MAE 598: Applied CFD Project #3

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Task 1:

General Setup –

The basic geometry and dimensions are shown in Figure 1 below. The blue circle in Figure 1 has a radius of 10cm. The following simulation is in 2 dimensions.

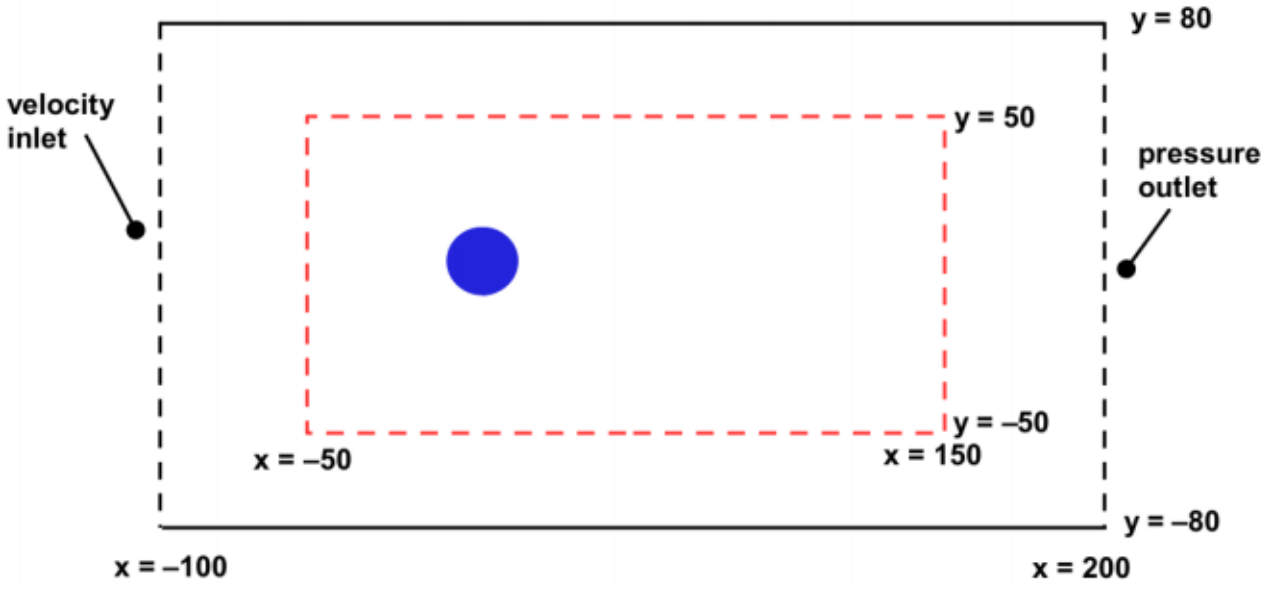

Figure 1: Basic Dimensions of Task 1

Part A –

General Setup –

The material used in this simulation is liquid kerosene with constant density and viscosity. The inlet velocity, shown in Figure 1, is 0.006 m/s. The model used by the simulation is Viscous-laminar. The simulation is run for 1 hour with a relevance center set to fine with an adapted region indicated with a red dashed line in Figure 1.

(1):

Estimate Reynolds number of the system.

$$\mathrm{Re} = \frac{\rho v D}{\mu}$$

$$\mathrm{Re} = \frac{780(0.006)(0.2)}{(0.0024)}$$

$$\mathrm{Re} = 390 \rightarrow \text{Transition}$$

(2):

The contour plot of the velocity magnitude is shown in Figure 2.

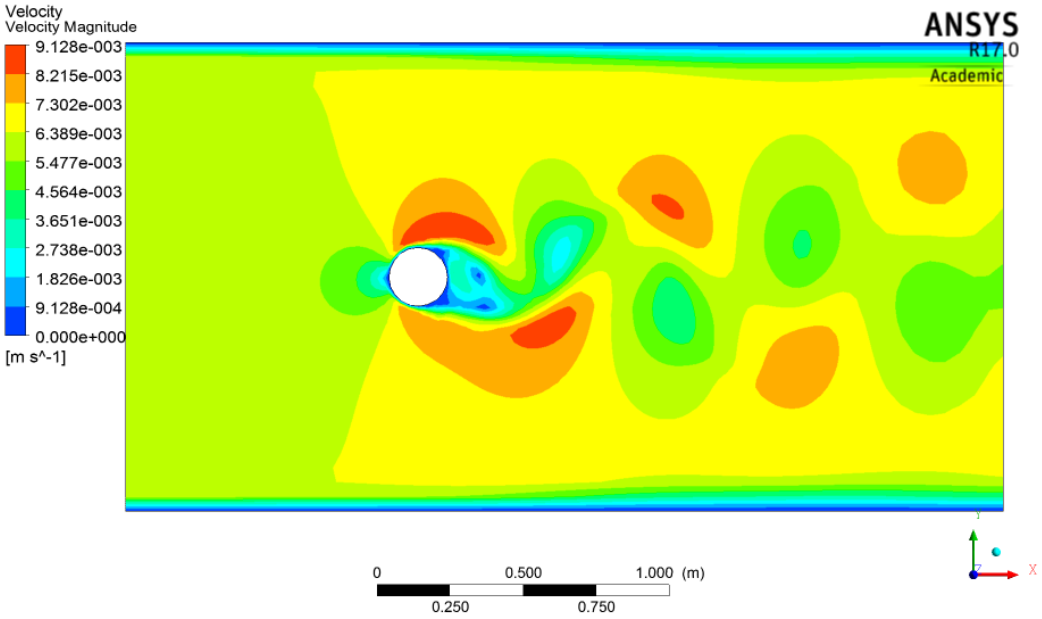

Figure 2: Velocity Magnitude Contour Plot for Task 1, Part A

The contour of the y-component of velocity is shown in Figure 3.

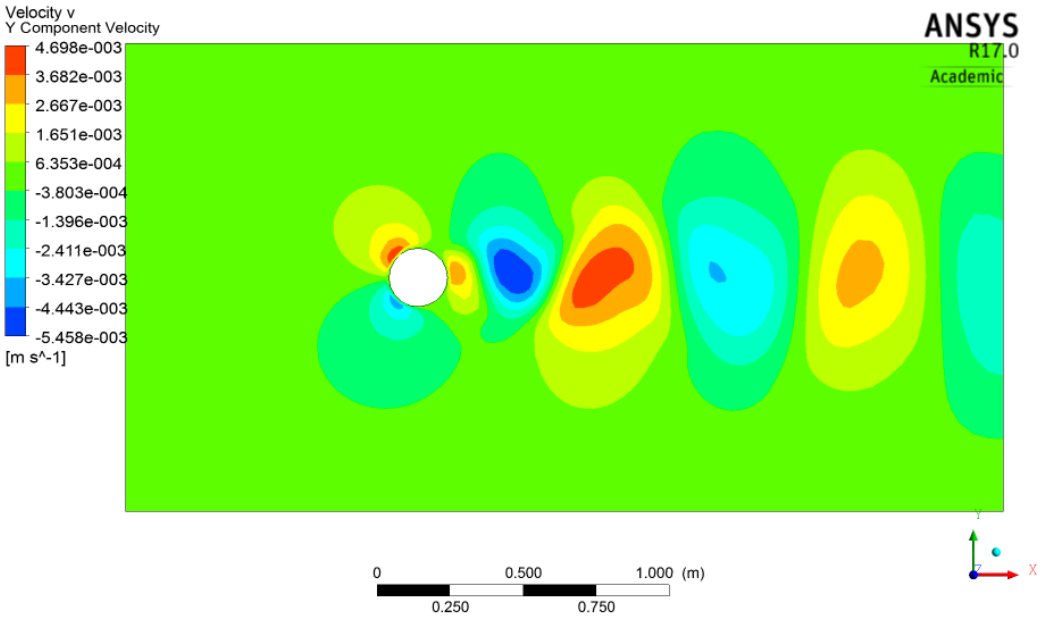

Figure 3: Y-Component of Velocity of Task 1, Part A

The contour plot of the static pressure is shown in Figure 4.

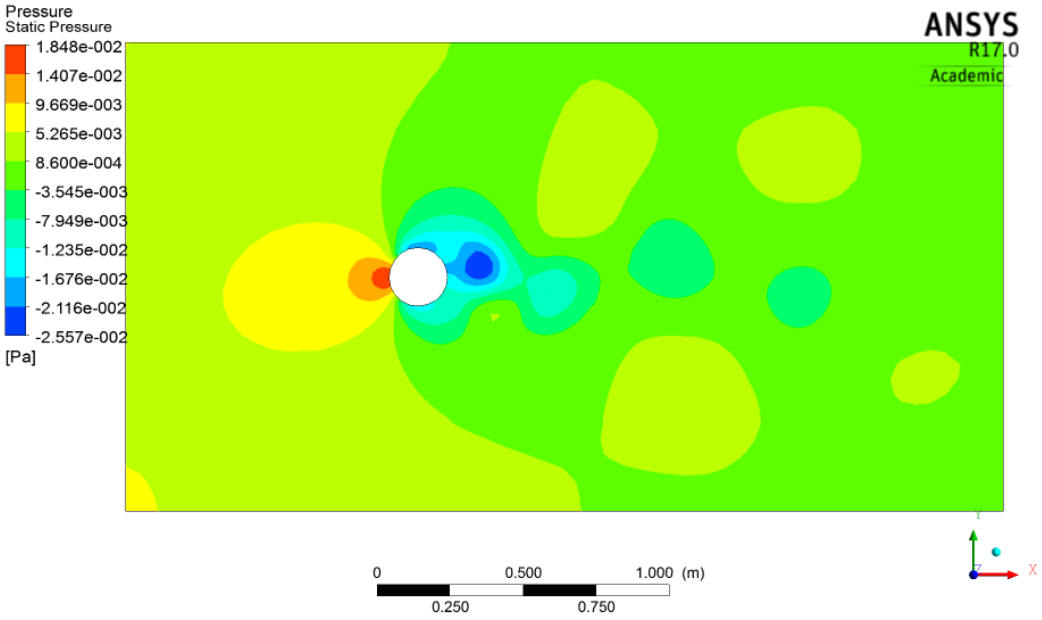

Figure 4: Static Pressure Contour Plot of Task 1, Part A

(3):

The line plots of the x-component of velocity at x=50 cm and x=150 cm is shown below in Figure 5.

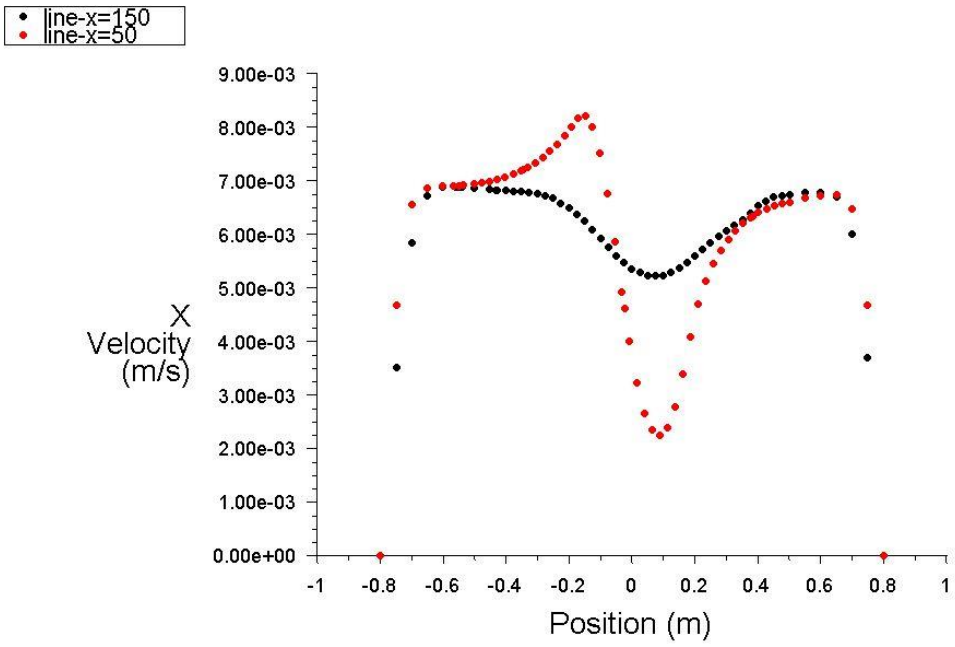

Figure 5: X-Component of Velocity Line Plots at x=50 cm and x=150 cm

Part B –

General Setup –

The material used in this simulation is liquid water with constant density and viscosity. The inlet velocity, shown in Figure 1, is 0.0003 m/s. The model used by the simulation is Viscous-laminar. The simulation is run for 1 hour with a relevance center set to fine with an adapted region indicated with a red dashed line in Figure 1.

(1):

Estimate Reynolds number of the system.

$$\mathrm{Re} = \frac{\rho v D}{\mu}$$

$$\mathrm{Re} = \frac{998.2(0.0003)(0.2)}{(0.001003)}$$

$$\mathrm{Re} = 59.11 \rightarrow \text{Transition}$$

(2):

The contour plot of the velocity magnitude is shown in Figure 6.

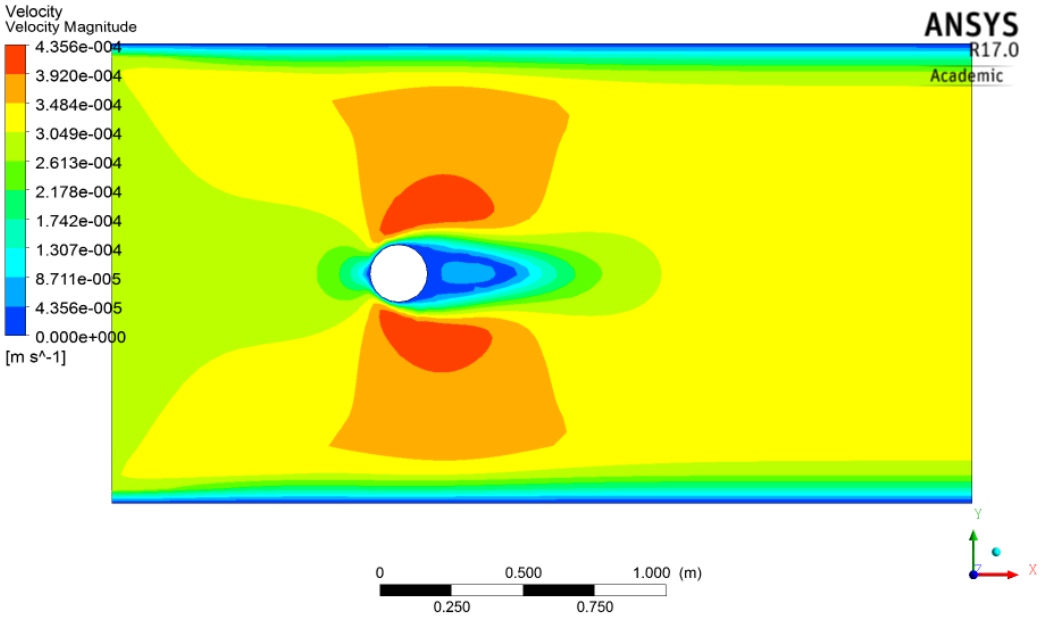

Figure 6: Velocity Magnitude Contour Plot for Task 1, Part B

The contour of the y-component of velocity is shown in Figure 7.

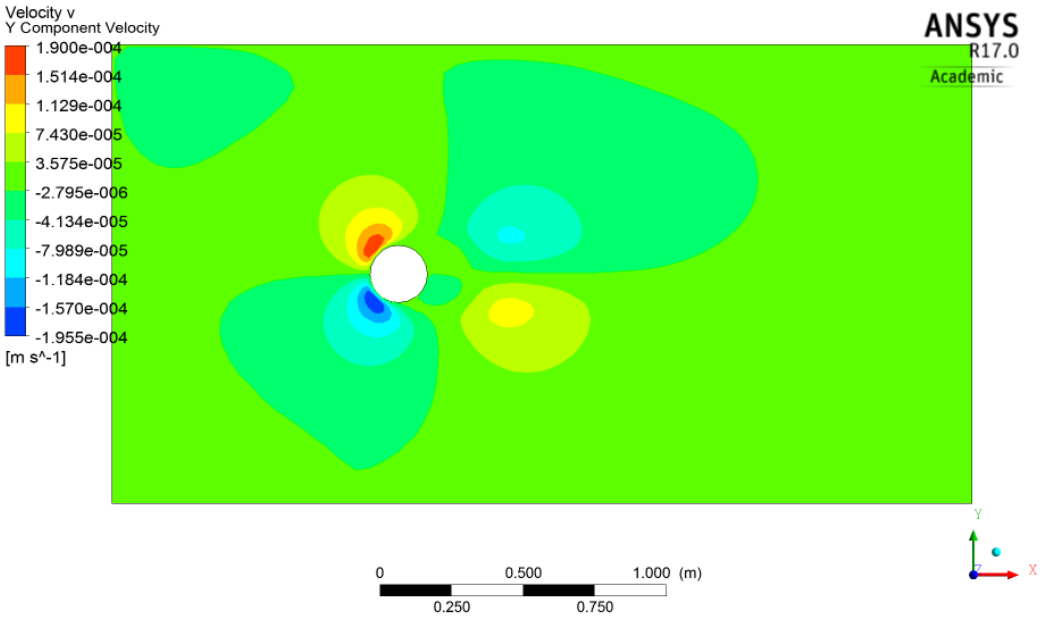

Figure 7: Y-Component of Velocity of Task 1, Part B

The contour plot of the static pressure is shown in Figure 8.

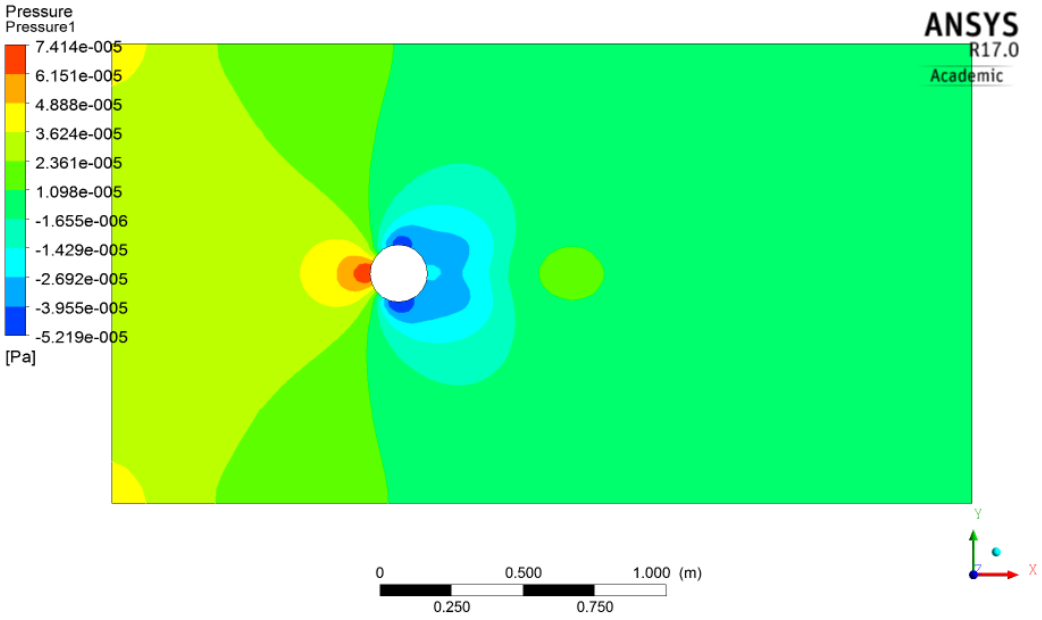

Figure 8: Static Pressure Contour Plot of Task 1, Part B

(3):

The line plots of the x-component of velocity at x=50 cm and x=150 cm is shown below in Figure 9.

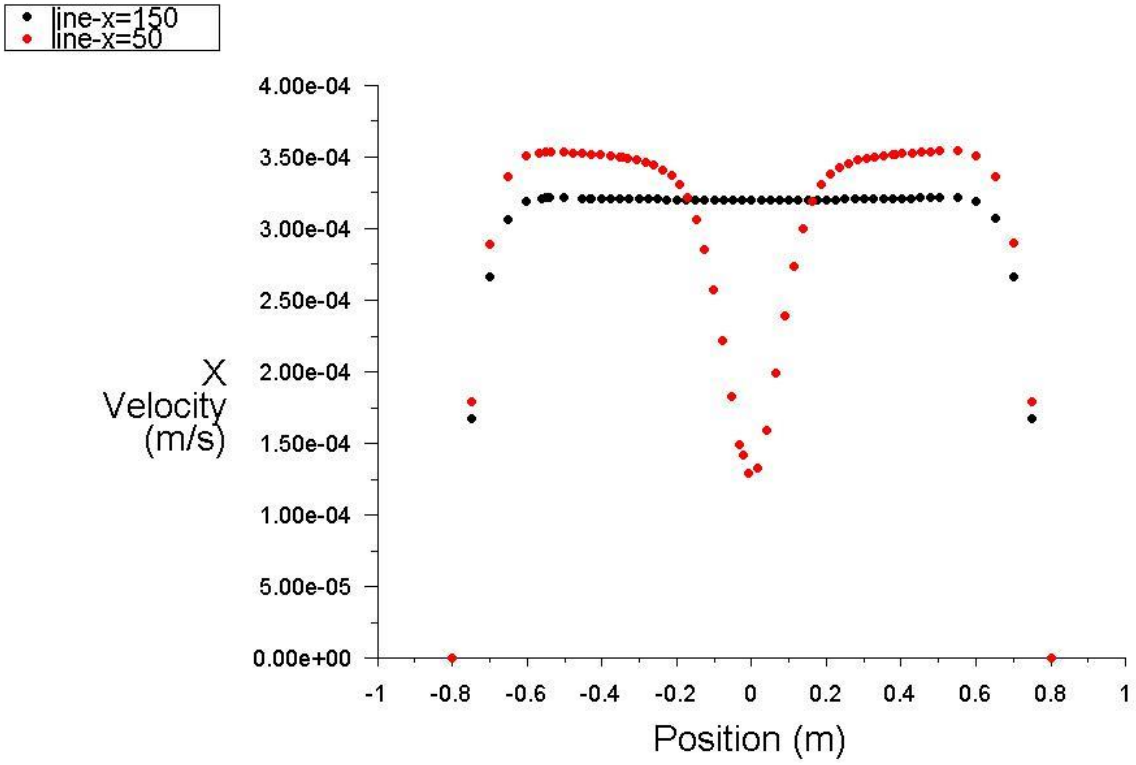

Figure 9: X-Component of Velocity Line Plots at x=50 cm and x=150 cm

Task 2:

General Setup –

The basic geometry and dimensions are shown in Figure 10 below. The geometry is provided by the instructor. The mesh applied to the geometry uses a relevance sizing of fine with adaptations to the mesh shown by the dashed red line in Figure 10. The following simulation is in 2 dimensions. The simulation uses air as the material with constant density and viscosity. The velocity inlet is set to 10 m/s, uniform. The calculations are done with the viscous-turbulence k-epsilon model. The results are gathered from the steady state solution.

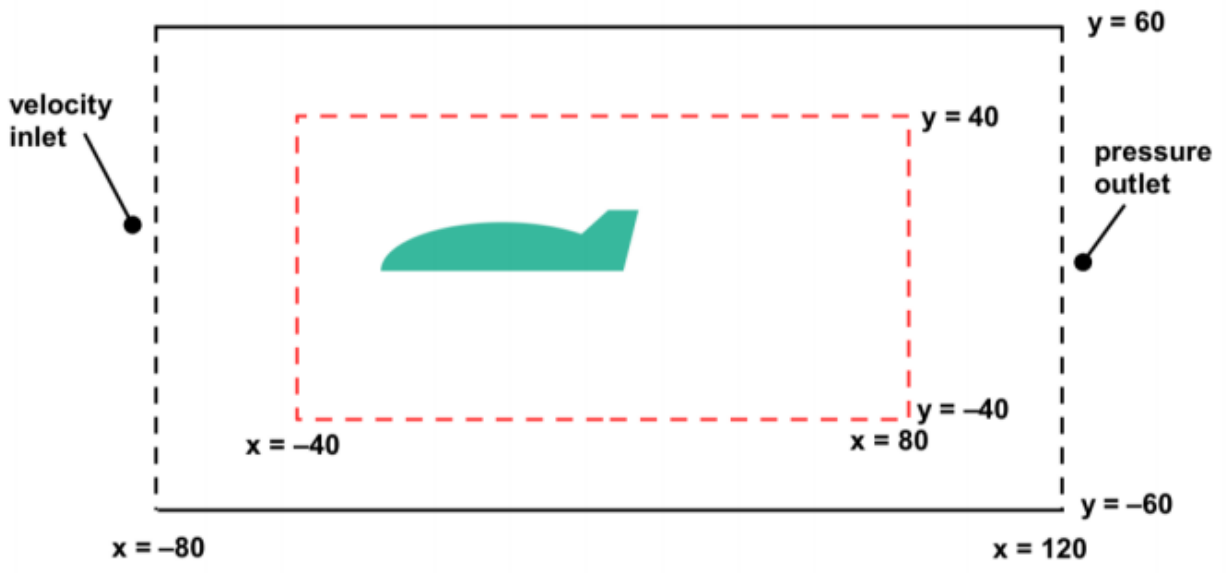

Figure 10: Basic Geometry and Dimensions for Task 2

(1):

The contour plot of the velocity magnitude is shown in Figure 11.

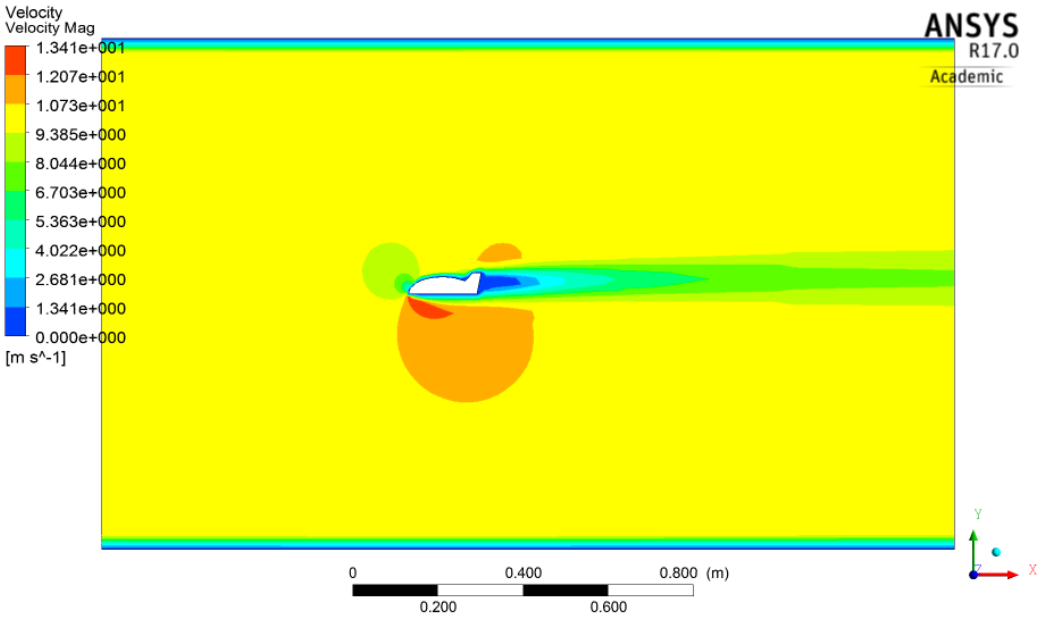

Figure 11: Velocity Magnitude Contour Plot for Task 2

The streamline function contour is shown in Figure 12.

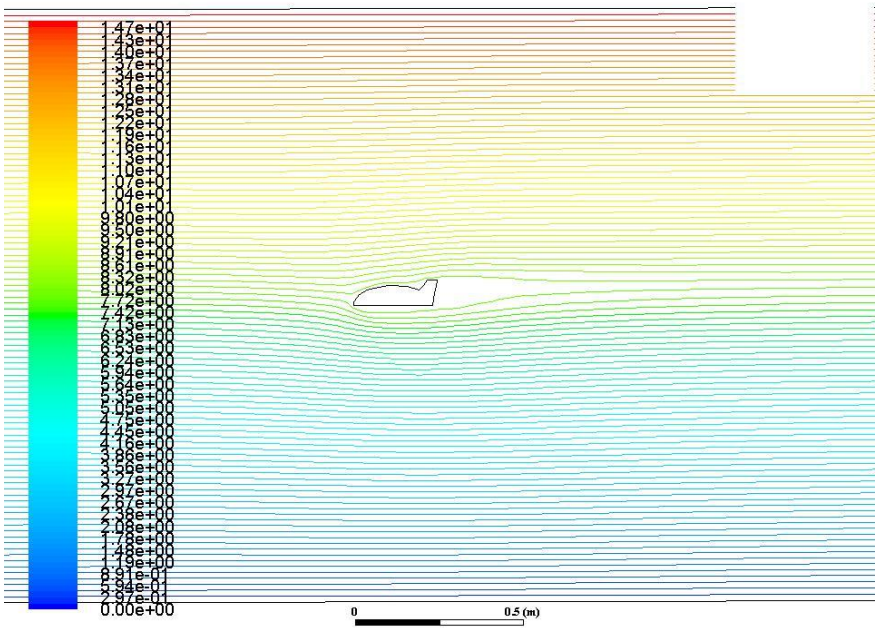

Figure 12: Streamline Function Contour Plot for Task 2

The static pressure contour plot is shown in Figure 13.

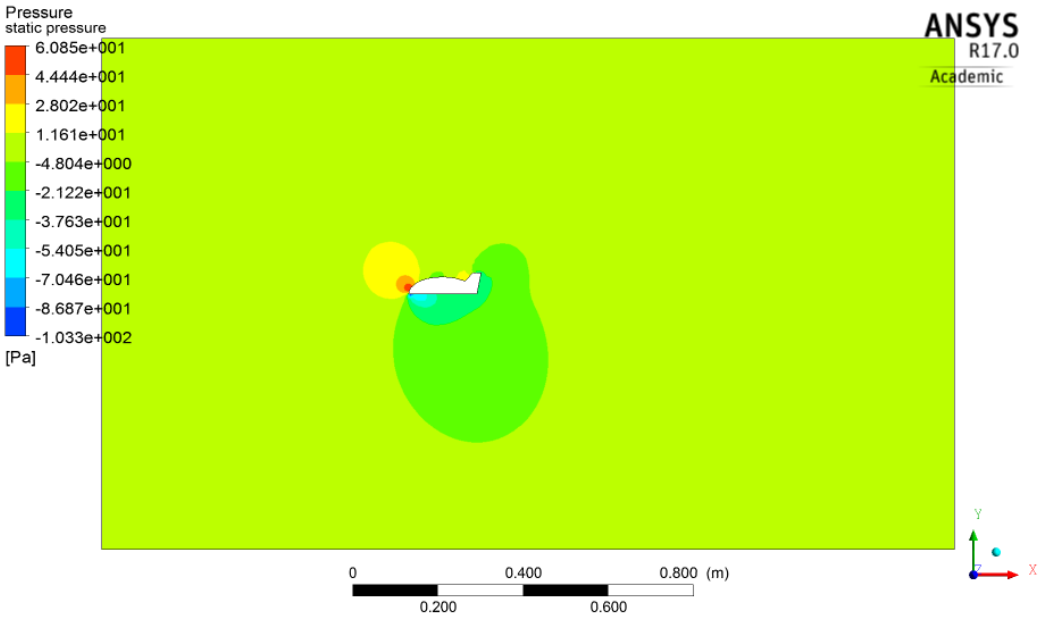

Figure 13: Static Pressure Contour Plot for Task 2

(2):

The calculation of the lift that the fluid exerts on the geometry is shown in Figure 14.

```
Forces - Direction Vector (0 1 0)
                         Forces (n)                                    Coefficients
Zone                     Pressure        Viscous         Total         Pressure        Viscous         Total
fish                     -7.8535562      0.0031830491    -7.8503731    -12.822132      0.0051968149    -12.816936
------------------------ --------------- --------------- ------------- --------------- --------------- ---------------
Net                      -7.8535562      0.0031830491    -7.8503731    -12.822132      0.0051968149    -12.816936
```

Figure 14: Lift Calculations on Geometry for Task 2

(3):

The calculation of the drag that the fluid exerts on the geometry is shown in Figure 15.

```
Forces - Direction Vector (1 0 0)
                         Forces (n)                                    Coefficients
Zone                     Pressure        Viscous         Total         Pressure        Viscous         Total
fish                     2.6363652       0.045086809     2.681452      4.3042697       0.073611116     4.3778808
------------------------ --------------- --------------- ------------- --------------- --------------- ---------------
Net                      2.6363652       0.045086809     2.681452      4.3042697       0.073611116     4.3778808
```

Figure 15: Drag Calculations on Geometry for Task 2

Task 3 –

General Setup –

The set up for this task is the same as Task 2 but in 3 dimensions. The basic dimensions and geometry is shown in Figure 16.

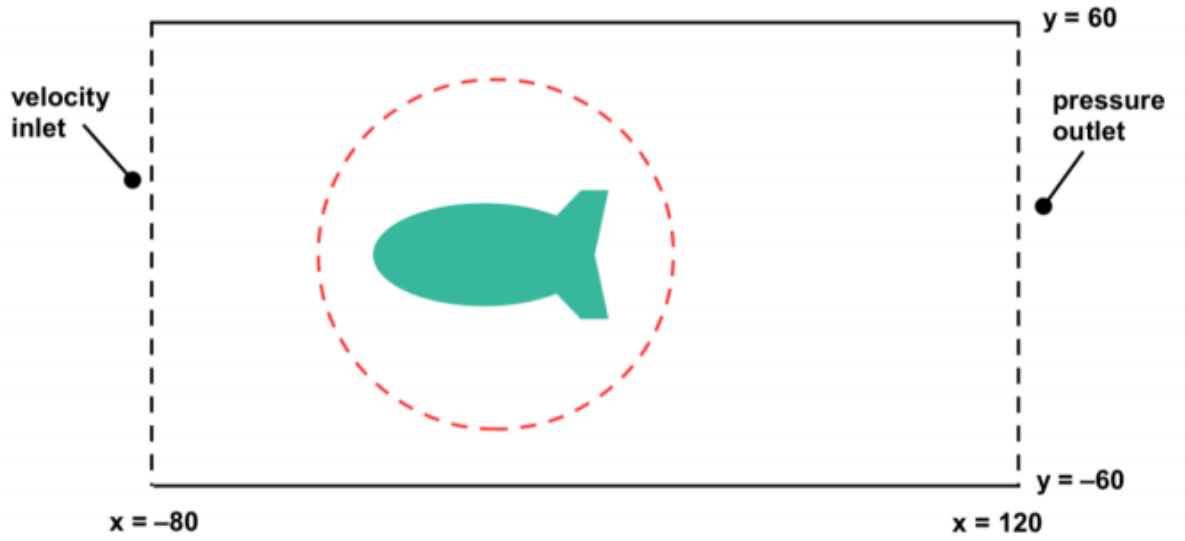

Figure 16: Basic Geometry and Dimensions for Task 3

(1):

Figure 17 and Figure 18 shows the adapted region of the mesh for Task 3.

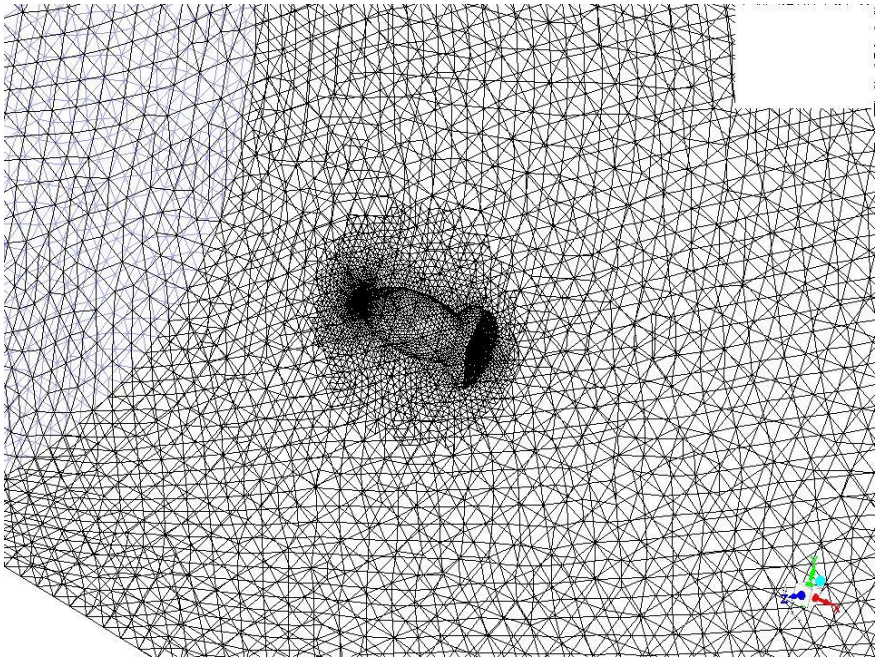

Figure 17: Adapted Region of Mesh for Task 3

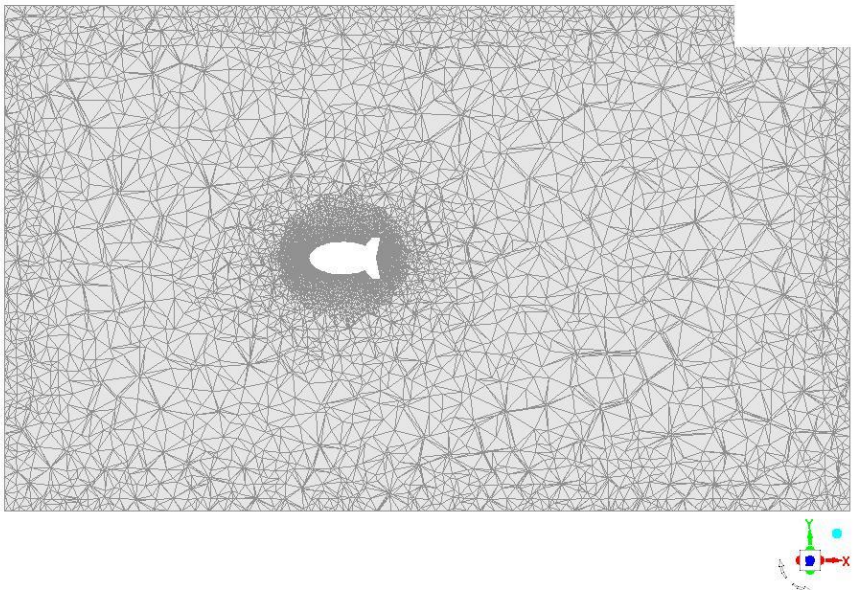

Figure 18: Profile View of Mesh Adaptation for Task 3

(2):

The contour plot of the velocity magnitude in the x-y plane is shown in Figure 19.

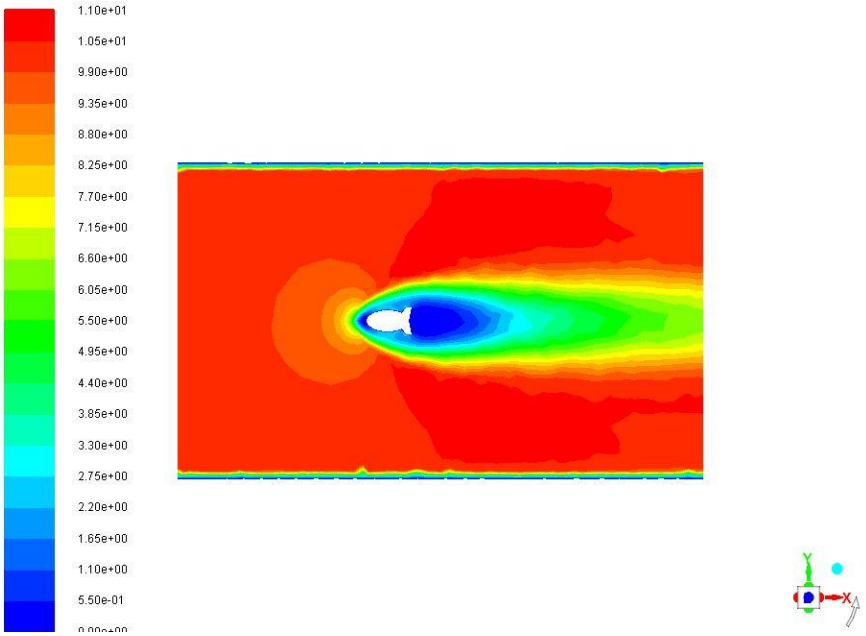

Figure 19: Velocity Magnitude in X-Y Plane Contour Plot for Task 3

The contour plot for static pressure in the x-y plane is shown in Figure 20.

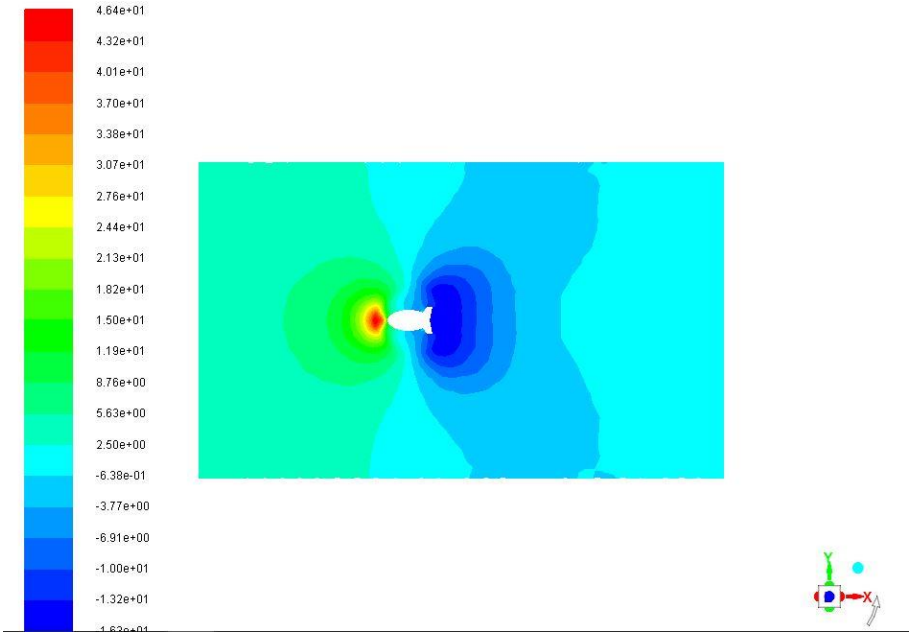

Figure 20: Static Pressure in the X-Y Plane Contour Plot for Task 3

The contour plot of the x-component of velocity on a plane offset from the y-z plane by 25 cm is shown in Figure 21.

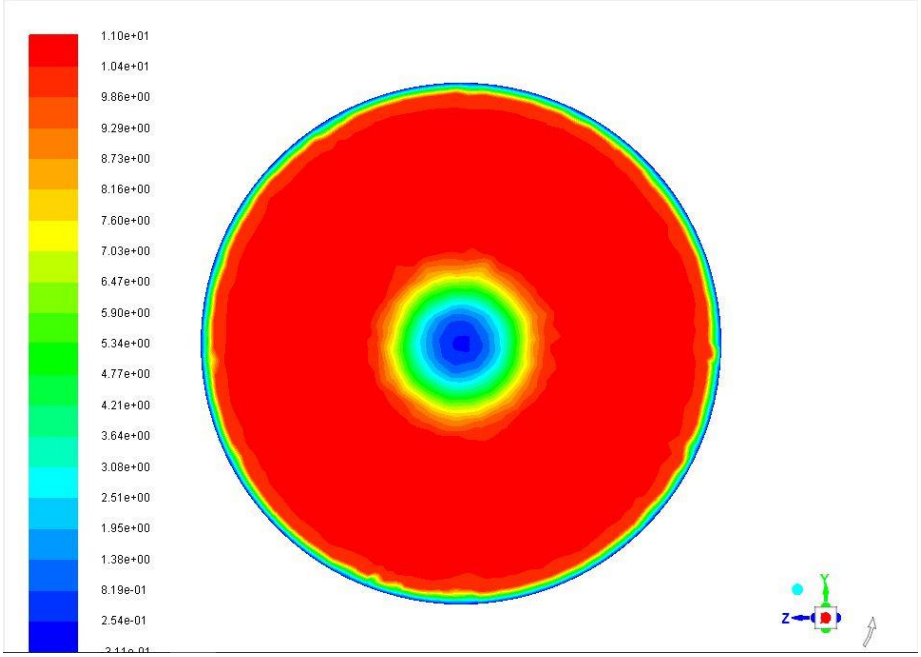

Figure 21: X-Component of Velocity on a Plane Offset of Y-Z Plane for Task 3

(3):

The calculation of the drag that the fluid exerts on the geometry is shown in Figure 22.

Forces - Direction Vector (1 0 0)

	Forces (n)			Coefficients		
Zone	Pressure	Viscous	Total	Pressure	Viscous	Total
fish	0.13589914	0.003716348	0.13961549	0.22187615	0.0060675069	0.22794366
Net	0.13589914	0.003716348	0.13961549	0.22187615	0.0060675069	0.22794366

Figure 22: Drag Calculations on Geometry for Task 3

Task 4 –

General Setup –

The set up for this task is the same as Task 3 but with a user defined function for the velocity inlet. The basic dimensions and geometry is shown in Figure 16.

The user defined function is shown below:

```
#include "udf.h"

DEFINE_PROFILE(inlet_x_velocity, thread, position)

{

real x[ND_ND];

real y;

real z;

real rad = 0.6;

real v_max=2*.10 ;

face_t f;

begin_f_loop(f, thread)

{

F_CENTROID(x,f,thread);

y = (x[1]);

z = (x[2]);

F_PROFILE(f, thread, position) = 2*10 - y*y/(rad*rad)*2*10 - z*z/(rad*rad)*2*10;

}

end_f_loop(f, thread)

}
```

(1):

The contour plot of the velocity magnitude in the x-y plane is shown in Figure *23*.

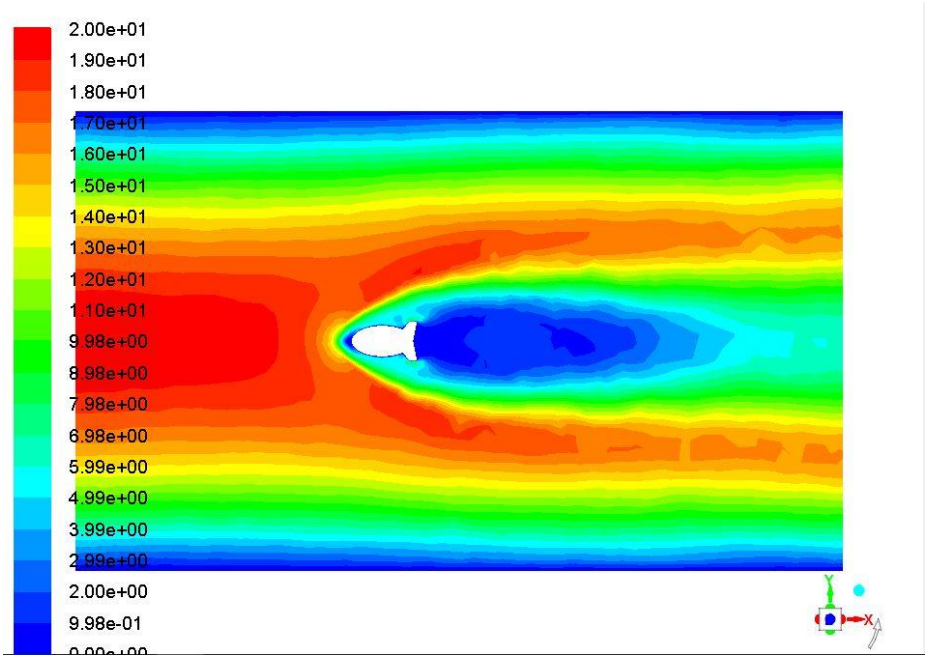

Figure 23: Velocity Magnitude in X-Y Plane Contour Plot for Task 4

The contour plot for static pressure in the x-y plane is shown in Figure *24*.

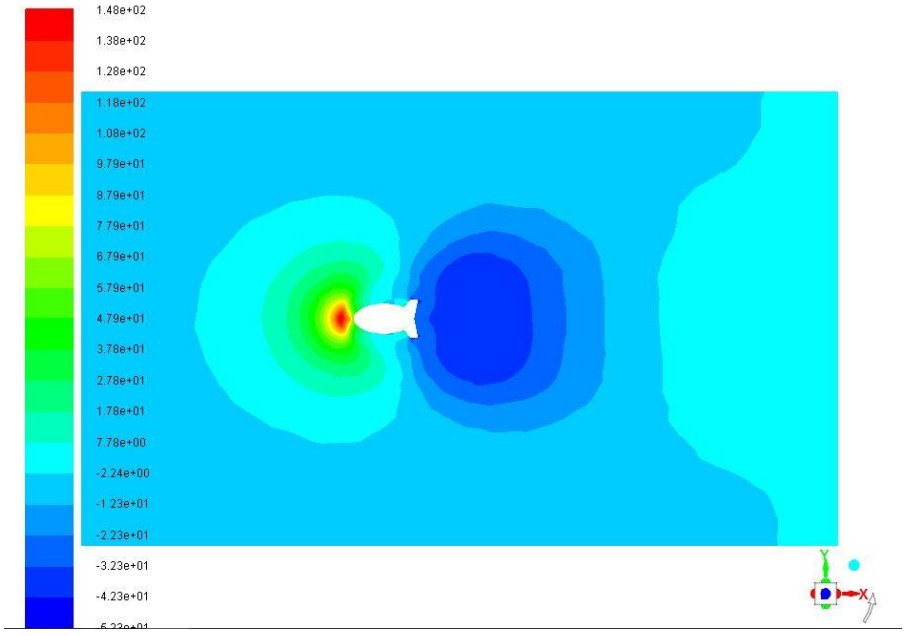

Figure 24: Static Pressure in the X-Y Plane Contour Plot for Task 4

The contour plot of the x-component of velocity on a plane offset from the y-z plane by 25 cm is shown in Figure *25*.

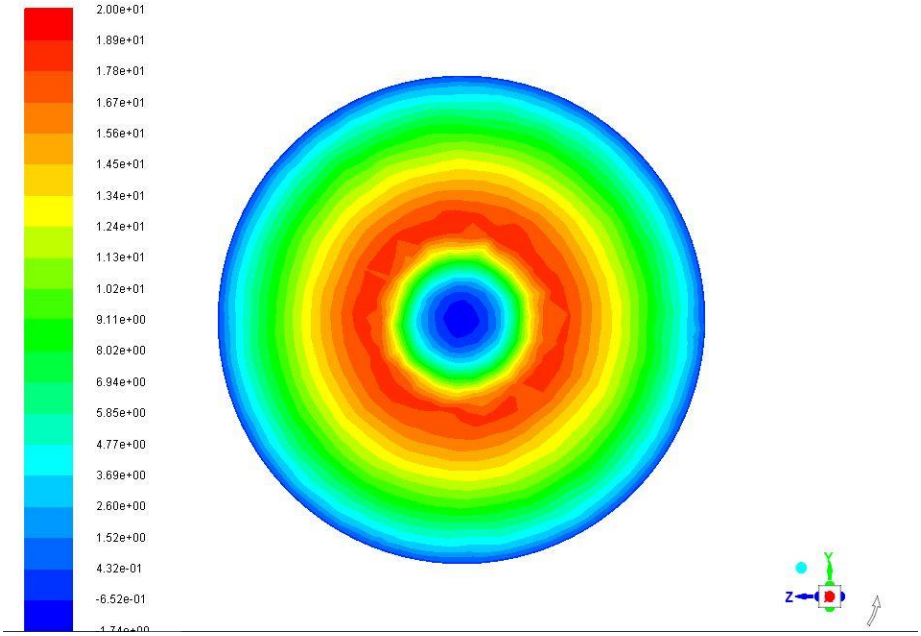

Figure 25: X-Component of Velocity on a Plane Offset of Y-Z Plane for Task 4

The contour plot of the x-component of velocity on a plane parallel to the y-z plane at the inlet is shown in Figure *26*.

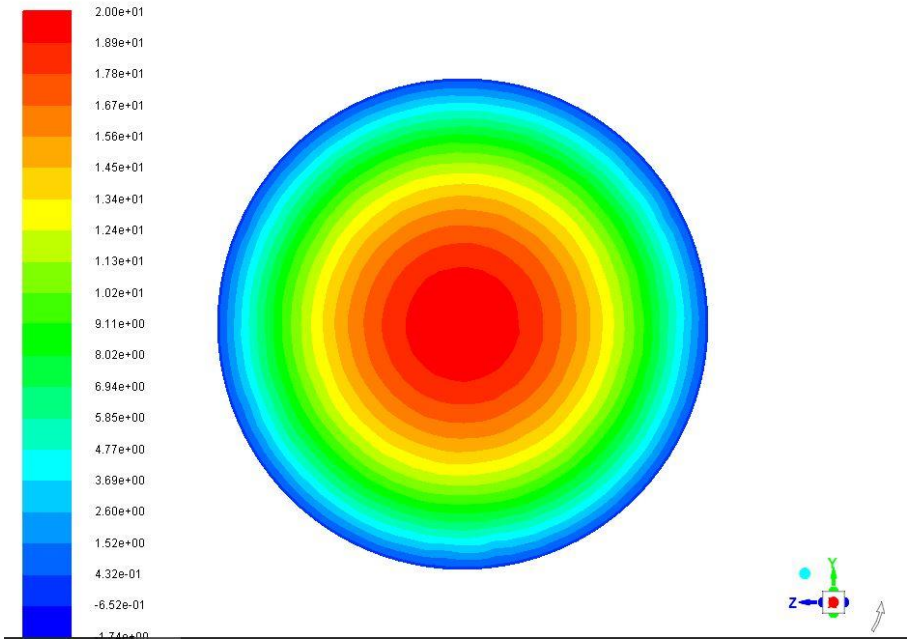

Figure 26: X-Component of Velocity on a Plane Offset of Y-Z Plane at Inlet for Task 4

(3):

The calculation of the drag that the fluid exerts on the geometry is shown in Figure *27*.

Forces - Direction Vector (1 0 0)

	Forces (n)			Coefficients		
Zone	Pressure	Viscous	Total	Pressure	Viscous	Total
fish	0.38167635	0.011657173	0.39333352	0.62314505	0.019032119	0.64217717
Net	0.38167635	0.011657173	0.39333352	0.62314505	0.019032119	0.64217717

Figure 27: Drag Calculations on Geometry for Task 4