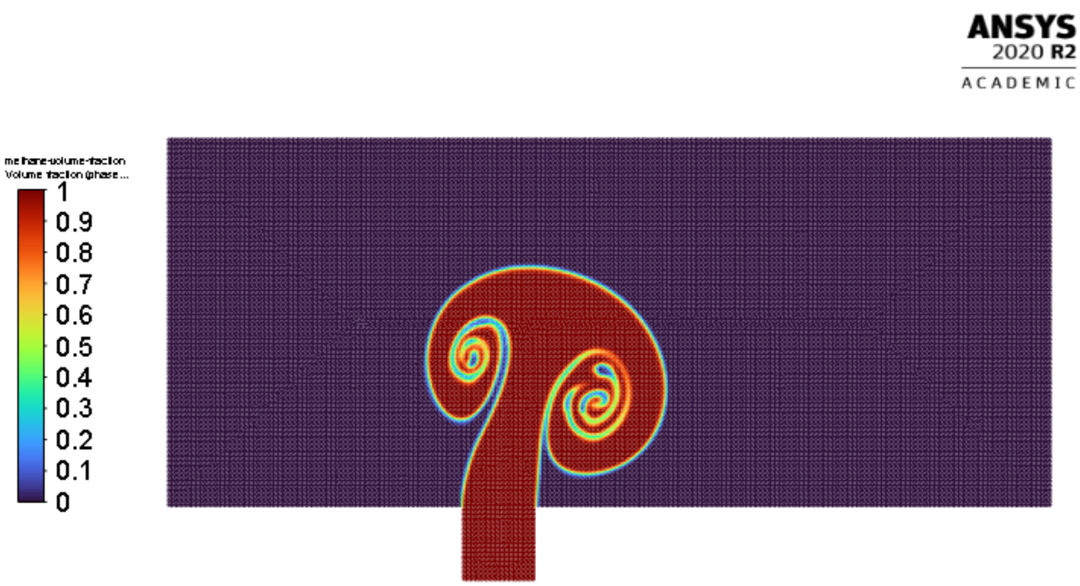

Figure 4: Task 1b Methane Volume Fraction Contour Plot

Task 2:

This problem simulates a drop of water falling through air and crashing into a bucket of water. In this simulation, the bottom, left, and right boundaries were considered to be walls, and the top boundary was considered to be a pressure outlet with zero gauge pressure and a backflow of air. The mesh resolution parameters are detailed in Table 1, and a mesh contour plot is shown in Figure 5, and the initial water volume fraction distribution is shown in Figure 6. The transient solution parameters are described in Table 6.

Table 5: Mesh Resolution Parameters

Element Size (m)	Number of Elements
0.0025	40000

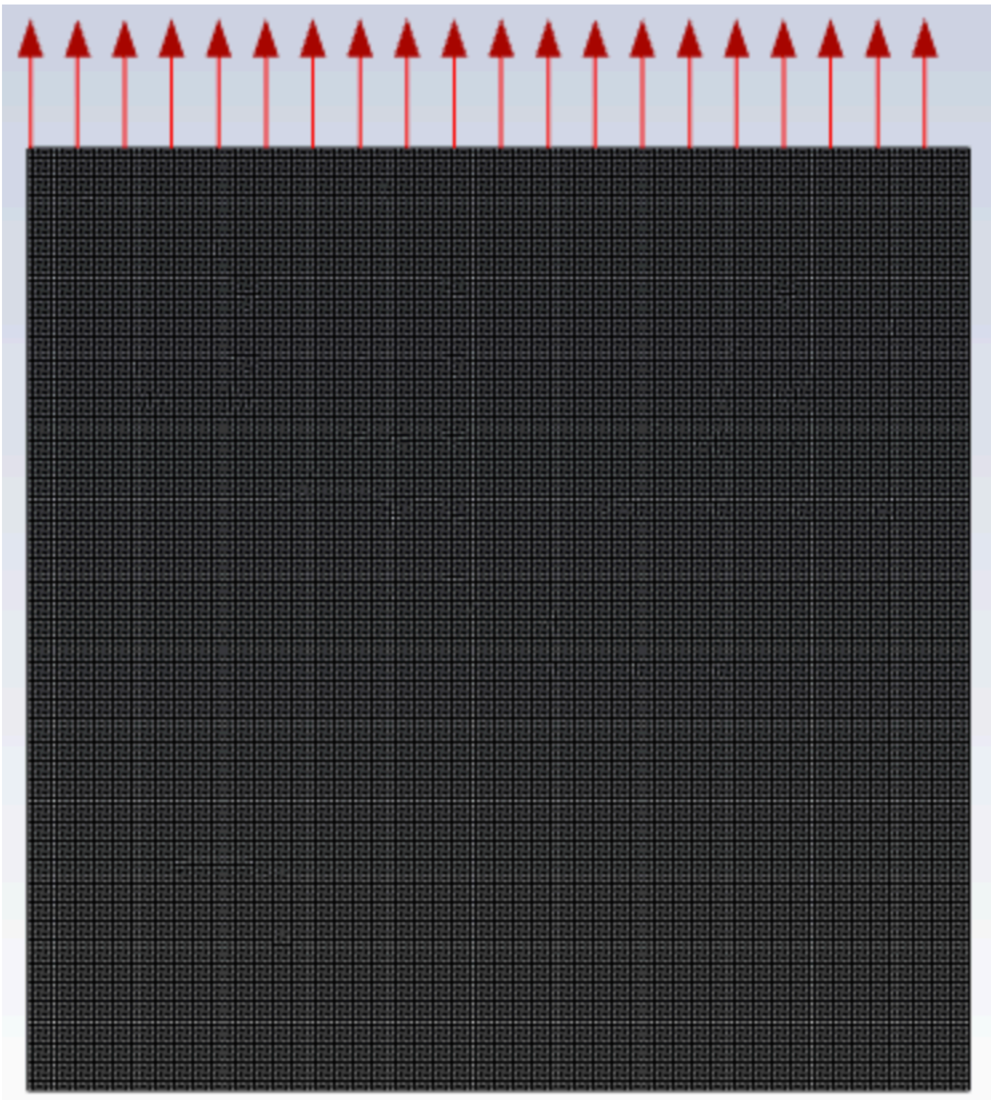

Figure 5: Task 2 Mesh

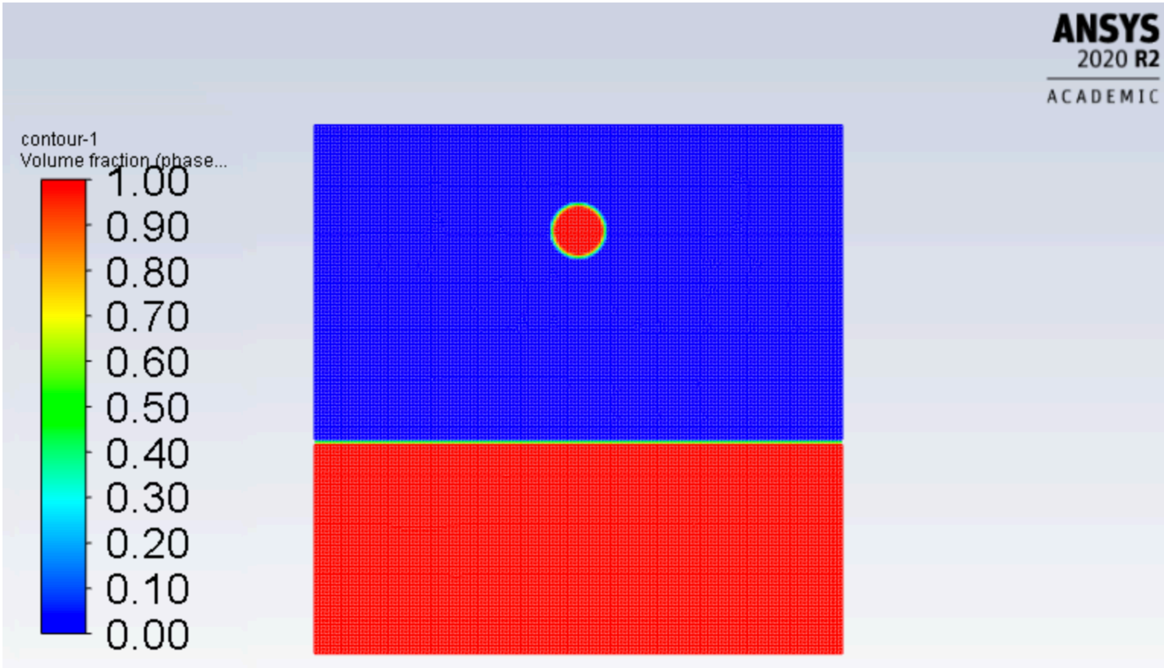

Figure 6: Initial Water Volume Fraction Distribution

Table 6: Transient Solution Parameters

Time Step (s)	Number of Time Steps	Max Iterations/Time Step
0.00125	400	15

The other four deliverables for this problem are contour plots of the water volume fraction at t = 0.2s, 0.3s, and 0.5s, and a velocity magnitude contour plot at t = 0.5s, and they are shown in Figures 7, 8, 9, and 10, respectively.

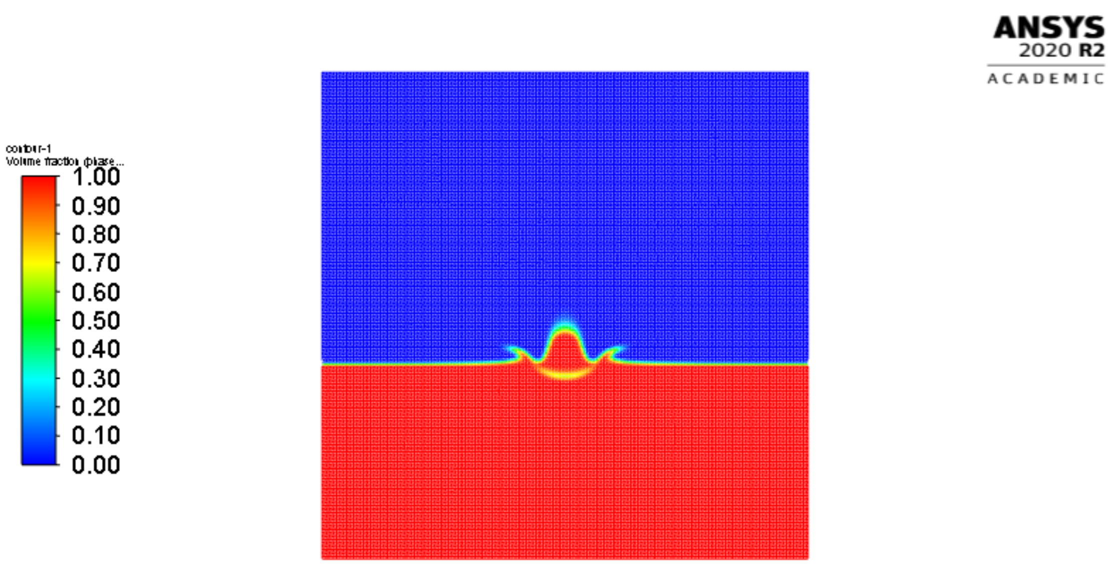

Figure 7: Water Volume Fraction Contour Plot t = 0.2s

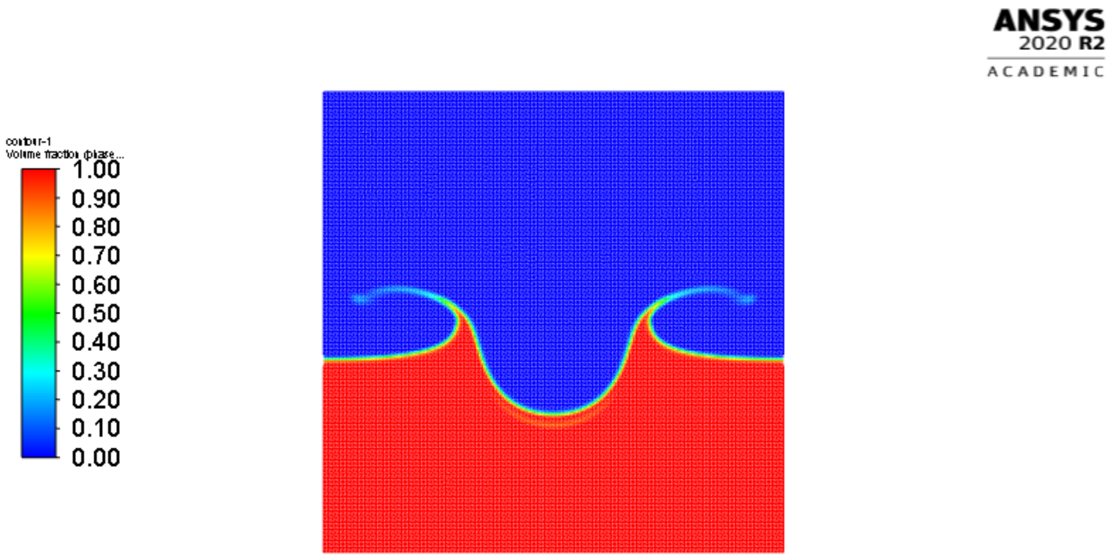

Figure 8: Water Volume Fraction Contour Plot t = 0.3s

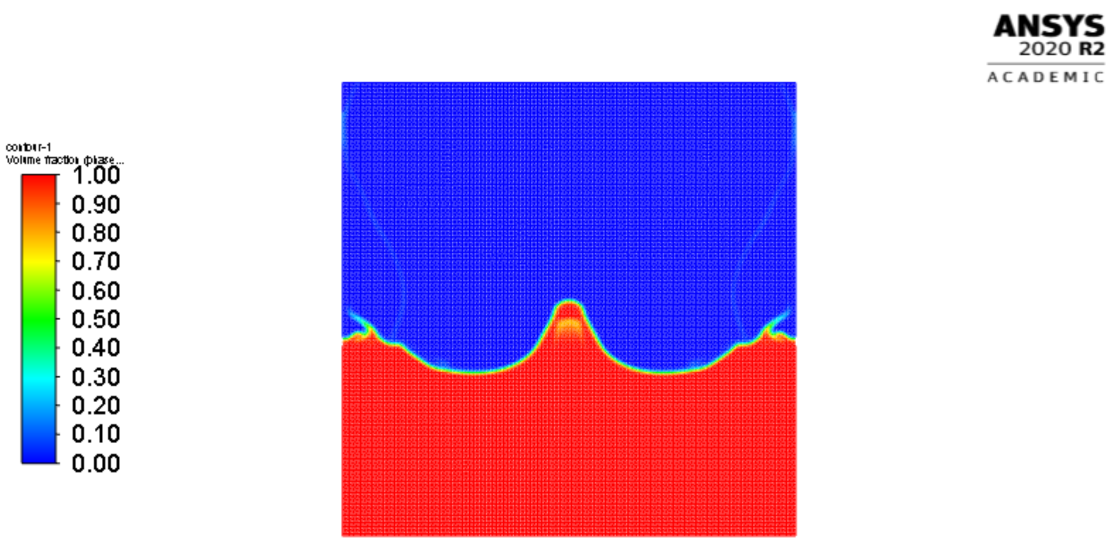

Figure 9: Water Volume Fraction Contour Plot t = 0.5s

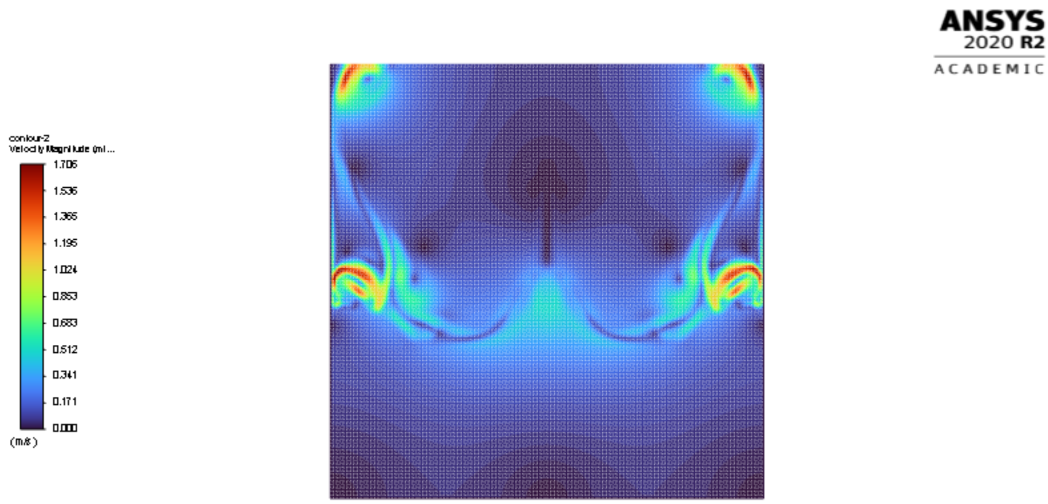

Figure 10: Velocity Magnitude Contour Plot t = 0.5s

Task 3:

The purpose of this task is to simulate a drop of glycerin sliding down a 45 degree incline slope. In this simulation, the bottom boundary condition of the rectangular computational domain was set to a wall and the other 5 boundary conditions were set to zero gauge pressure outlets with air backflow. The computational domain is a 10x15x4cm rectangle. Note that the mesh has a refined zone where the droplet is located during the transient simulation. The domain was initialized as 100% air and then a hemispherical droplet of glycerin was added using the patch function. The mesh resolution parameters are detailed in Table 7, and a cutaway mesh contour plot is shown in Figure 11. The transient solution parameters are described in Table 8.

Table 7: Mesh Resolution Parameters

Element Size (m)	Number of Elements
0.002	75000 (before refinement)

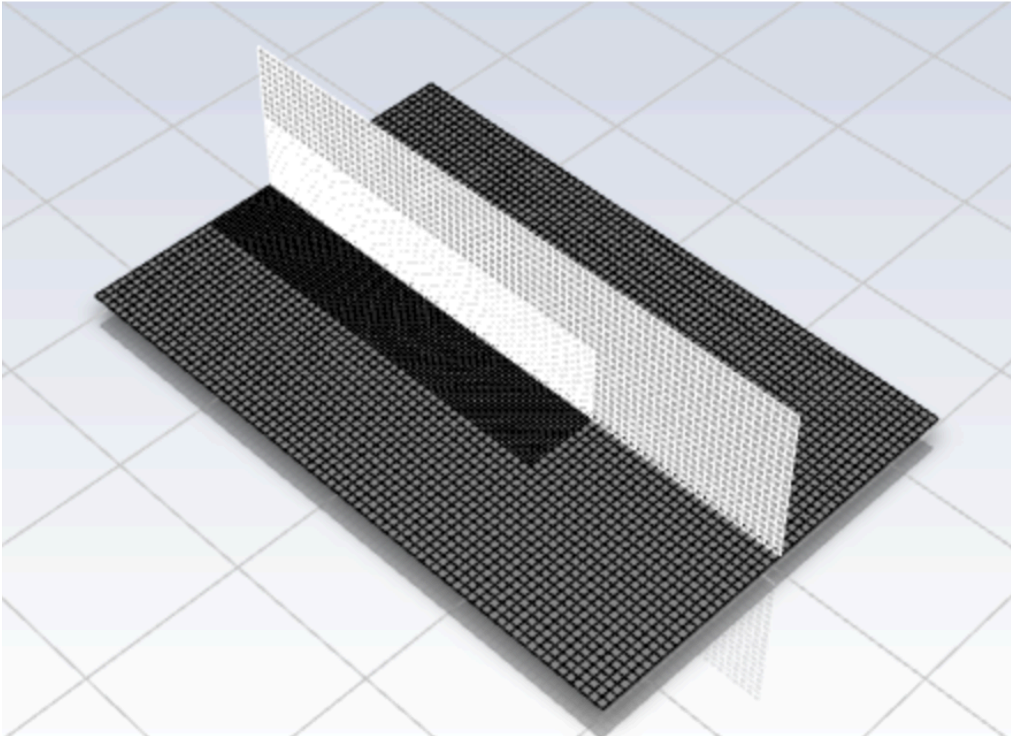

Figure 11: Task 3 Mesh Contour Plot

Table 8: Transient Solution Parameters

Time Step (s)	Number of Time Steps	Max Iterations/Time Step
0.0002	500	15

The 3D representations of the droplet at 0, 0.05, and 0.1s are shown in Figure 12, 13, and 14, respectively.

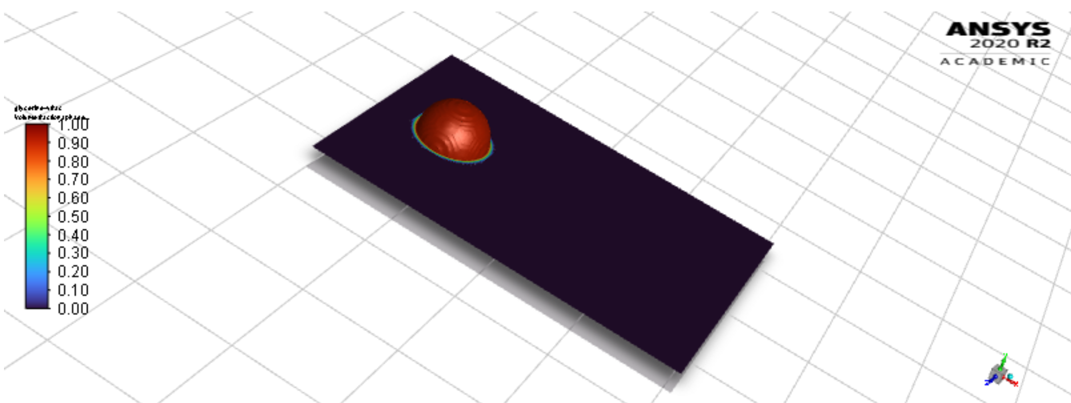

Figure 12: 3D Visualization of Droplet at t = 0s

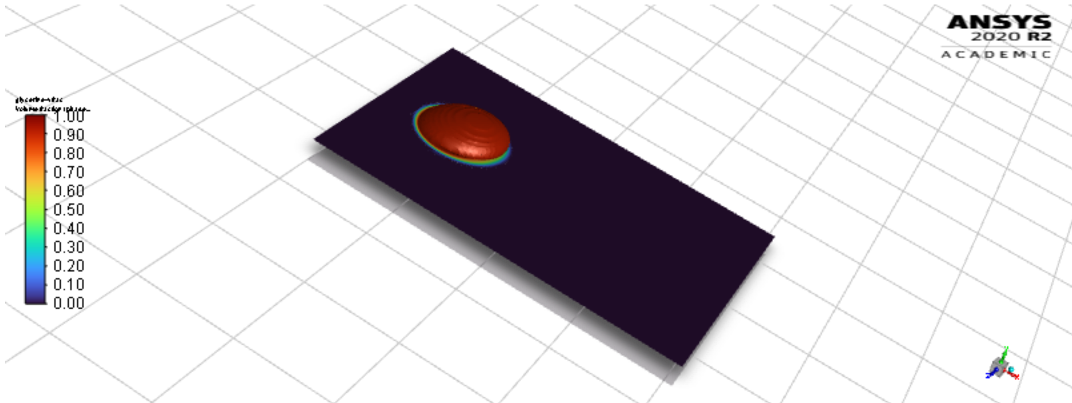

Figure 13: 3D Visualization of Droplet at t = 0.05s

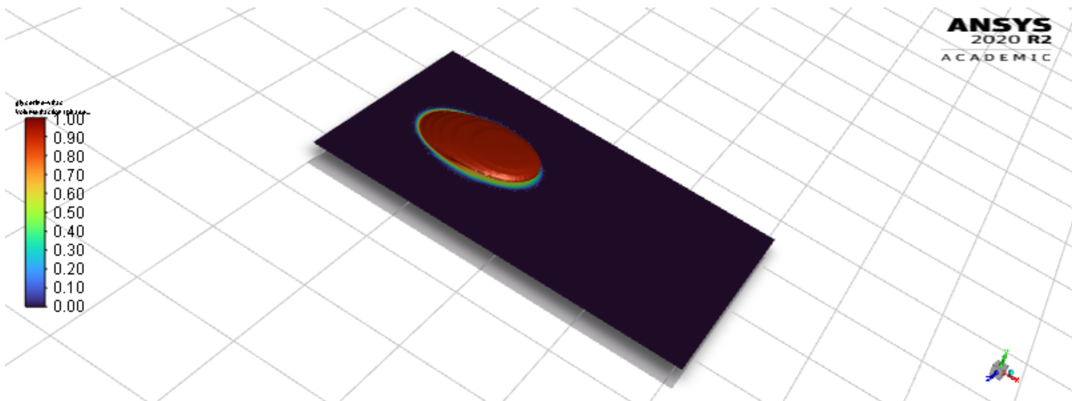

Figure 14: 3D Visualization of Droplet at t = 0.1s

The glycerin volume fraction contour plots in the plane of symmetry of the droplet at 0, 0.05, and 0.1s are shown in Figure 15, 16, and 17, respectively.

Figure 15: Glycerin Volume Fraction Contour Plot at t = 0s

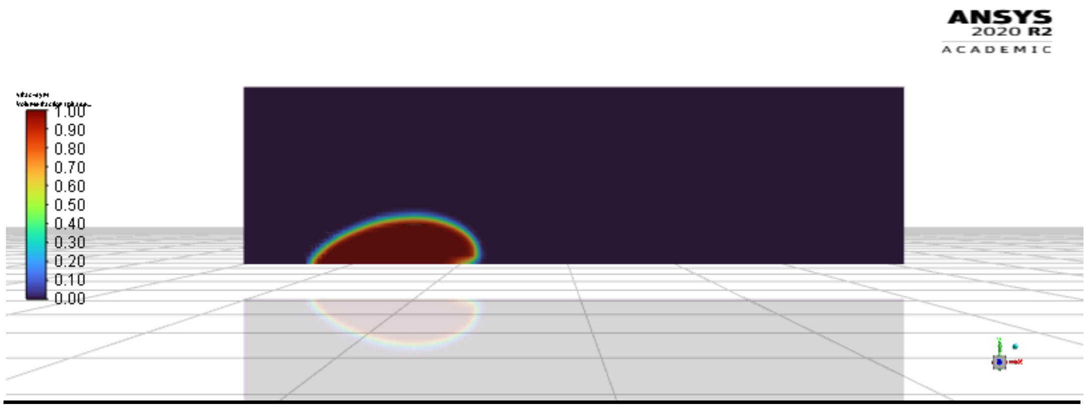

Figure 16: Glycerin Volume Fraction Contour Plot at t = 0.05s

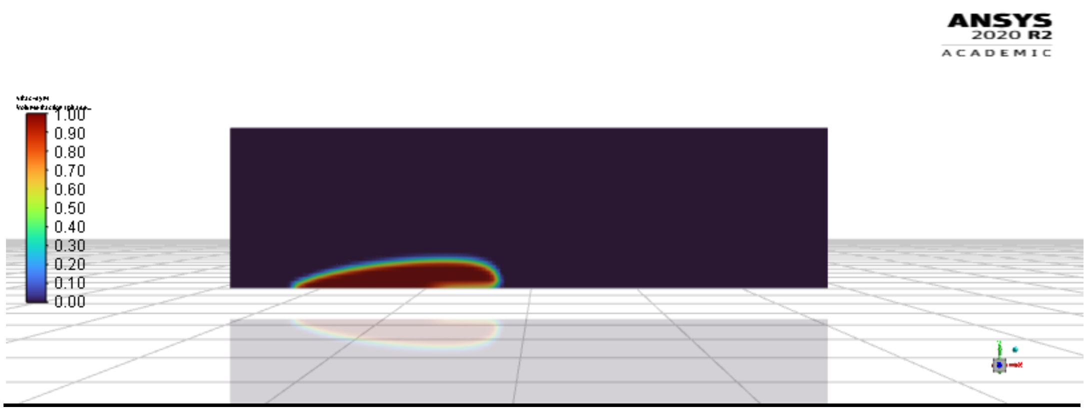

Figure 17: Glycerin Volume Fraction Contour Plot at t = 0.1s

Task 4:

The purpose of this task is to simulate the oscillation of water in a u-shaped pipe with the tops open to air. I chose to use the half-pipe geometry and invoked symmetry. In this simulation, the left and right openings at the top of the pipe used boundary conditions were set to zero gauge pressure outlets with air backflow. This was done to allow the air to freely move in and out of the pipe as the water oscillates. The mesh resolution parameters are detailed in Table 9, and a cutaway mesh contour plot is shown in Figure 18. The transient solution parameters are described in Table 10.

Table 9: Mesh Resolution Parameters

Element Size (m)	Number of Elements
0.002	387210

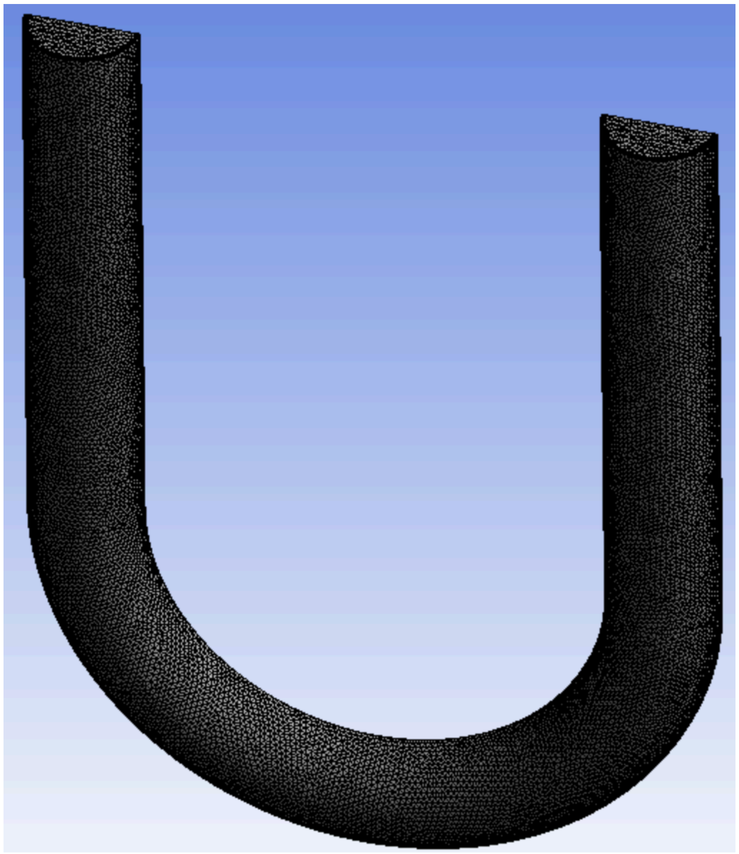

Figure 18: Task 4 Mesh Contour Plot

Table 10: Transient Solution Parameters

Time Step (s)	Number of Time Steps	Max Iterations/Time Step
0.0043	500	15

The initial water volume fraction distribution is shown in Figure 19.

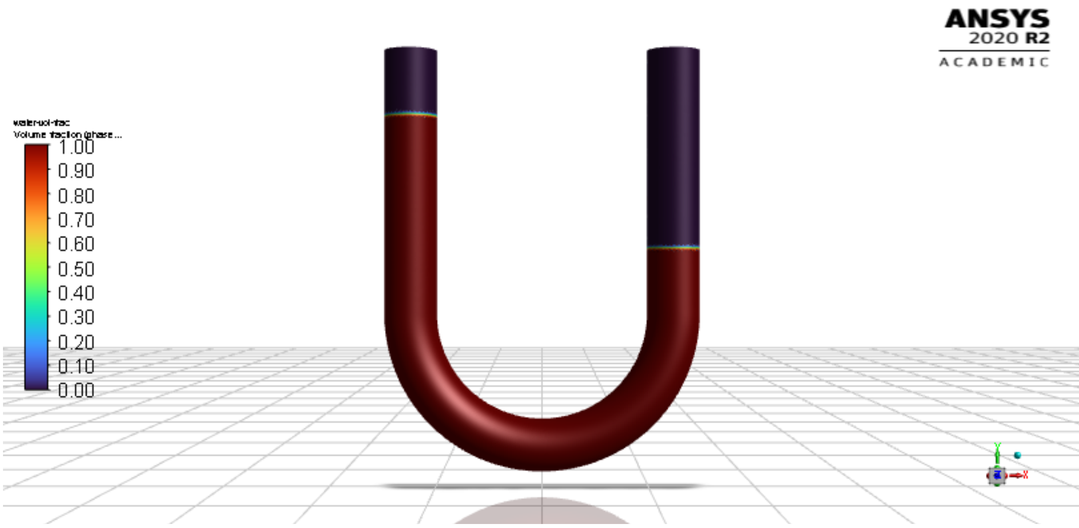

Figure 19: Initial Water Volume Fraction Distribution

The second deliverable involves a plot of h as a function of time, which is shown in Figure 20. Additionally, the period of oscillation and the interpolated values of t1 and t2 are reported in Table 11.

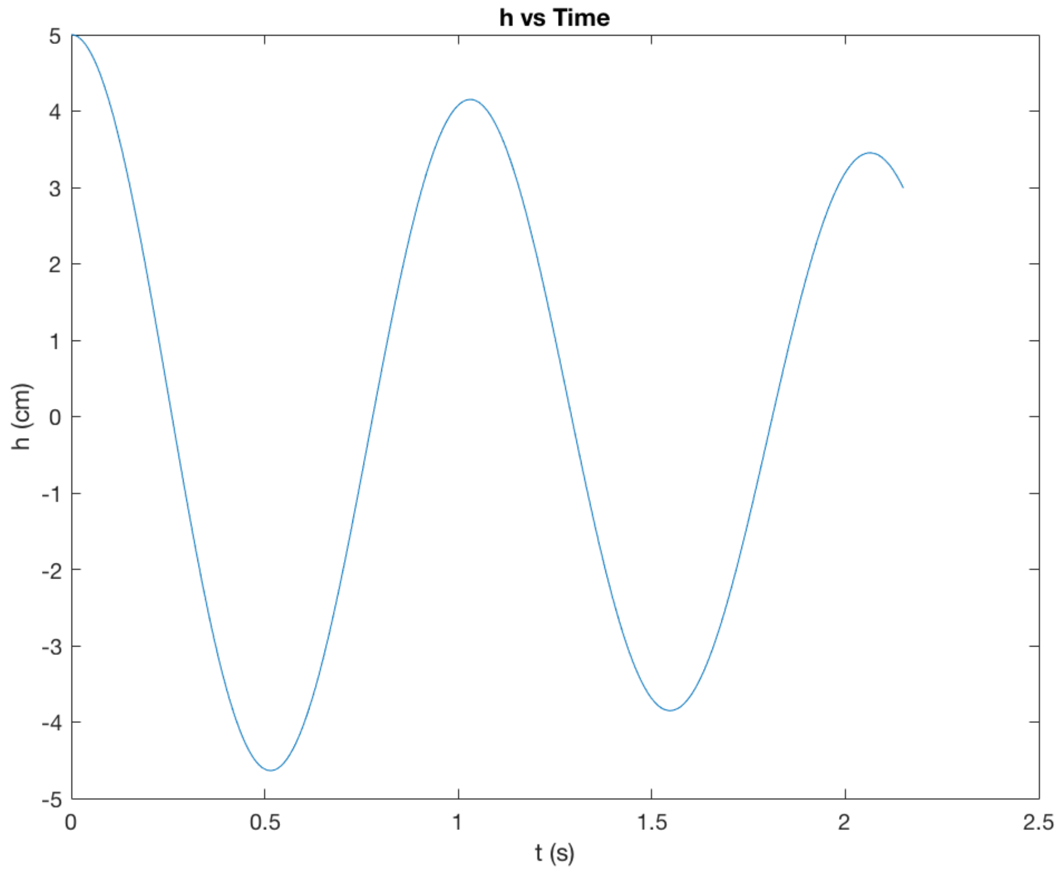

Figure 20: Line Plot of h(t)

Table 11: Oscillation Period and Interpolated values of t1 and t2

Period of Oscillation (s)	1.031
t1 (s)	0.2605
t2 (s)	0.7790

The third deliverable involves two contour plots of the x-velocity at the computed flow time values that are closest to the interpolated values of t1 and t2 reported in the table above. The t1 u-velocity contour was taken at t1 ~= 0.2580 shown in Figure 21, and the second one was taken at t2 ~= 0.7783 and is shown in Figure 22.

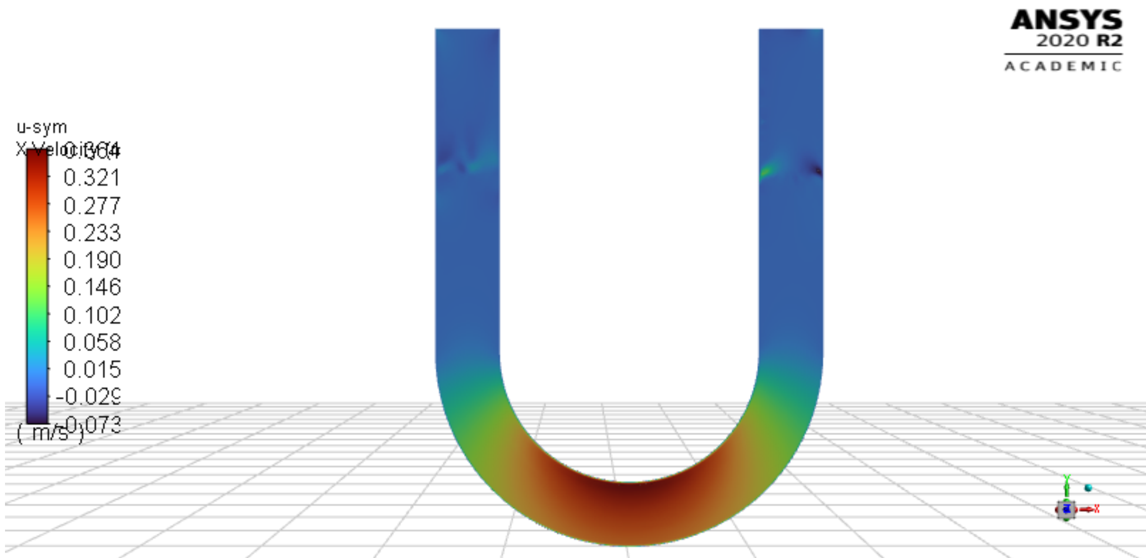

Figure 21: X Velocity Contour at t1 = 0.2580

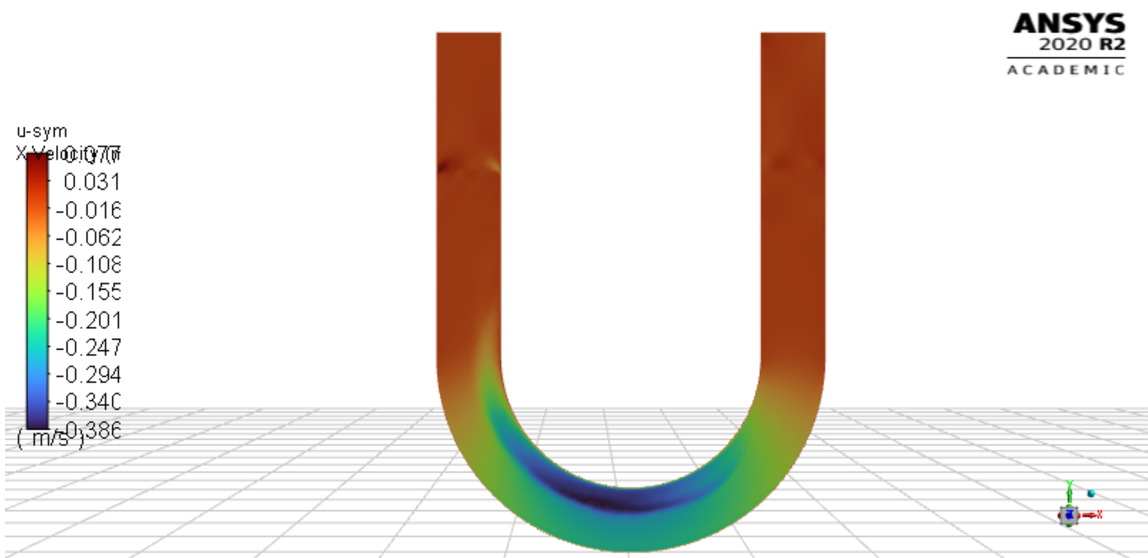

Figure 21: X Velocity Contour at t2 = 0.7783

From the previous two figures, it is evident that the maximum x-velocity magnitude of a little greater than 1/3 of a meter per second occurs at the innermost edge of the pipe in both cases.