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MAE598
Project 3
11/16/17

Task 1 a)

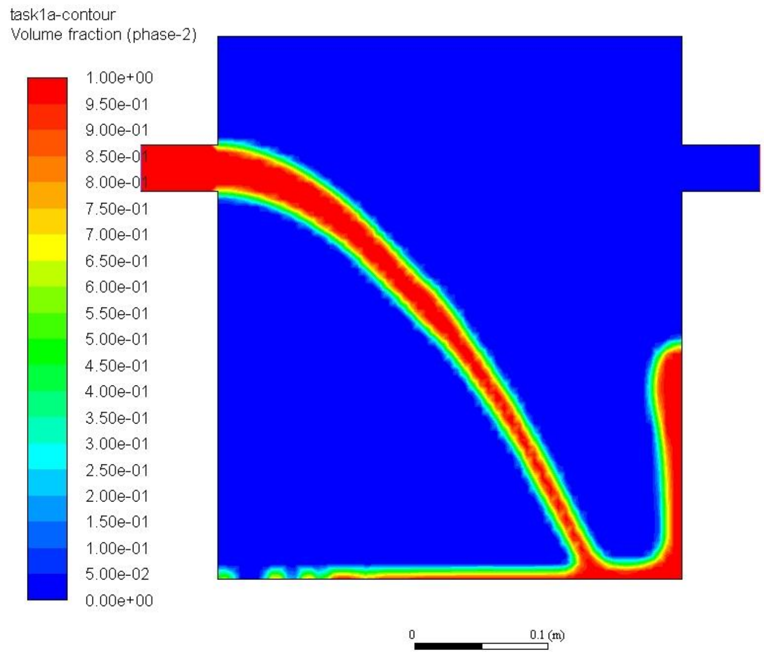

Figure 1: Volume Fraction Of Water At 0.4s

Task 1 b)

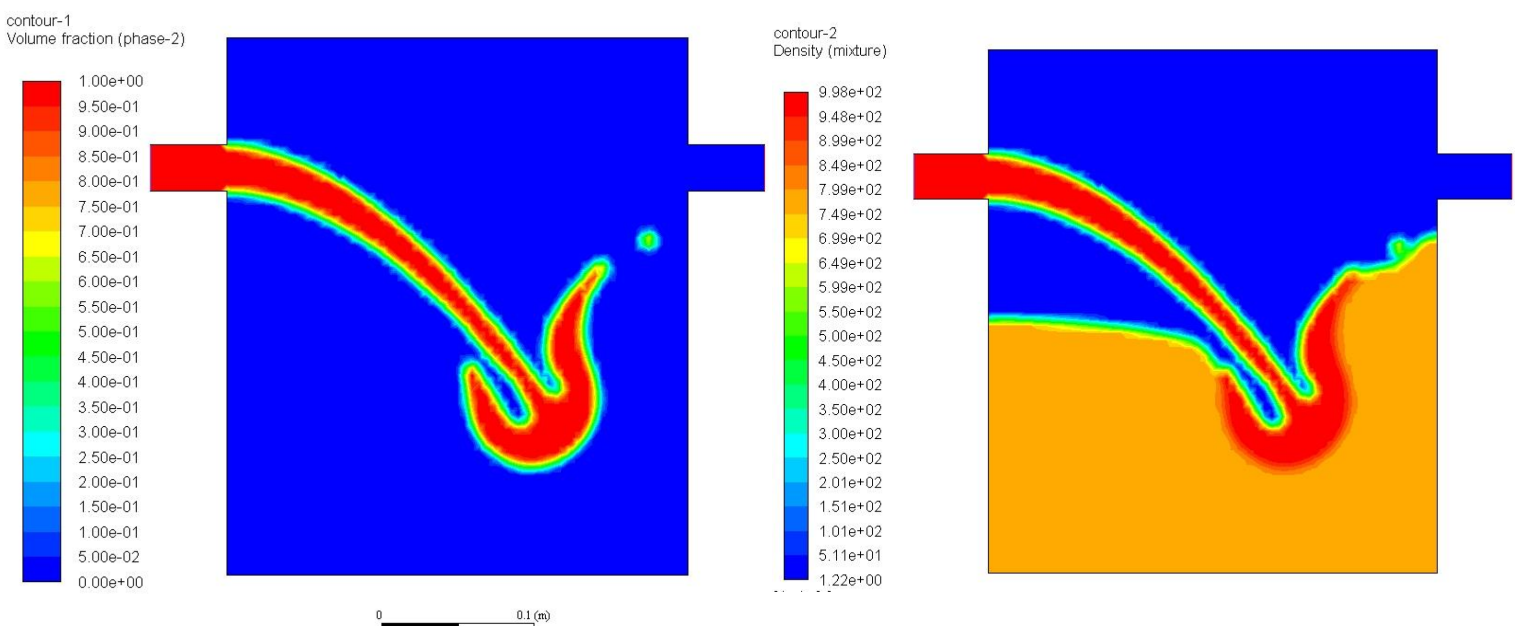

Figure 2: Water Into Kerosene, Volume Fraction (Left) And Total Density Of Mixture (Right)

Task 2 a) V_B=1 m/s

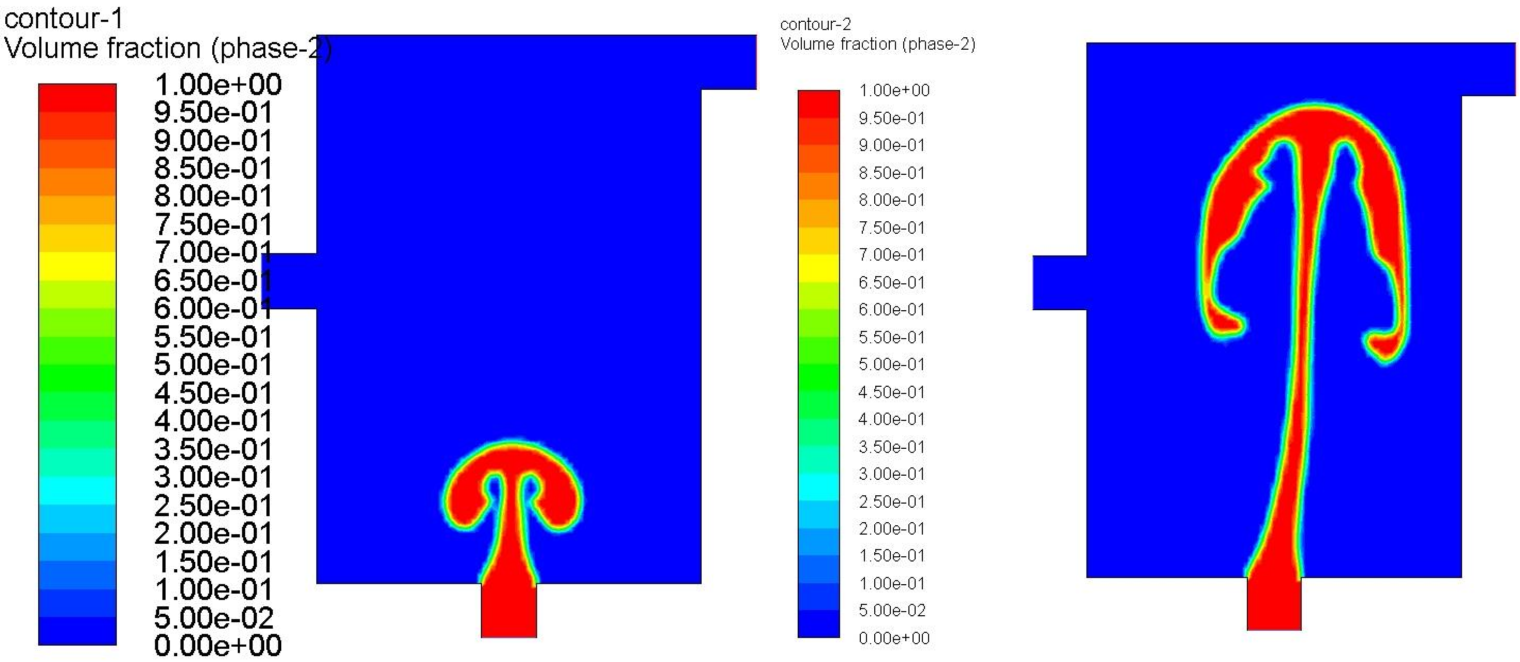

Figure 3: Volume Fraction Of Methane At 2s (Left) And 5s (Right)

Task 2 b) V_B=5 m/s

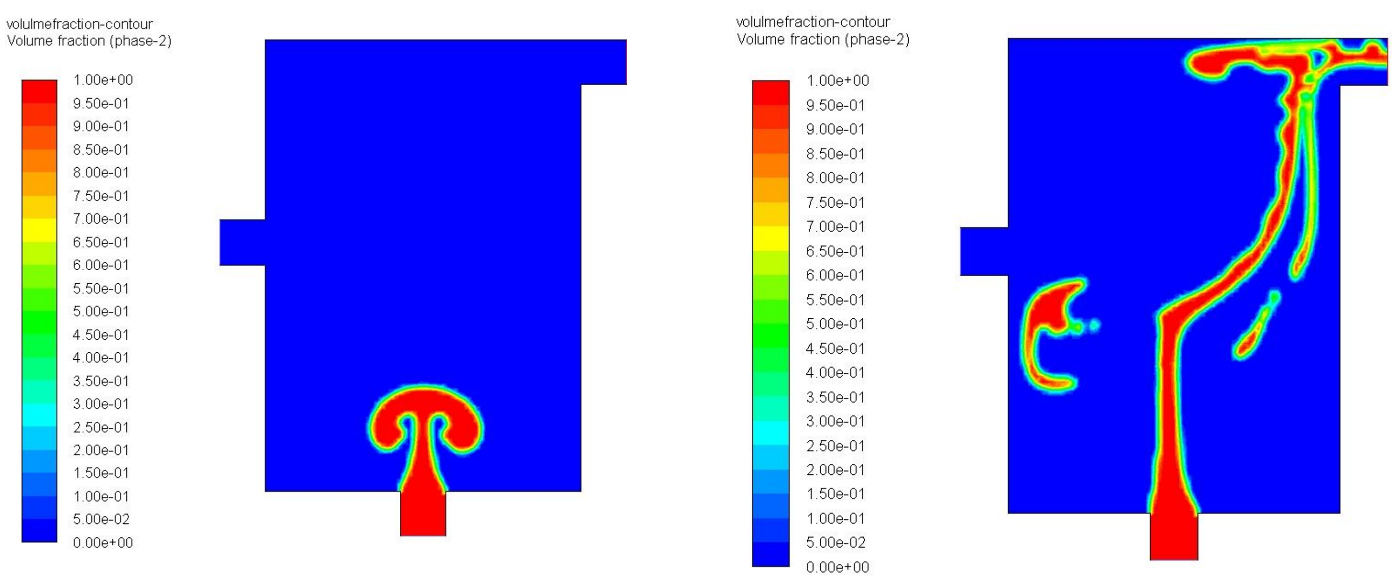

Figure 4: Volume Fraction Of Methane At 2s (Left) And 5s (Right)

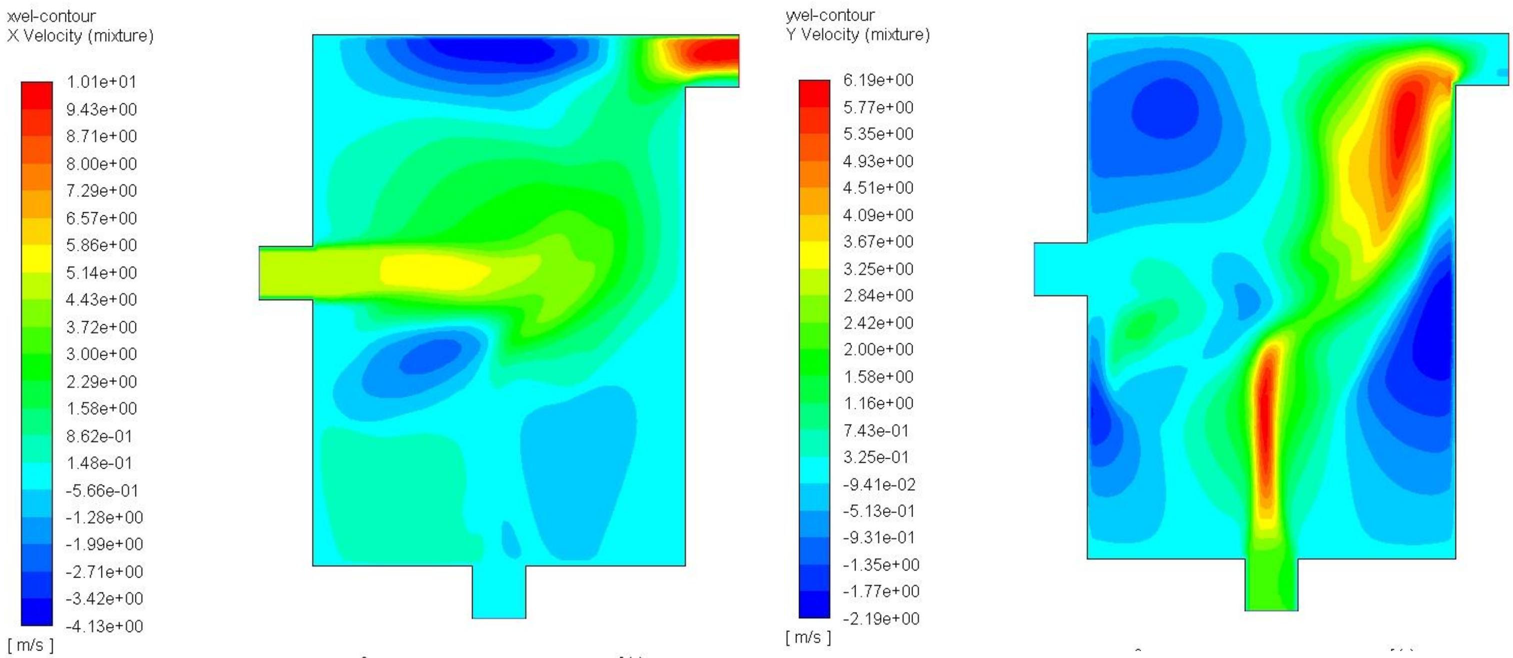

Figure 5: X Velocity (Left) And Y Velocity (Right) Of The Building

Task 3 a) (viscous-laminar model)

After setting up the model and meshing the system, boundary conditions had to be set in order to properly model the behavior of the system. By setting by the openings defined as A and B by the problem statement as pressure outlets with no outflow conditions. This allowed air to freely cross boundaries A and B, ensuring the system would be modelled as intended. In order to track the depth of the water, four vertical lines were defined in the left chamber to act as "measuring sticks" across which a surface integral of the volume fraction of water could be calculated. The depth in the right chamber was defined as a difference of the total available water height minus the average depth from the left chamber (an approximation that is accurate due to the incompressible nature of the fluid and the conservation of mass in the system). From the gathered data, an average was determined and plotted over time as seen in Figure 6 below.

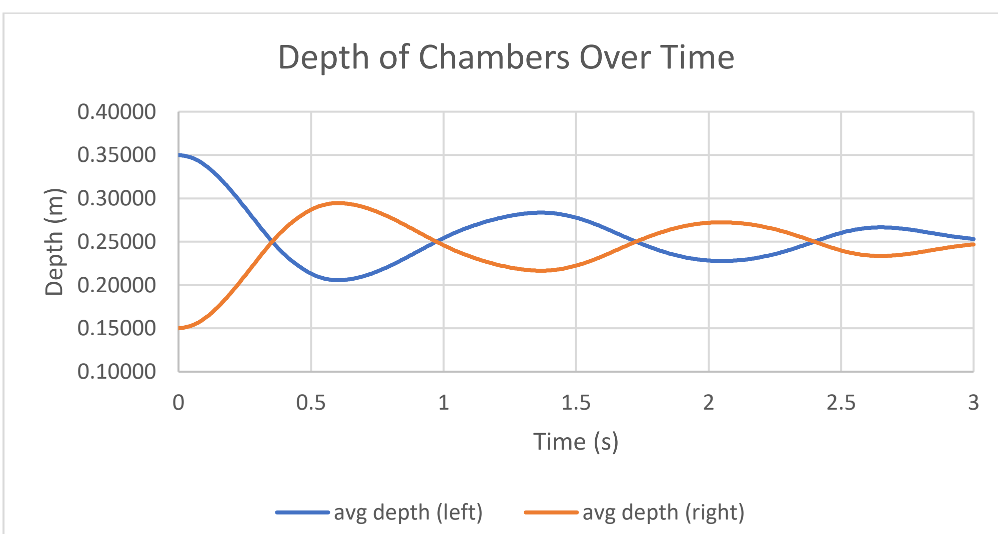

Figure 6: Water Depth Over Time Of Viscous-Laminar Modeled Fluid

From the plot, we can see the first two times at which the depths are equal occur at **t_1 ~0.353s and t_2~0.973s.** Additionally, we can determine the period of oscillation to be approximately **1.33s** by averaging the peak to peak times from the first two periods of oscillations. At t_1 and t_2 we can see the following velocity vector plots in Figure 7 below.

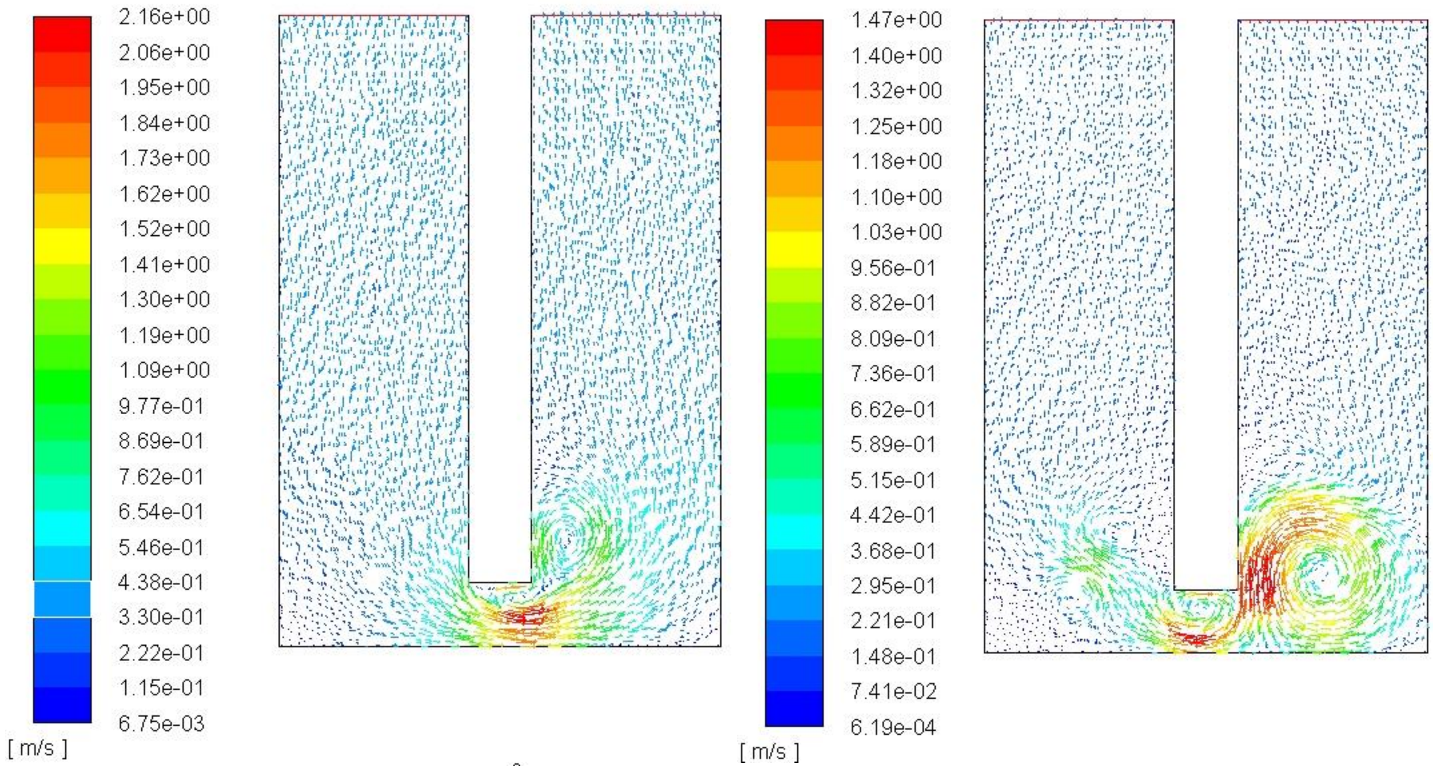

Figure 7: Velocity Vector Plot At T1=0.353s (Left) And T2=0.973s (Right)

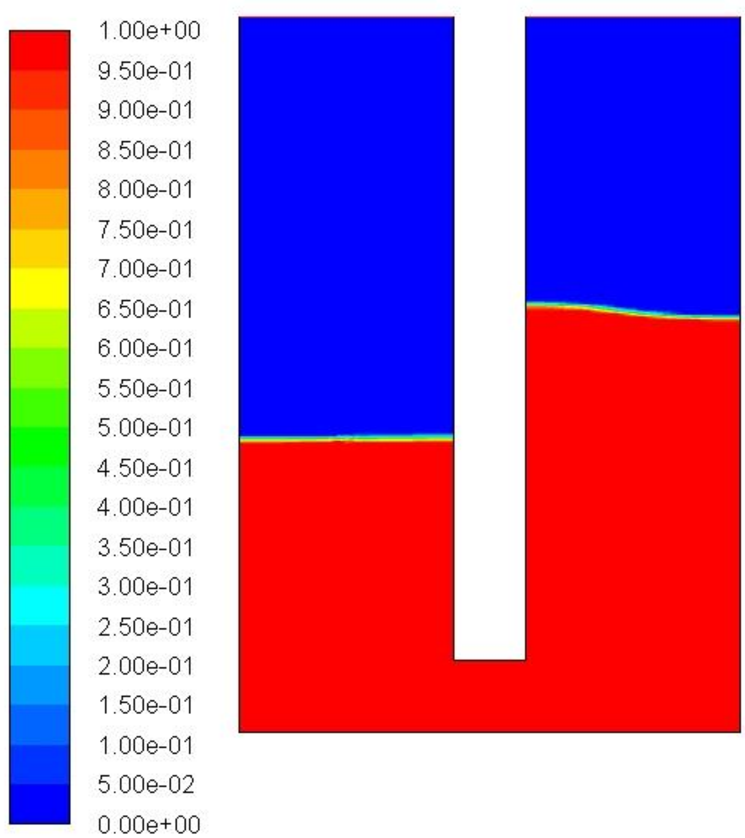

Figure 8: Water Volume Fraction At First Peak Of Right Chamber (T=0.6s)

Task 3 b) (inviscid model)

Using the same pressure outlet conditions for outlets A and B, the simulation was repeated modeling an inviscid fluid. The same method was used to gather the data for the water depth plot as seen in Figure 9 below.

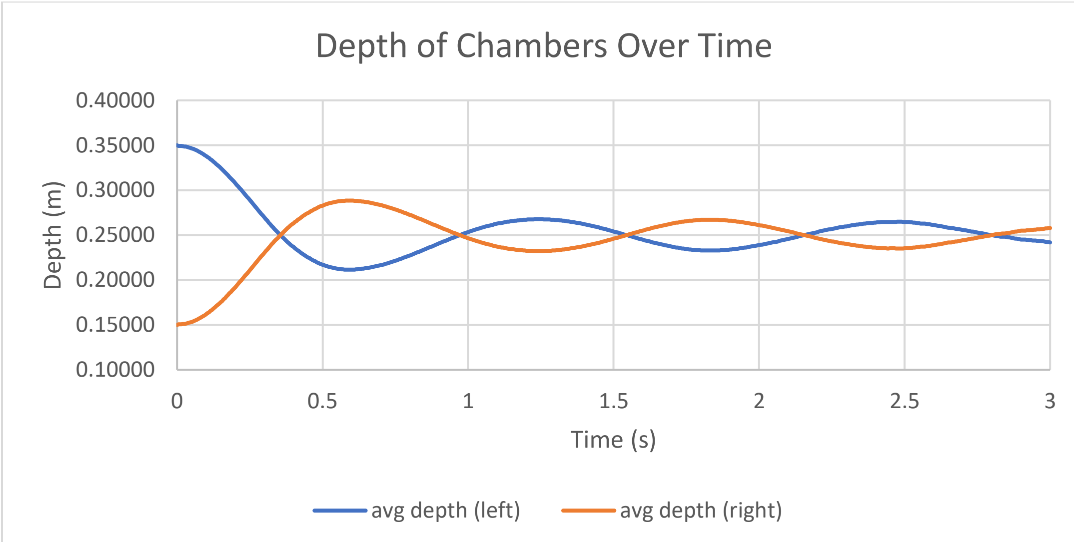

Figure 9: Water Depth Of The Two Chambers Of An Inviscid Modelled System

We can see from the graph that the two lines intersect the first two times at approximately **t_1=0.355 and t_2=0.972s**. We can also determine the period of oscillation by the same method of averaging the first two peak to peak times to obtain a period of **1.24s.** To facilitate comparison of the viscous and inviscid models, the following was generated by only comparing the depth of water in the left tank as seen below.

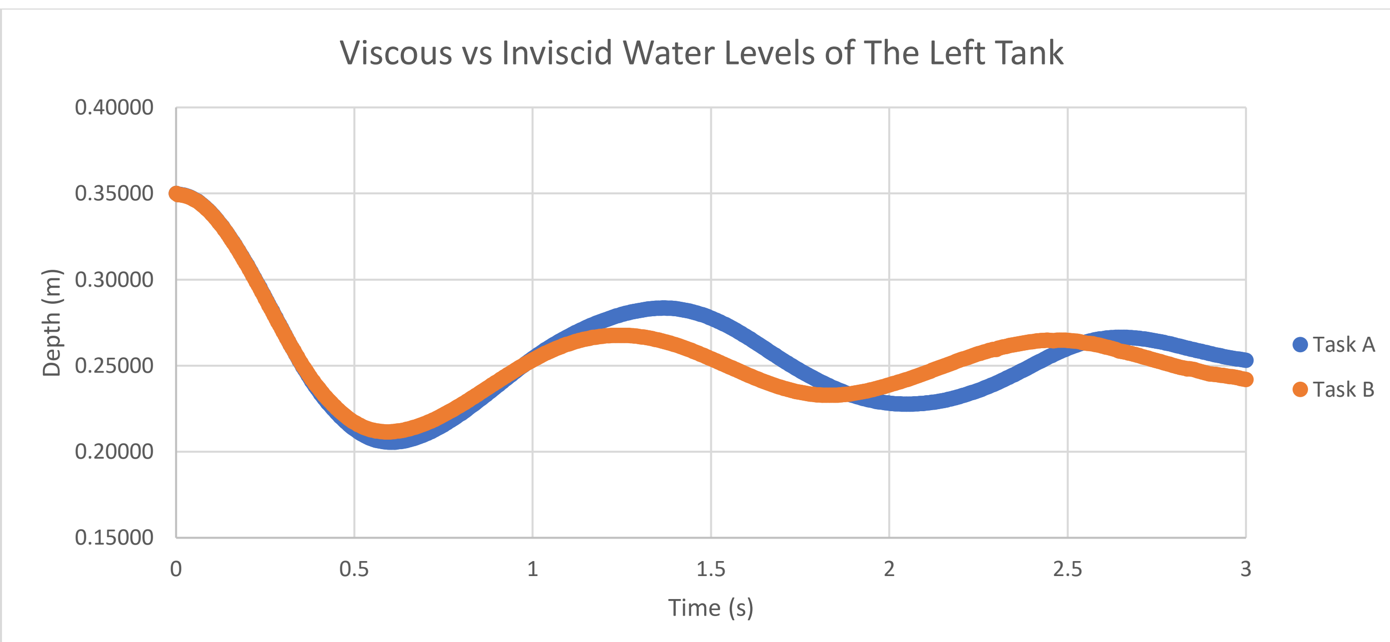

Figure 10: Comparing the Simulation of Viscous (Task A) vs Inviscid (Task B) Flow

We can see that the inviscid model has a shorter period of oscillation and that the amplitude drops off more rapidly initially. We would naturally expect the inviscid case to not damp out as quickly as the viscous case since it neglects the internal fluid forces. However, it is not the case due to the Kelvin-Helmholtz Instability, which creates a “roll” on the fluid surface. This effect reduces the energy of the system rapidly, leading to the quicker decay compared to the viscous case.

Task 4 a) 2D

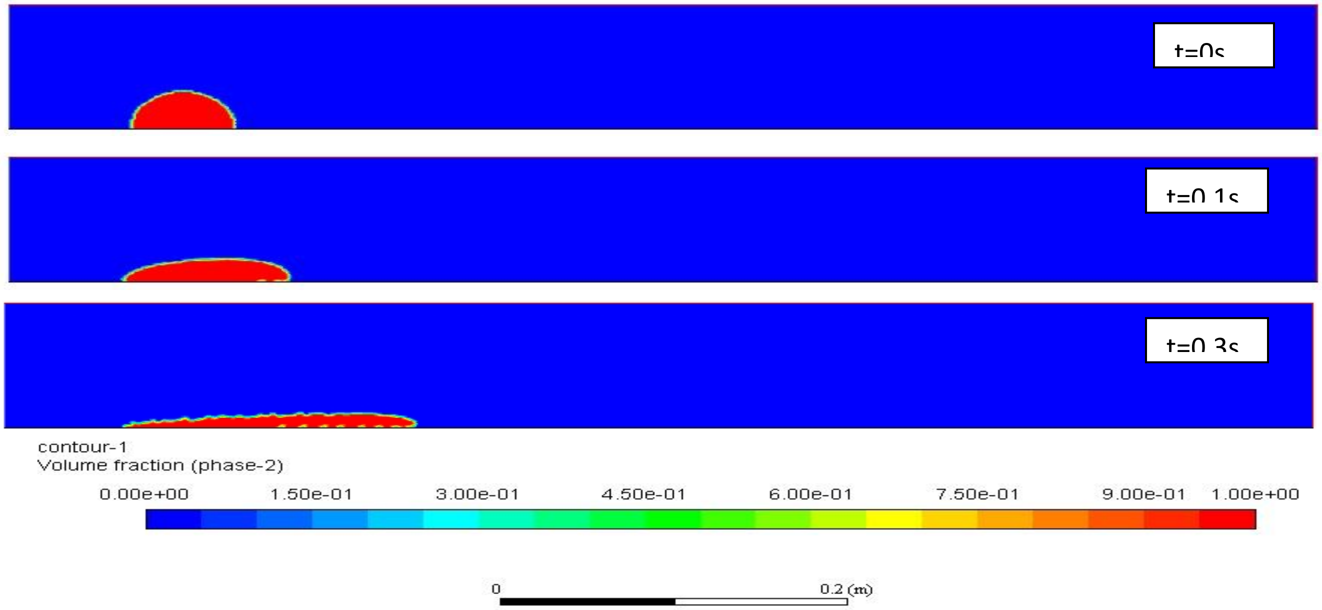

Figure 11: 2D Evolution Of Oil Droplet At T= 0s, 0.1s, And 0.3s

In order to properly model the system, a domain had to be established that was large enough to allow for the uninterrupted evolution of the droplet. With a 3cm tall droplet, the height and length of the chamber were chosen to be 10cm and 75cm respectively. To make the geometry easier, the angled plate was modeled as a flat plate and the gravity vector decomposed into appropriate x and y components as follows:

$$g_y = (9.81 m/s^2)*\cos 30° = 8.4957\ m/s^2$$

$$g_x = (9.81 m/s^2)*\sin 30° = 4.905\ m/s^2$$

Mesh sizing was set to fine, then further refined to an element size of 1.25e-003m, which provided sufficient resolution to model the problem. The left side of the geometry was set with an inlet condition of 0m/s, and the top and right side were set as pressure outlets with 0 gage pressure. The listed domain and boundary conditions allowed for the simulation to be accurately carried out, and we can see that the oil droplet flattens out and moves to the right as expected.

Task 4 b) 3D

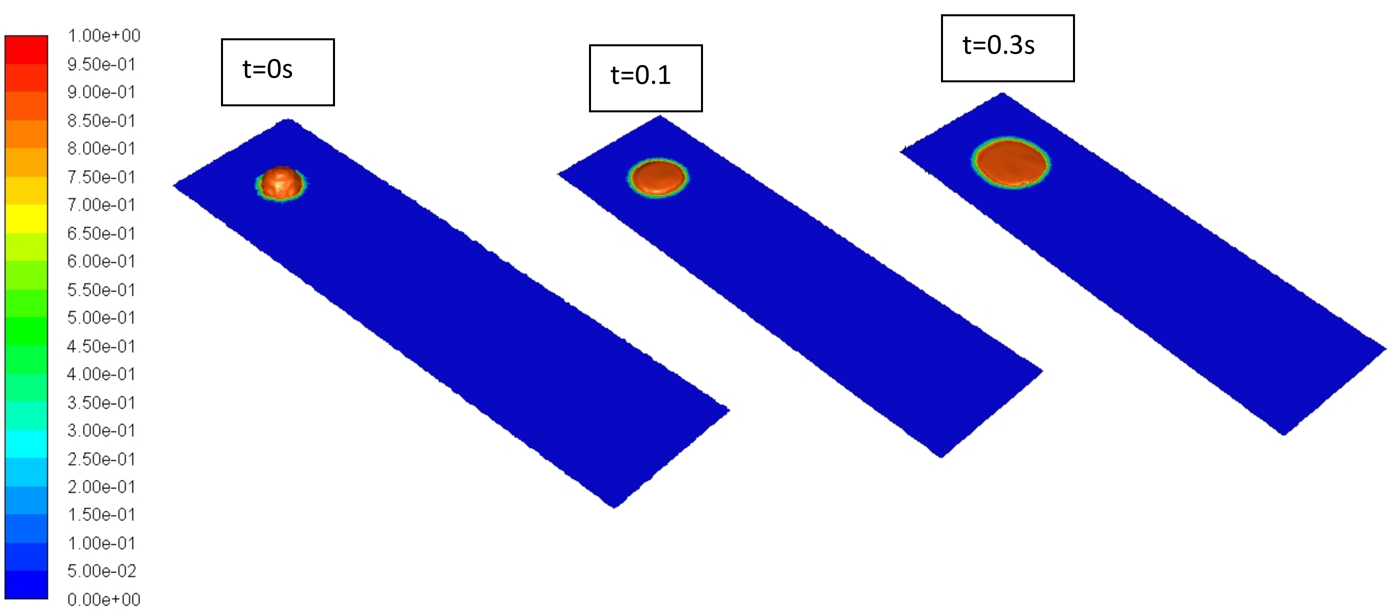

Figure 12: 3D Evolution Of Oil Droplet At T= 0s, 0.1s, And 0.3s