Project #2: Multiphase flow; Flow with interface

MAE 560

Daniel Luna Rubio

Statement of collaboration

I declare that I had **"No collaboration"** with any student of the class of MAE 560: Applied Computational Fluid Dynamics for solving Project #2.

Daniel Luna Rubio

Task 1

Task 1a:

(D1)

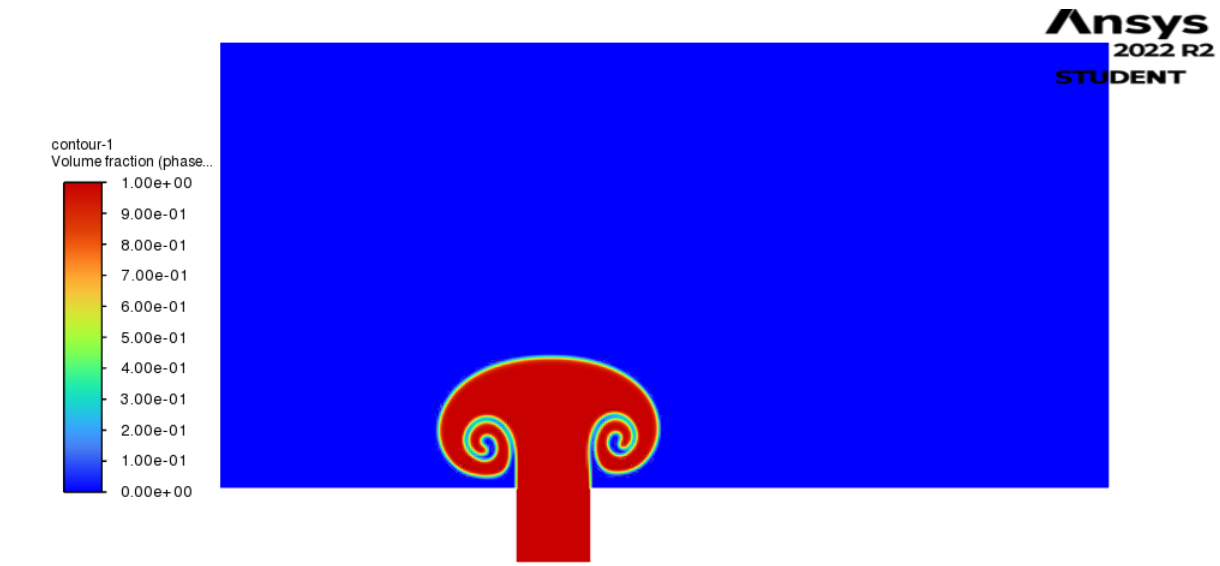

Figure D1.1: Contour plot of the volume fraction of methane at $t = 3\ s$

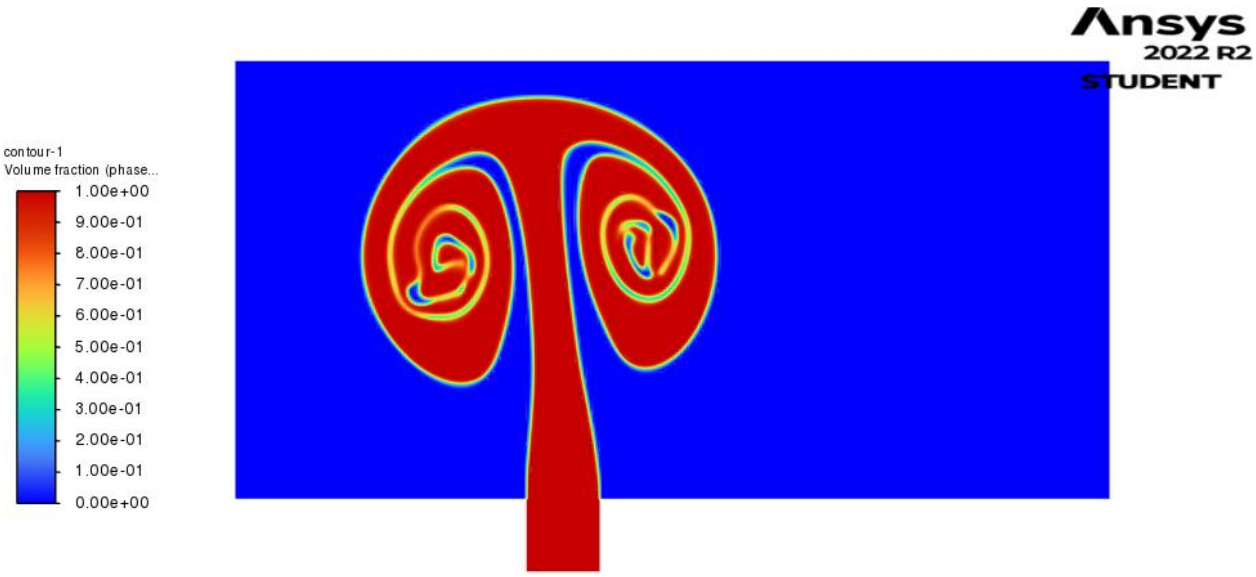

Figure D1.2: Contour plot of the volume fraction of methane at $t = 6\ s$

Task 1b:

(D2)

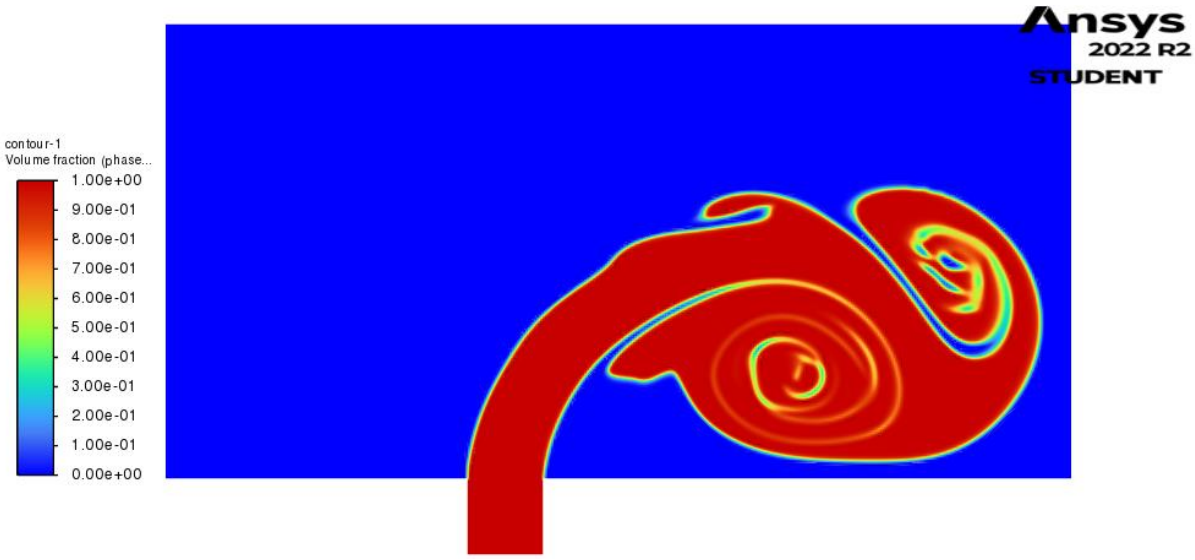

Figure D2: Contour plot of the volume fraction of methane at $t = 6\ s$

(D3)

Geometry and mesh resolution:

Figure D3: Mesh resolution plot

Mesh specifications:

- Element size $= \mathbf{15\ cm}$
- Nodes $= \mathbf{81629}$
- Elements $= \mathbf{80997}$

Run calculations parameters:

- Time step size $= \mathbf{0.01\ s}$
- Maximum number of iterations per time step $= \mathbf{20}$

Task 2

(D4)

Geometry and mesh resolution:

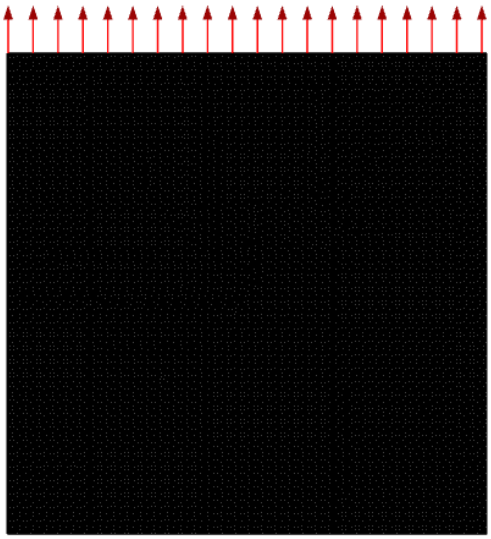

Figure D4: Mesh resolution plot

Mesh specifications:

- Element size $= \mathbf{0.1}\ \boldsymbol{cm}$
- Nodes $= \mathbf{63001}$
- Elements $= \mathbf{62500}$

Run calculations parameters:

- Time step size $= \mathbf{0.0004}\ \boldsymbol{s}$
- Maximum number of iterations per time step $= \mathbf{10}$

(D5)

The *custom field function* used for plotting the contours is: $\boldsymbol{CF = 0.1 * VF1 + 0.2 * VF2 + 0.3 * VF3}$

Figure D5.1: Contour plot of custom field function "CF" at $t = 0.1\ s$

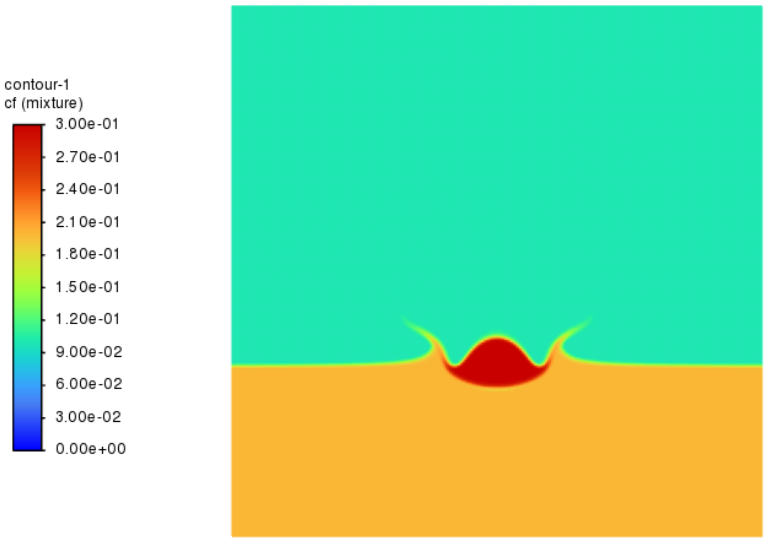

Figure D5.2: Contour plot of custom field function "CF" at $t = 0.16\ s$

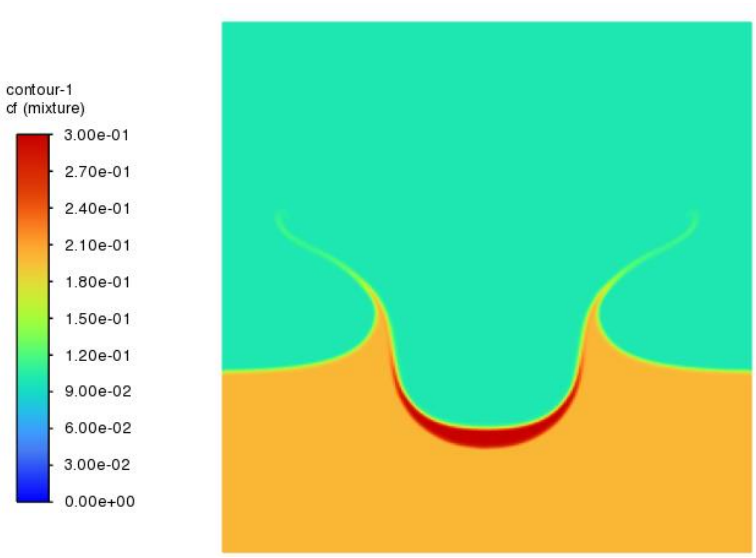

Figure D5.3: Contour plot of custom field function "CF" at $t = 0.2\ s$

Task 3

(D6)

Computational domain = $\boldsymbol{20X10X5\ cm}$

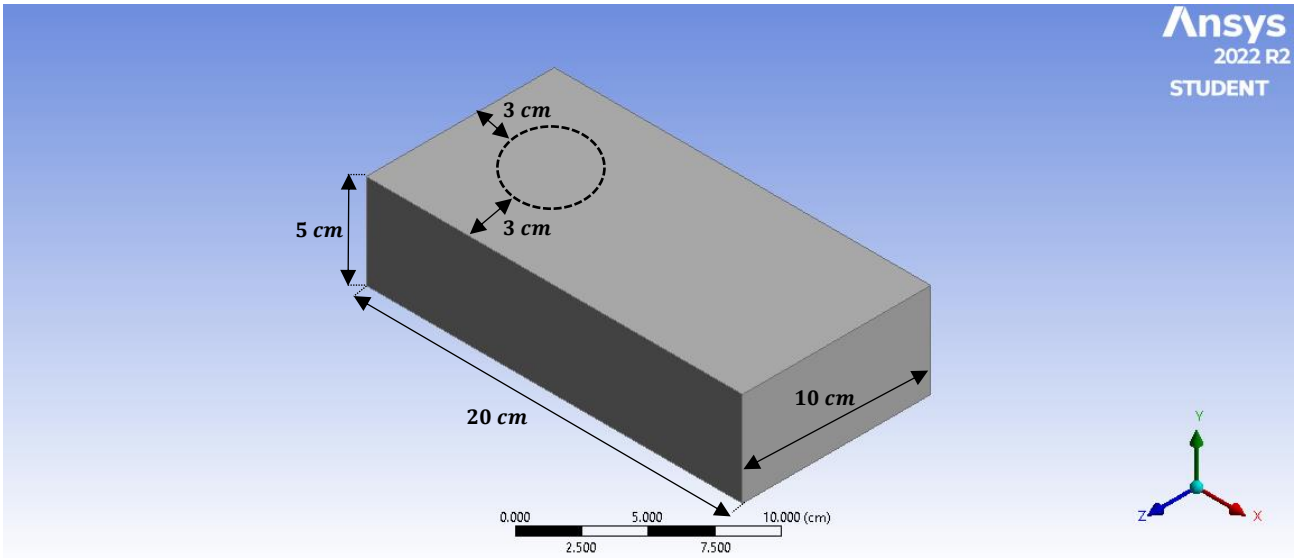

Figure D6.1: Computational domain

Boundary conditions:

- All the walls out of bottom face are set as **pressure-outlet** with **gauge pressure** of $\boldsymbol{0\ Pa}$.
- Gravitational acceleration values:

$$X\left[m^2/s^2\right] = \left(9.81\, m^2/s^2\right)(\sin 30) = \boldsymbol{4.905\ m^2/s^2} \quad Y\left[m^2/s^2\right] = \left(-9.81\, m^2/s^2\right)(\cos 30) = \boldsymbol{-8.496\ m^2/s^2}$$

Geometry and mesh resolution:

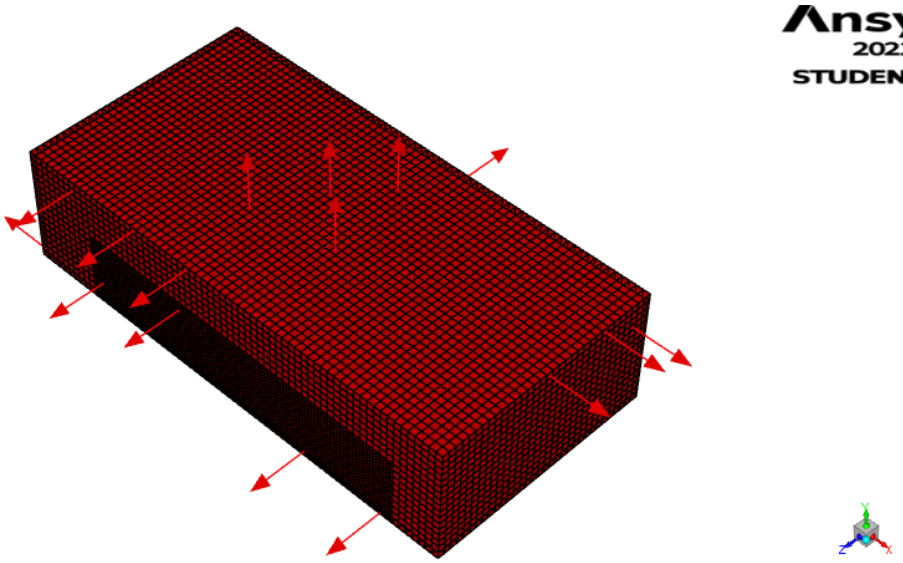

Figure D6.2: Mesh resolution plot

Mesh adaption region:

Shape: **Hex**

Input coordinates:

$X\ Min\ [m] = \mathbf{0.03}$ $X\ Max\ [m] = \mathbf{0.18}$

$Y\ Min\ [m] = \mathbf{0}$ $Y\ Max\ [m] = \mathbf{0.03}$

$Z\ Min\ [m] = \mathbf{0}$ $Z\ Max\ [m] = \mathbf{0.1}$

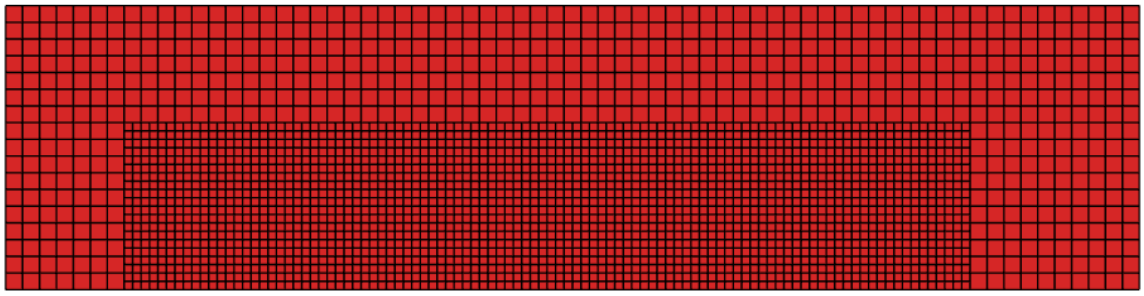

Figure D6.3: Mesh adaption plot

Mesh specifications:

- Element size $= \mathbf{0.2}\ \boldsymbol{cm}$
- Nodes $= \mathbf{133926}$
- Elements $= \mathbf{125000}$

Run calculations parameters:

- Time step size $= \mathbf{0.0005}\ \boldsymbol{s}$
- Maximum number of iterations per time step $= \mathbf{15}$

(D7)

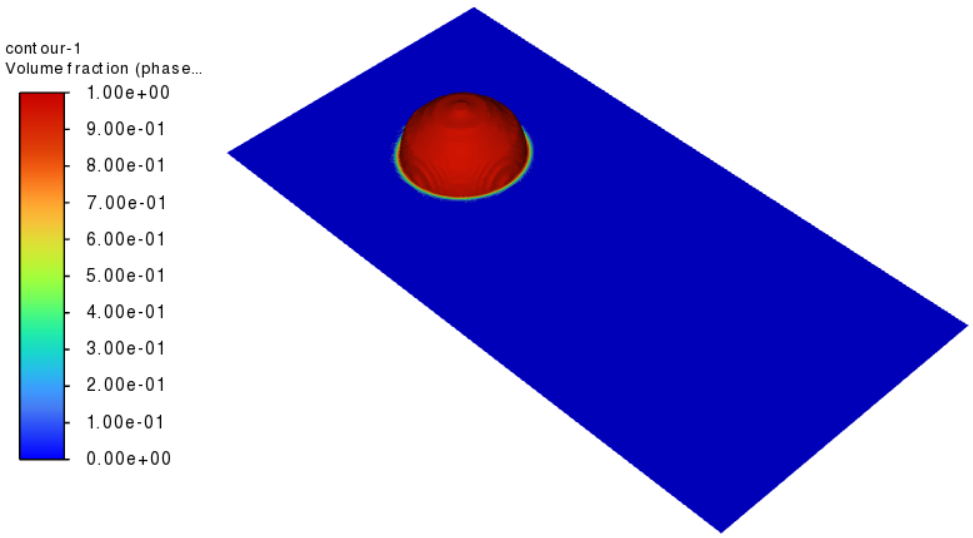

Figure D7.1: Isometric view contour plot of 3-D glycerin blob at $t = 0\ s$

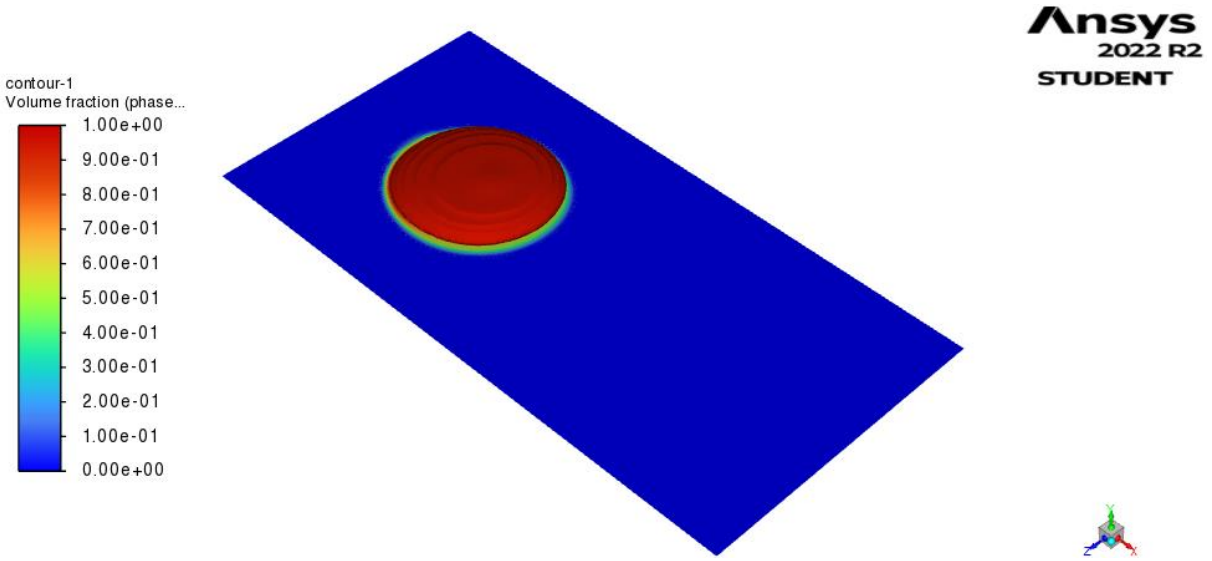

Figure D7.2: Isometric view contour plot of 3-D glycerin blob at $t = 0.08\ s$

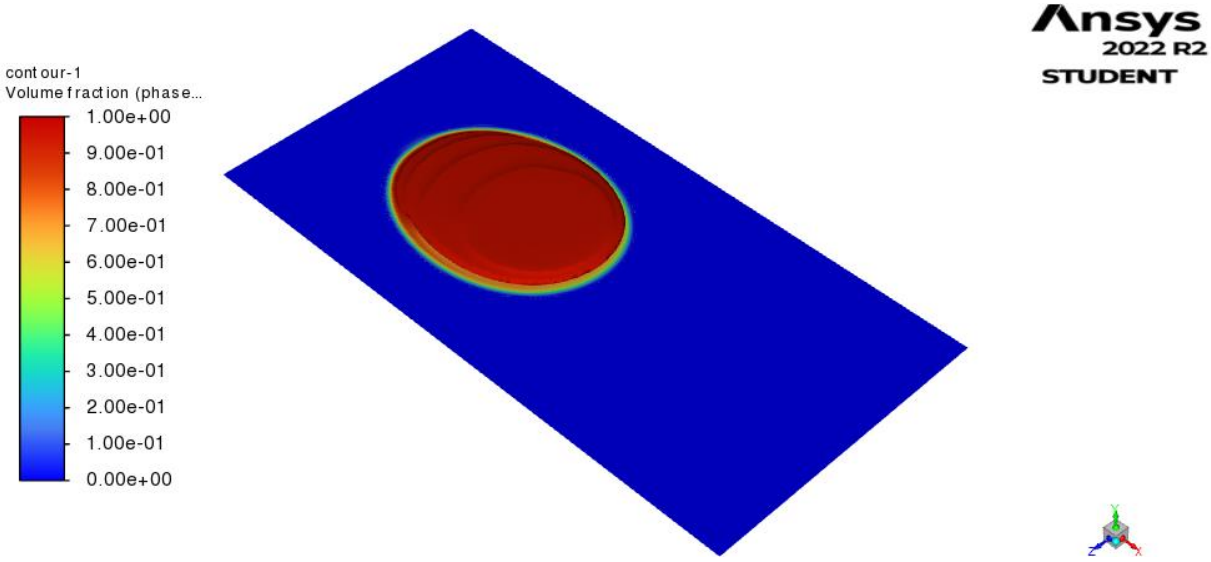

Figure D7.3: Isometric view contour plot of 3-D glycerin blob at $t = 0.2\ s$

(D8)

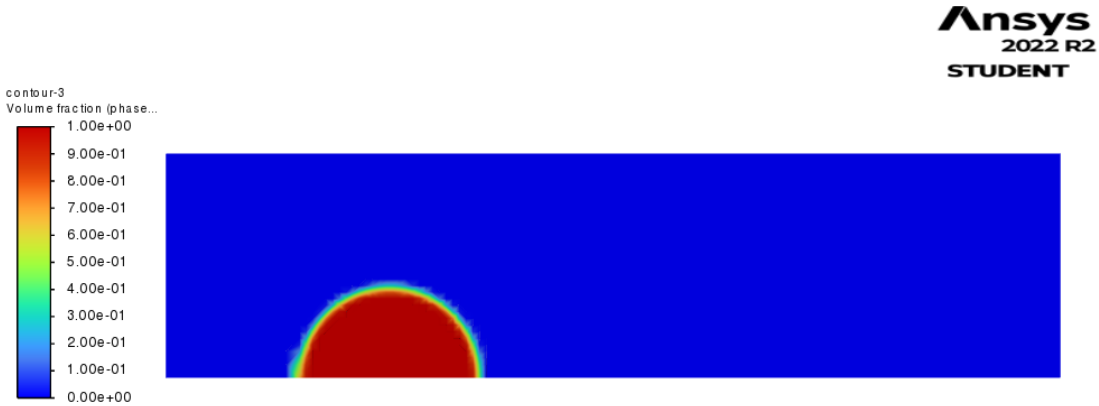

Figure D8.1: Plane of symmetry contour plot of glycerin volume fraction at $t = 0\ s$

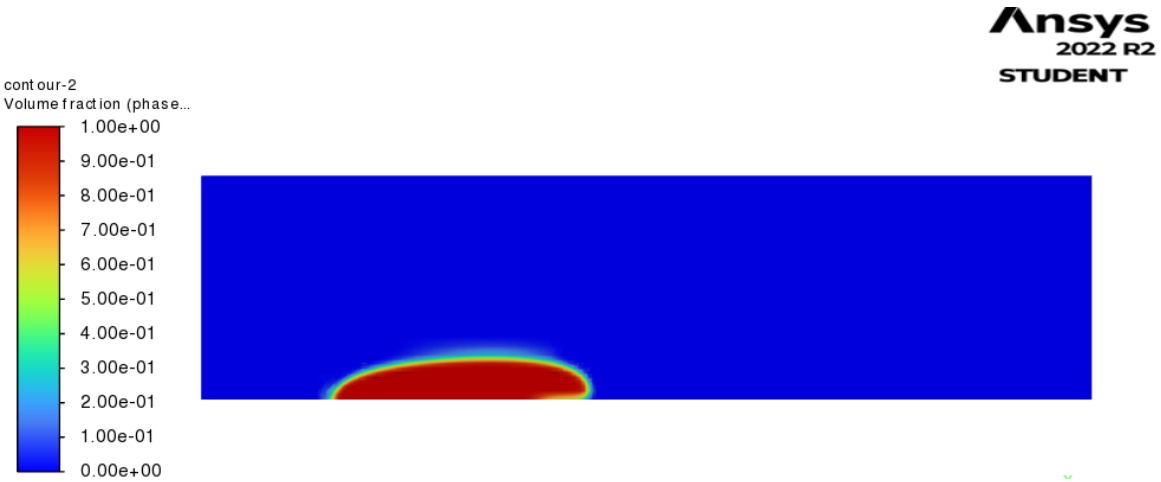

Figure D8.2: Plane of symmetry contour plot of glycerin volume fraction at $t = 0.08\ s$

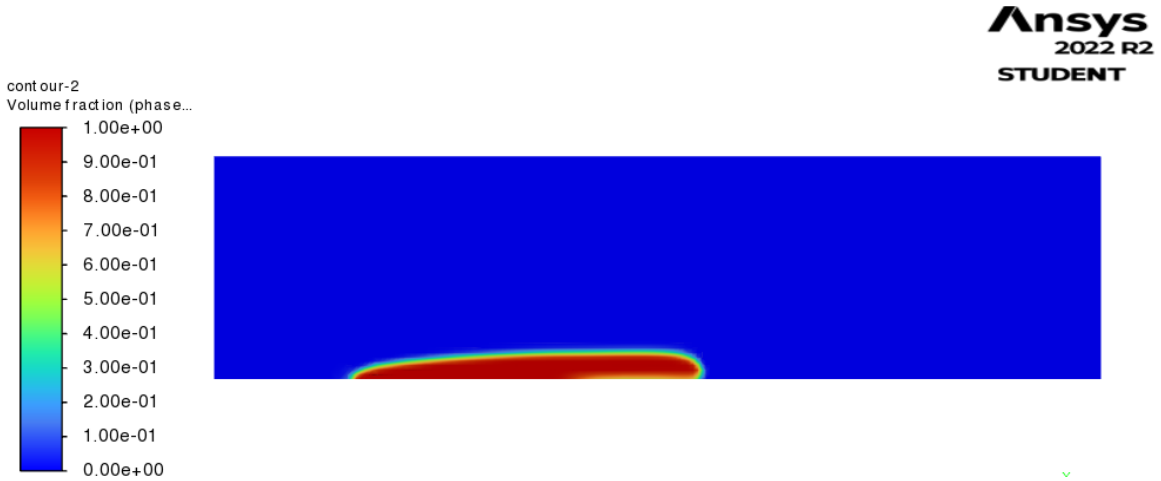

Figure D8.3: Plane of symmetry contour plot of glycerin volume fraction at $t = 0.2\ s$

Task 4

(D9)

Boundary conditions:

- Top and bottom openings are set as **pressure-outlet** with **gauge pressure** of $\mathbf{0}\ \boldsymbol{Pa}$.
- Gravitational acceleration values:

$$Z\left[{}^{m^2}/_{s^2}\right] = -9.81\ {}^{\boldsymbol{m^2}}/_{\boldsymbol{s^2}}$$

Geometry and mesh resolution:

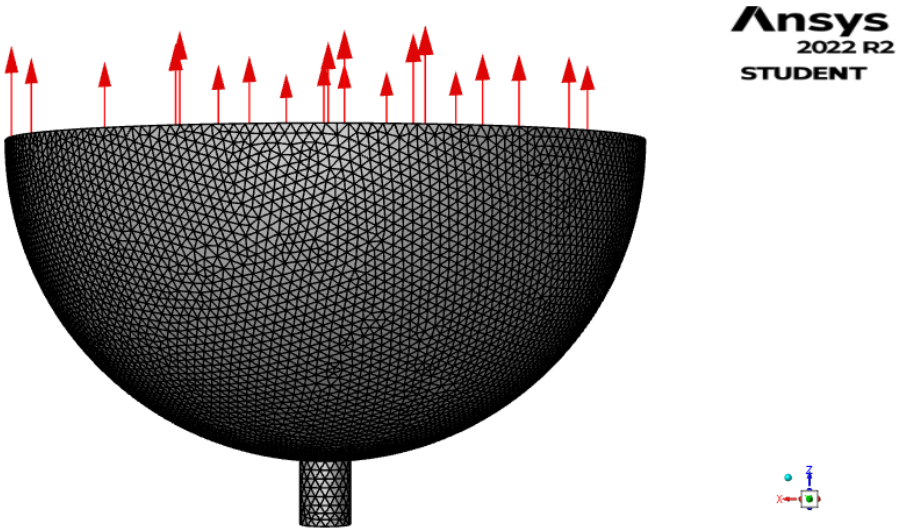

Figure D9: Mesh resolution plot

Mesh specifications:

- Element size $= \mathbf{0.8}\ \boldsymbol{cm}$
- Nodes $= \mathbf{39870}$
- Elements $= \mathbf{206101}$

Run calculations parameters:

- Time step size $= \mathbf{0.1}\ \boldsymbol{s}$
- Maximum number of iterations per time step $= \mathbf{10}$

Note: Previous parameters are set for both case A and B.

(D10)

Case A:

Performing the transient simulation on the system, the time $\boldsymbol{t_A}$, at which half of the water is drained is approximately $\mathbf{7.9}\ \boldsymbol{s}$**.**

Case B:

Performing the transient simulation on the system, the time $\boldsymbol{t_B}$, at which half of the engine oil is drained is approximately $\mathbf{12.1}\ \boldsymbol{s}$**.** Therefore, **water will drain faster since** $\boldsymbol{t_A < t_B}$ **.**

Note: Time values for both cases were extracted from report data file.

(D11)

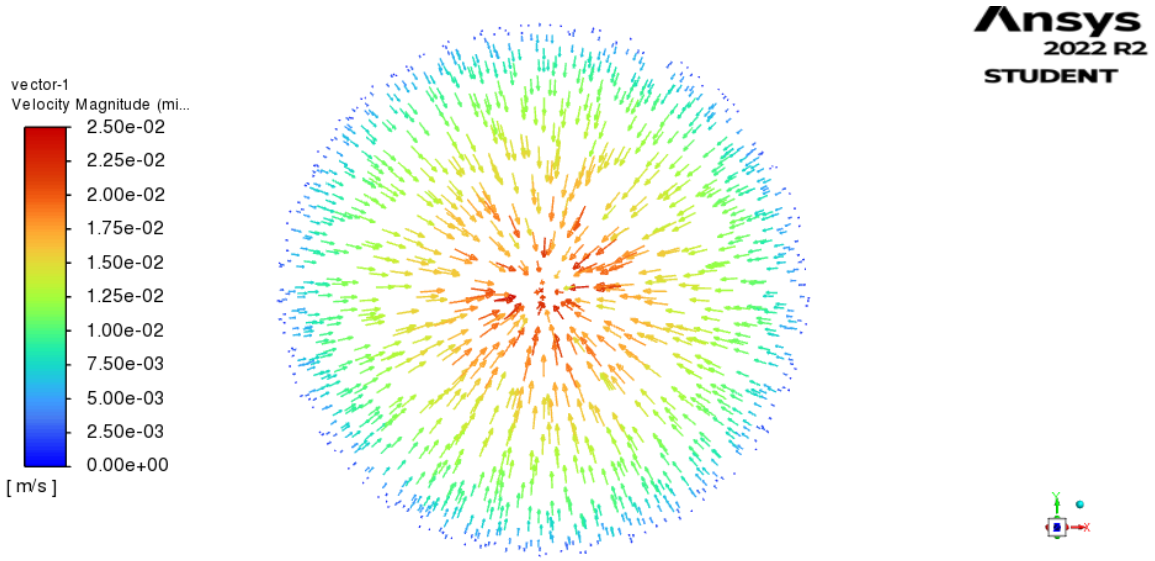

Figure D11: Velocity vectors on horizontal plane located 15 cm below top basin for case B at t_B