Project 3

MAE 560: Applied Computational Fluid Dynamics

Anney Romo

Statement of Collaboration: Collaborated with Heather Palfreyman

	Report owner: Anney Romo **Collaborator**: Heather Palfreyman
Task(s), specific detail	**Contribution to collaborative effort**
Task 1	Worked on geometry, mesh refinement, calculations, and set-up together. The setup was then run by Anney.
Task 2	Worked on geometry, mesh refinement, calculations, and set-up together. The setup was then run by Heather.
Task 3	Worked on geometry, mesh refinement, calculations, and set-up together. The setup was then run by Heather.
Task 4	No collaboration.

Task 1

(D1)

The Reynolds number for the system was approximately 487, calculated below:

$\text{Re} = \frac{\rho u l}{\mu} = \frac{(730)(0.04)(0.04)}{(0.0024)} = 486.666 = 487$

The mesh used an element size of 0.2cm. Additionally, there was 1 refinement along the edge of the circle. This is displayed in figure 1 below. Additionally, all iterations were run using a time step size of 0.02 and 3000 time steps. This is indicated in figure 2.

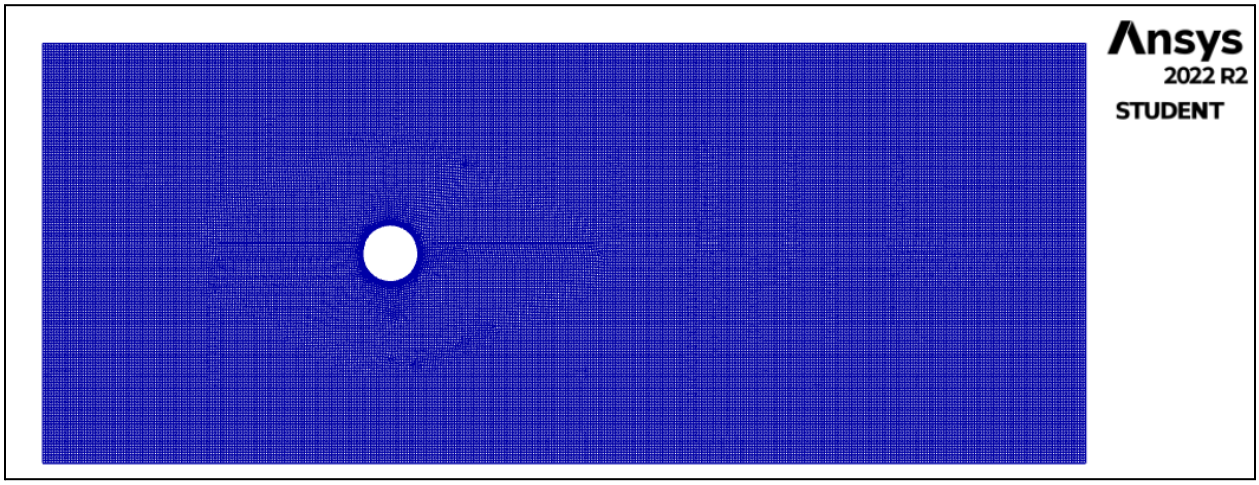

Figure 1. Task 1 Mesh Resolution

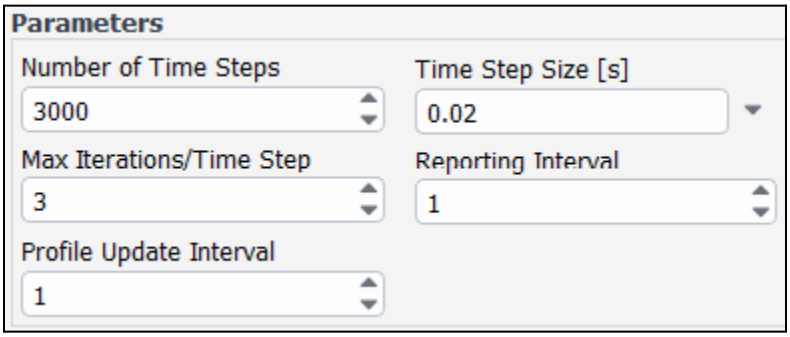

Figure 2. Task 1 Time Step Settings

(D2)

The contour plots of y-velocity, stream function, and vorticity magnitude are shown in the figures below. These are both with unadjusted and adjusted ranges.

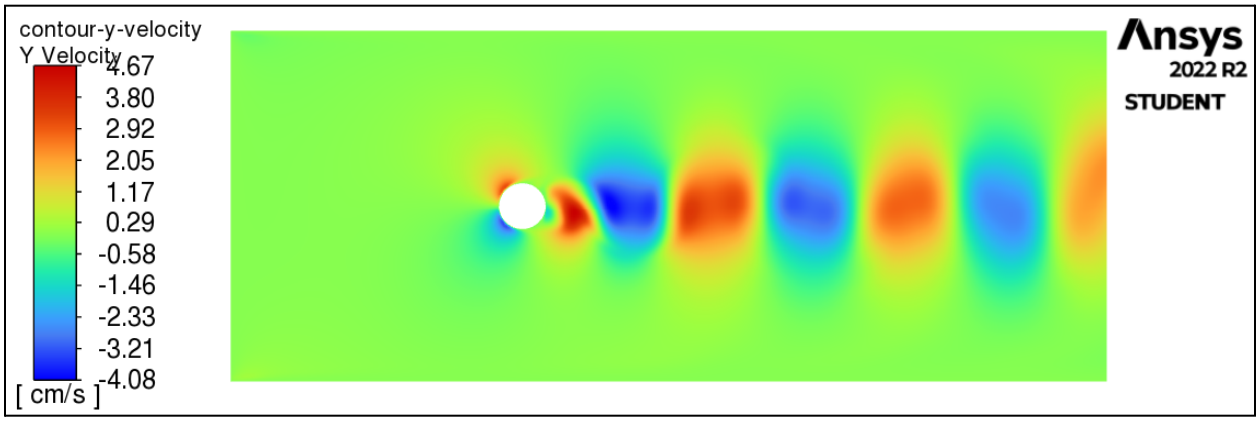

Figure 3. Task 1 Circle Y-Velocity Unadjusted Range

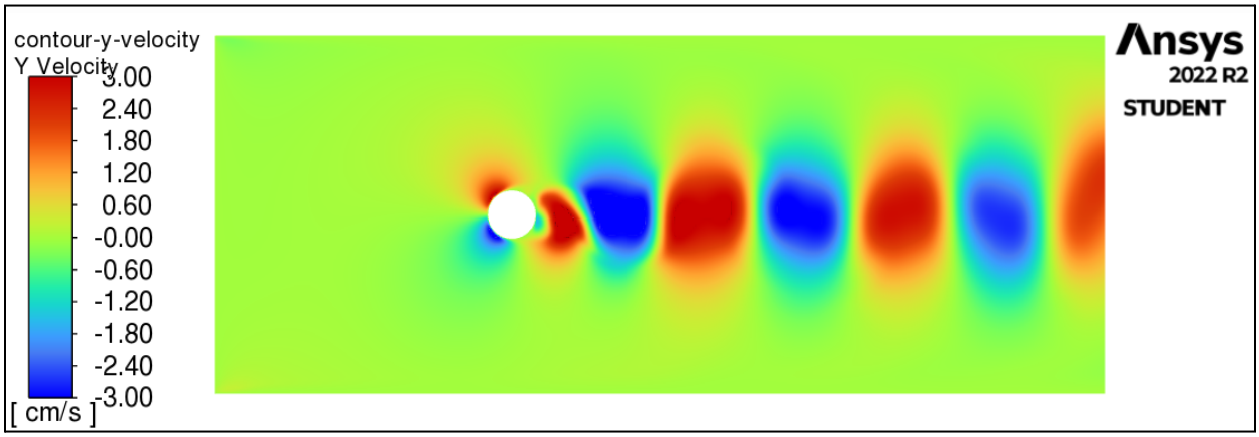

Figure 4. Task 1 Circle Y-Velocity Adjusted Range

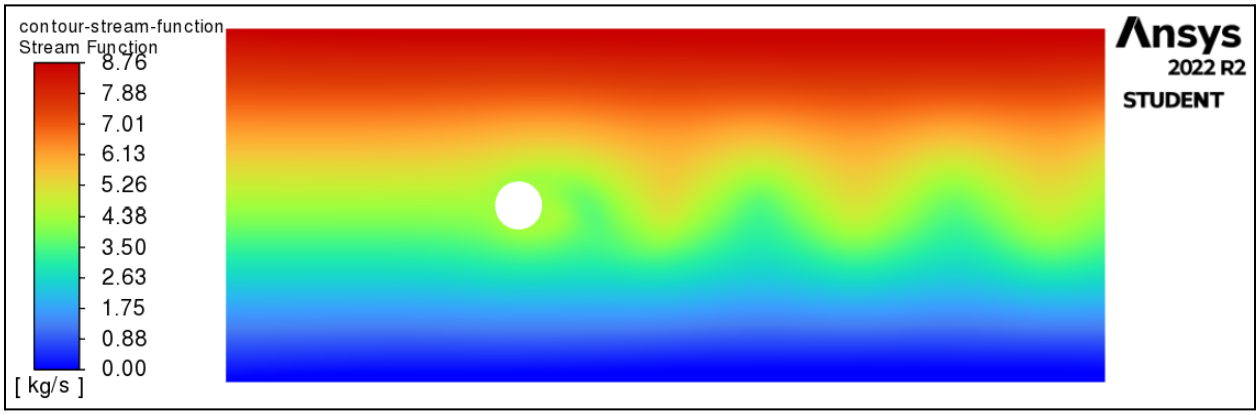

Figure 5. Task 1 Circle Stream Function Unadjusted Range

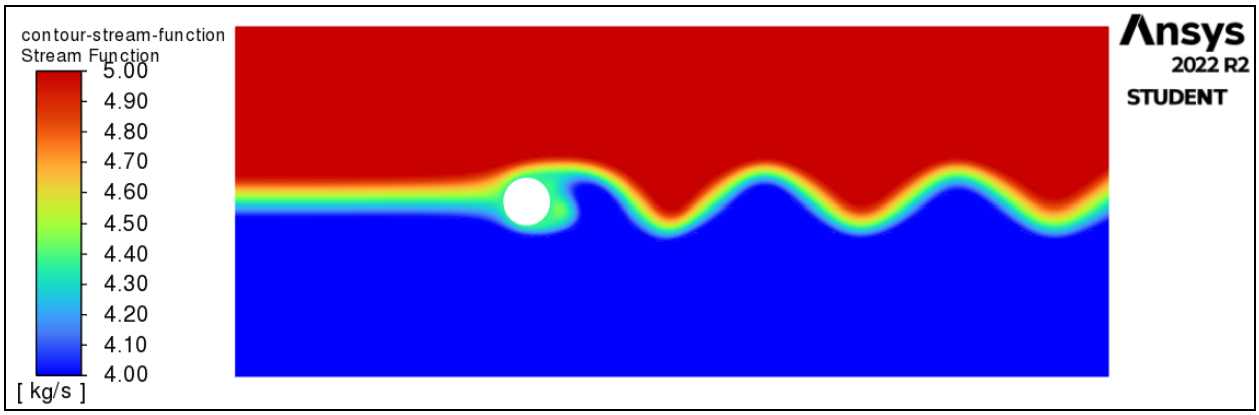

Figure 6. Task 1 Circle Stream Function Adjusted Range

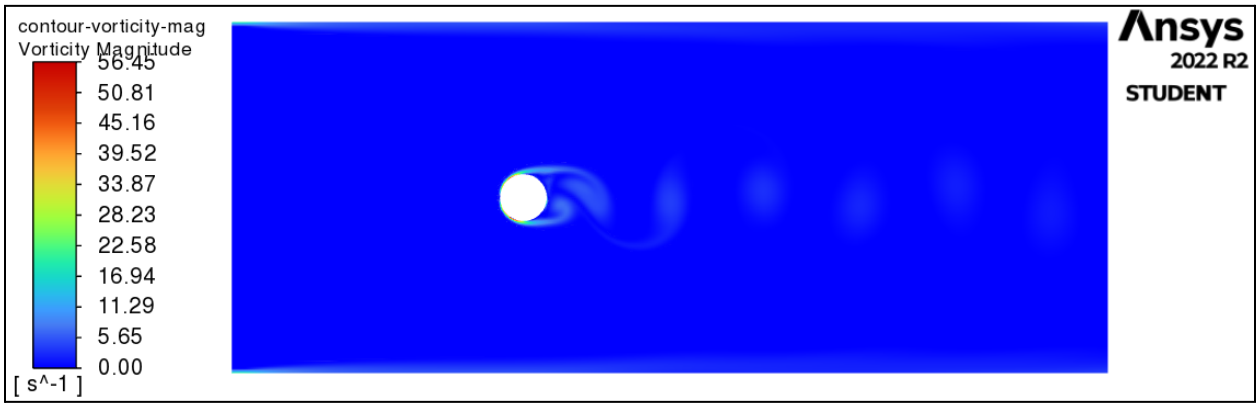

Figure 7. Task 1 Circle Vorticity Magnitude Unadjusted Range

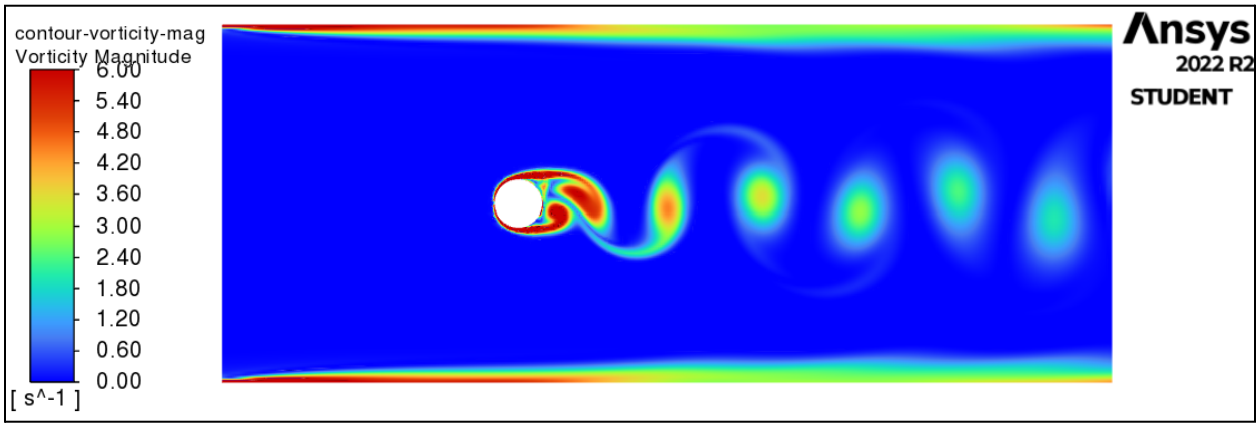

Figure 8. Task 1 Circle Vorticity Magnitude Adjusted Range

(D3)

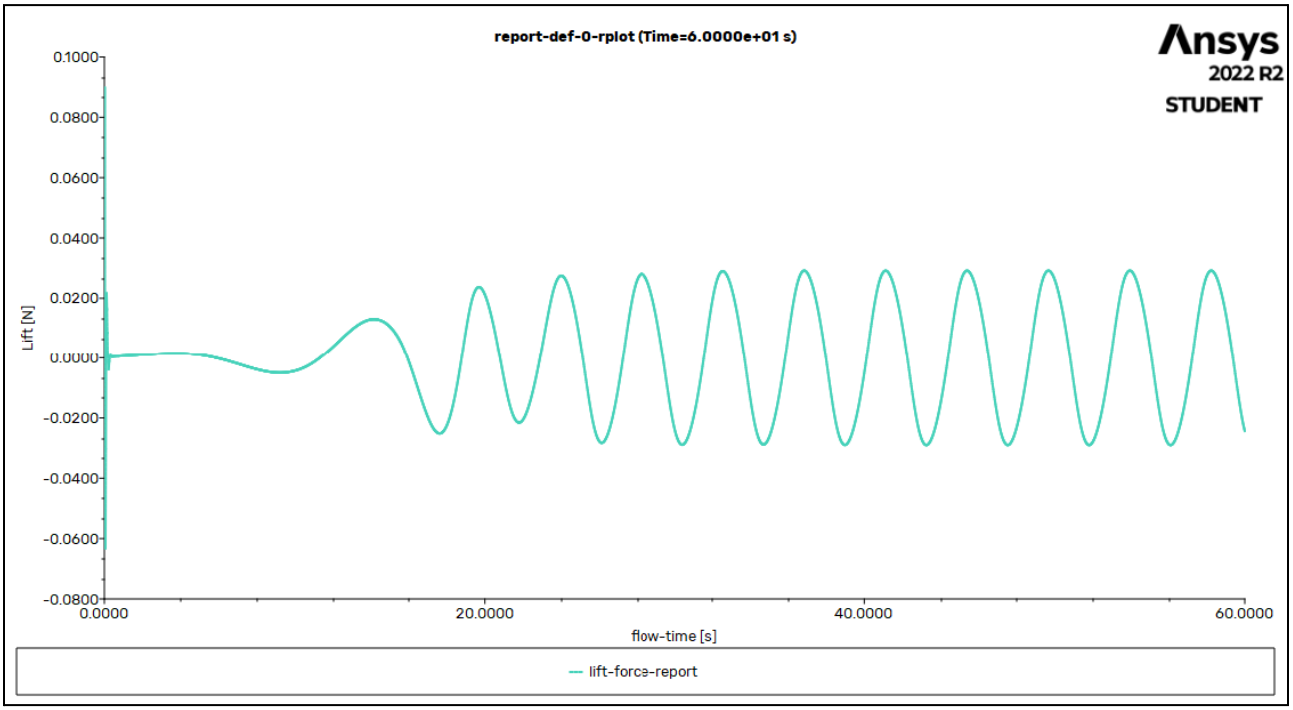

Figure 9. Lift Force on Circle

Amplitude = $\frac{0.029+0.029}{2}$ = 0.029

Period of oscillation = 41.119 - 36.853 = 4.266 s

(D4)

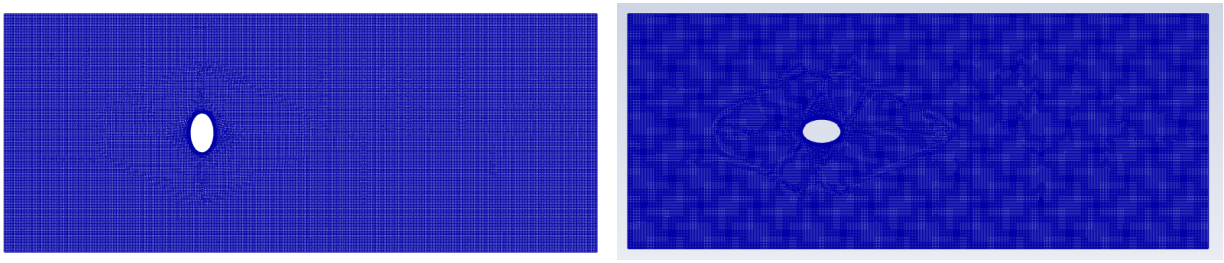

Figure 10. General Mesh For Elongated Runs

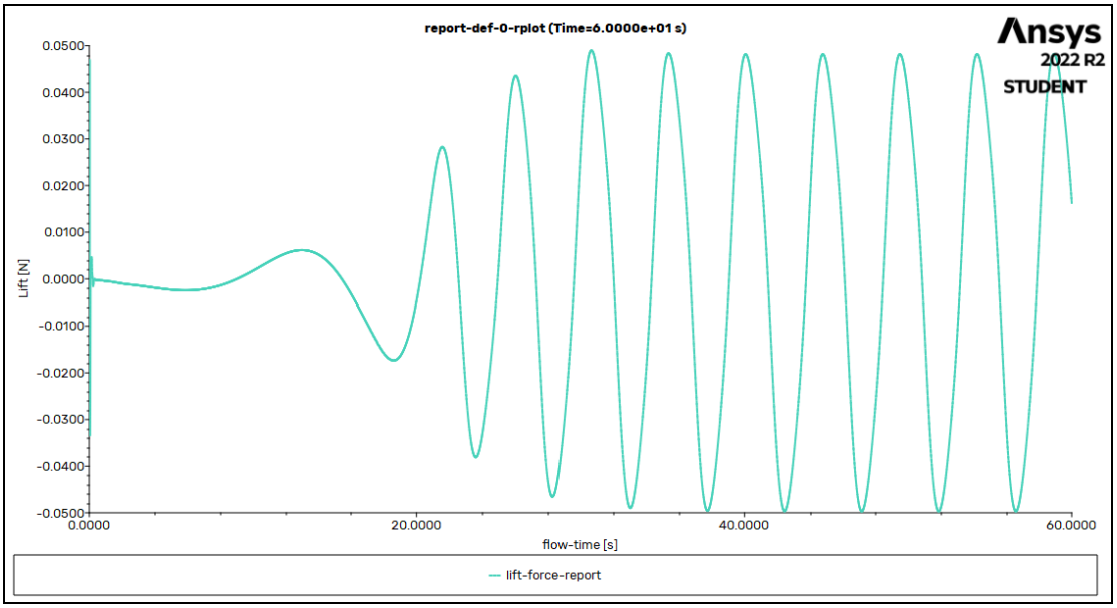

Figure 11. Lift Force on Y-Elongated Circle

Amplitude = $\frac{0.0485+0.0498}{2}$ = 0.04915 N

Period of oscillation = 54.3057 - 49.5105 = 4.7952 s

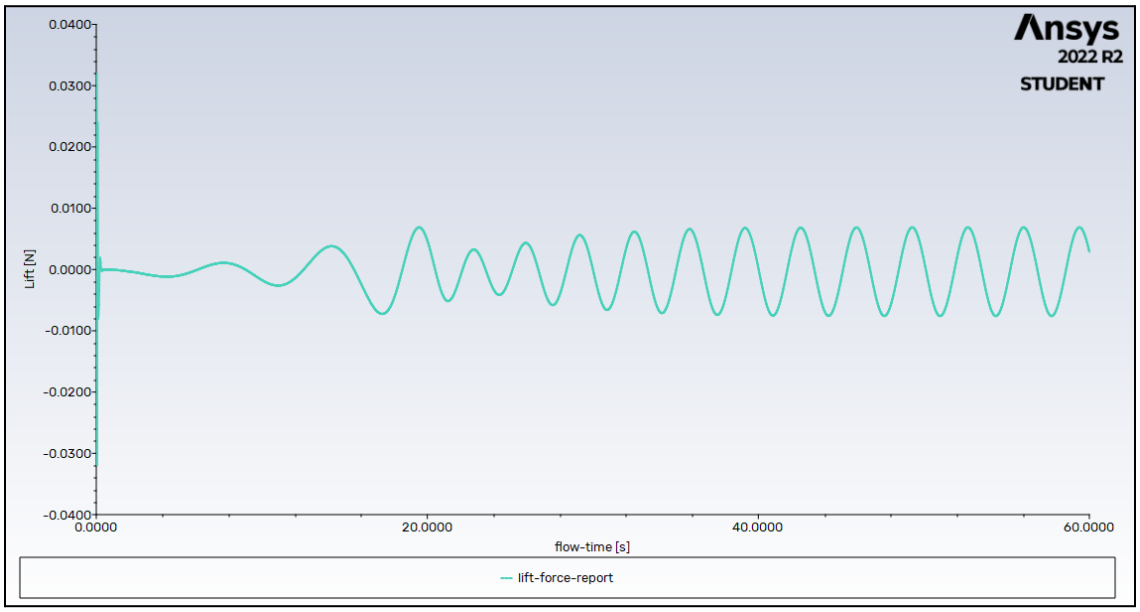

Figure 12. Lift Force on X-Elongated Circle

Amplitude = $\frac{0.0070+0.0076}{2}$ = 0.00731 N

Period of oscillation = 49.2694 - 45.8937 = 3.3757s

Table 1. Amplitude and Period for Every Run

	Amplitude (in Newtons)	**Period (in second)**
Circular cylinder	0.029 N	4.266 s
Elliptical cylinder, Run 1	0.04915 N	4.7952 s
Elliptical cylinder, Run 2	0.00731 N	3.3757s

Task 2

(D5)

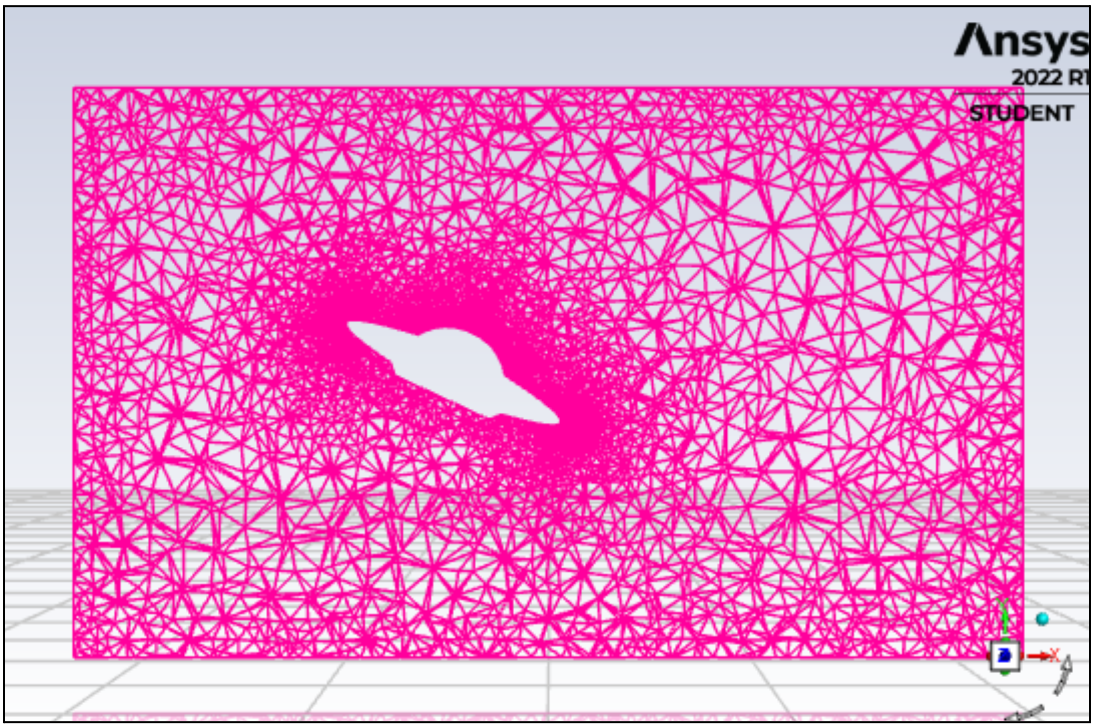

Figure 13. Mesh Along Symmetry for θ=25°

(D6)

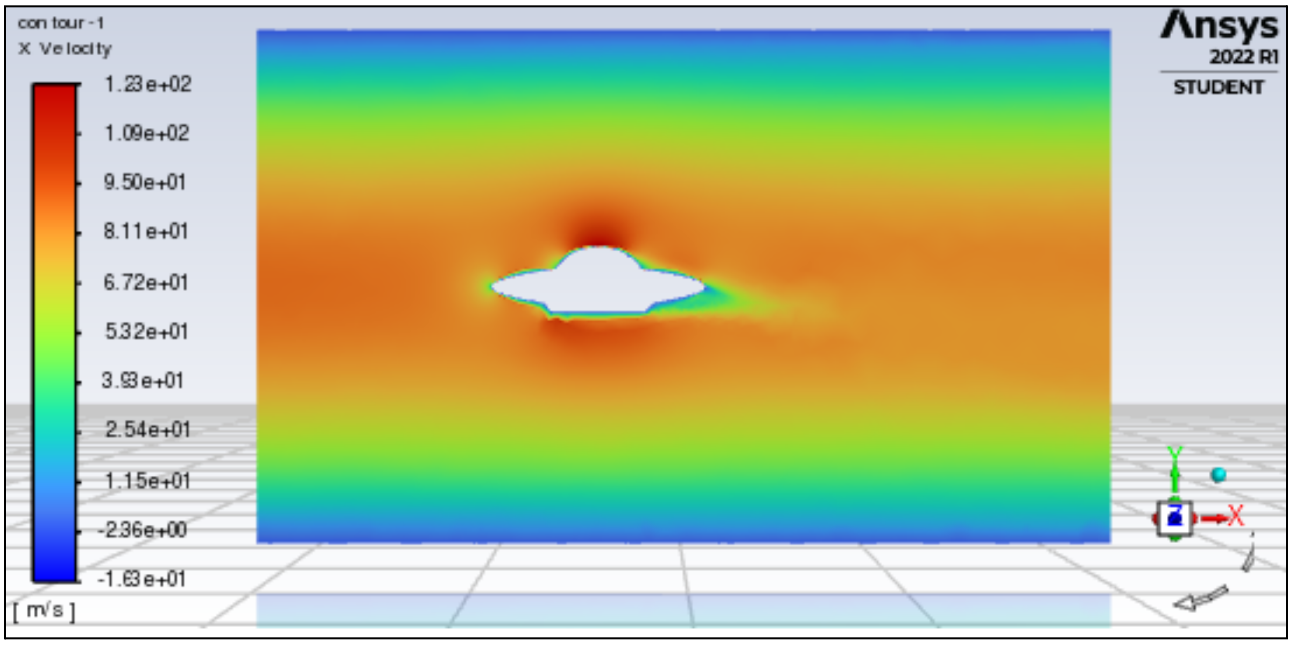

Figure 14. X-Velocity Contour for θ=0°

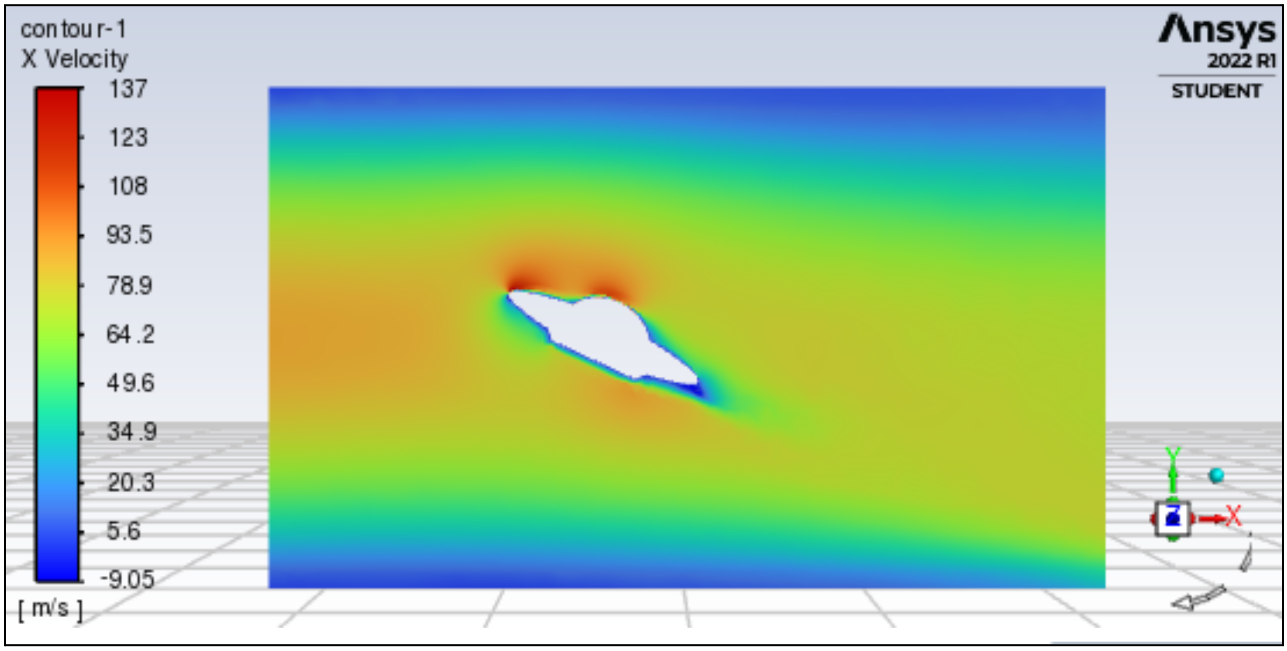

Figure 15. X-Velocity Contour for θ=25°

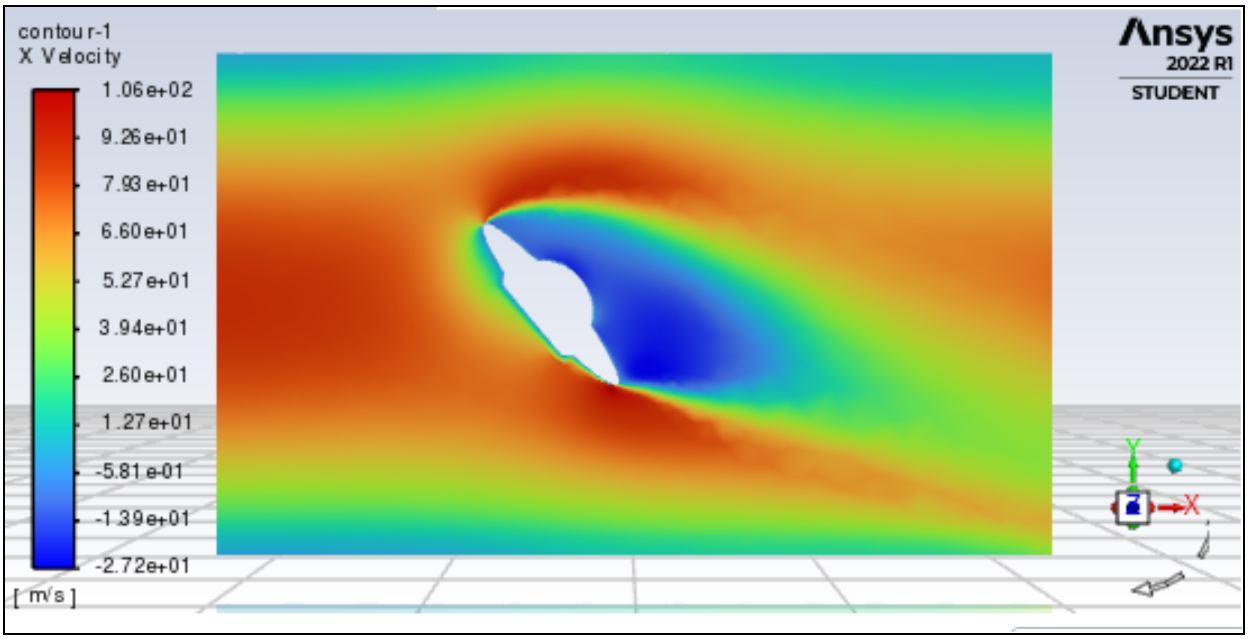

Figure 16. X-Velocity Contour for θ=50°

(D7)

Table 2. Lift And Drag Forces As A Function of θ

	Lift Force (in Newtons)	**Drag Force (in Newtons)**
θ = 0°	11.00 N	8.40 N
θ = 25⁰	120.8 N	40.65 N
θ = 50⁰	79.2 N	128.6 N

Task 3

(D8)

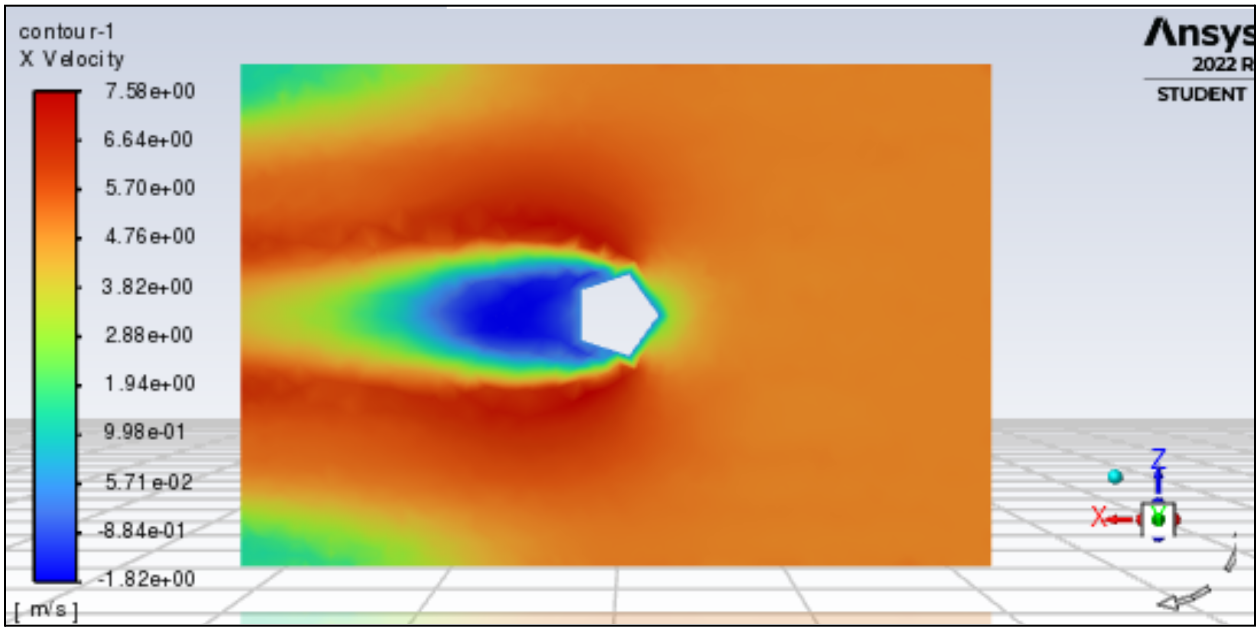

Figure 17. Run 1 (On Flat Edge) Horizontal Plane Y-Velocity

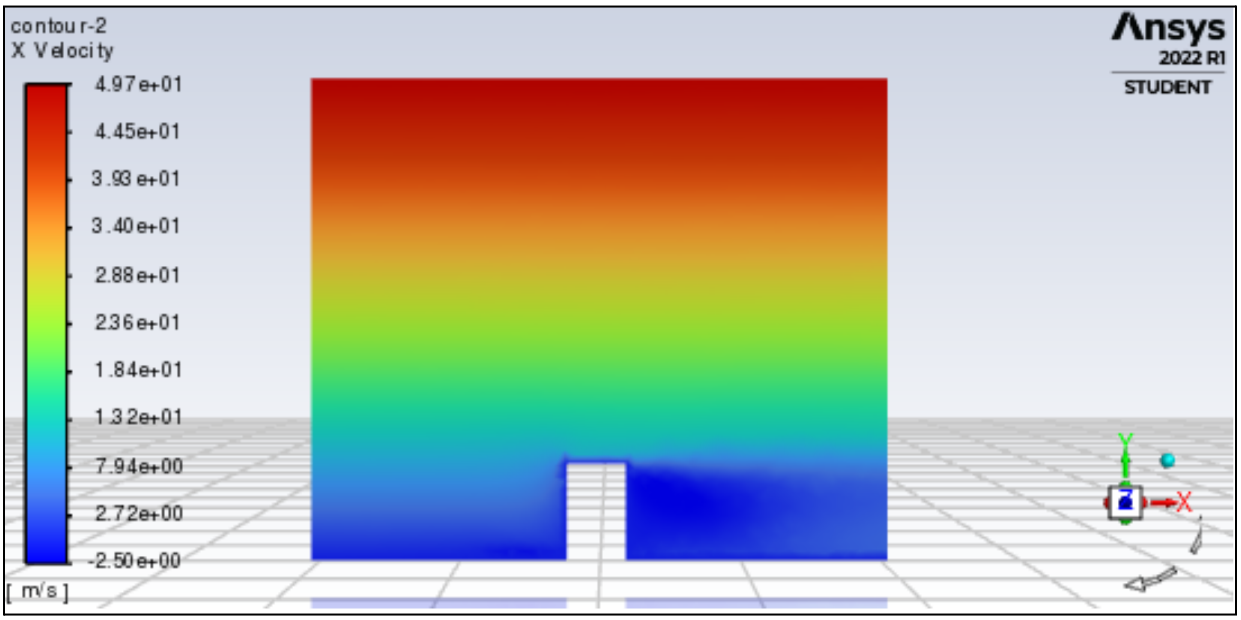

Figure 18. Run 1 (On Flat Edge) Vertical Plane Y-Velocity

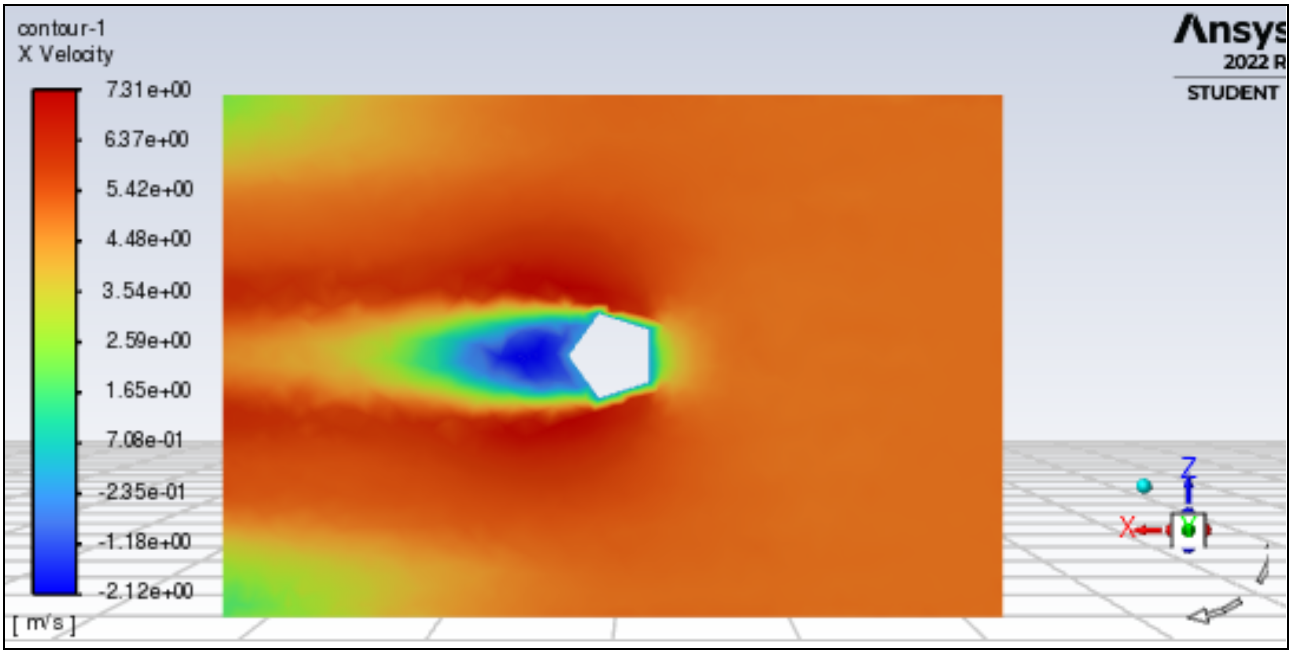

Figure 19. Run 2 (On Vertex) Horizontal Plane Y-Velocity

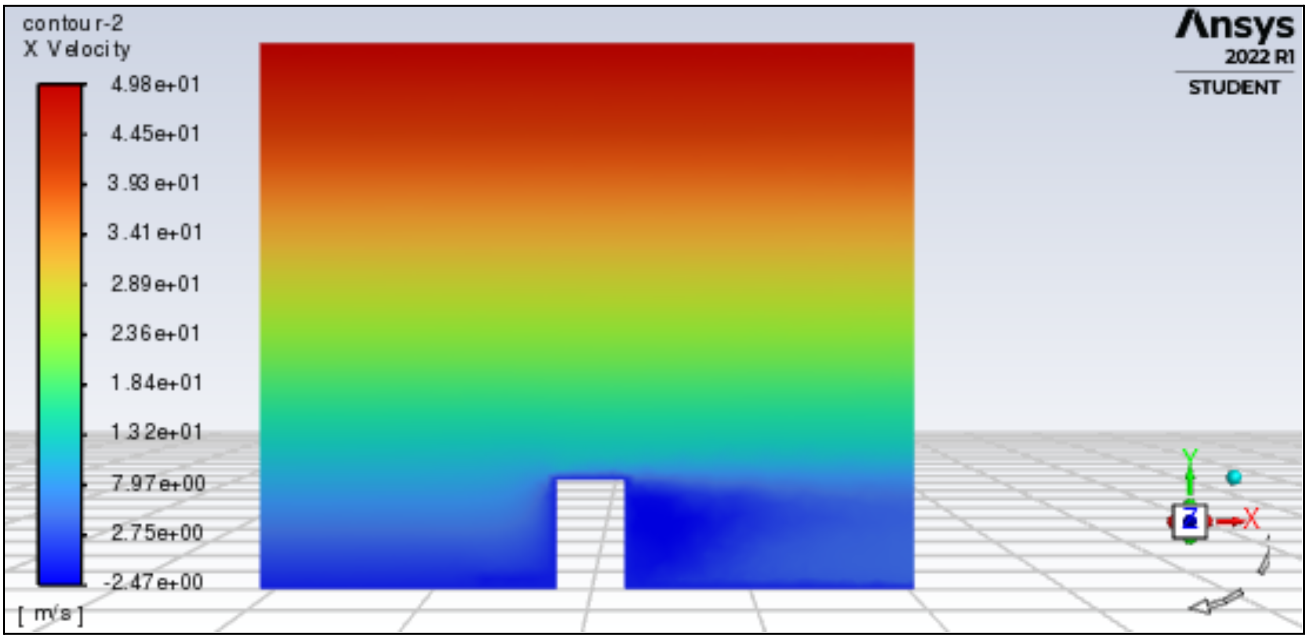

Figure 20. Run 2 (On Vertex) Vertical Plane Y-Velocity

Note: The screenshots above say “x-velocity” in Ansys. This is simply because the geometry was defined in different directions than in the assignment.

(D9)

Table 3. Drag Force Fluid Exerts On Building

	Total drag (N)	**Pressure term of drag (N)**	**Viscous term of drag (N)**
Run 1	360.81 N	360.1 N	0.715 N
Run 2	485.6 N	485.3 N	0.382 N

Task 4

I tried this task with two different asymmetric cylinders to compare the results and they were relatively the same. Therefore, both deliverables 10 and 11 are shown twice below (for example, as D10.1 and D10.2).

(D10.1)

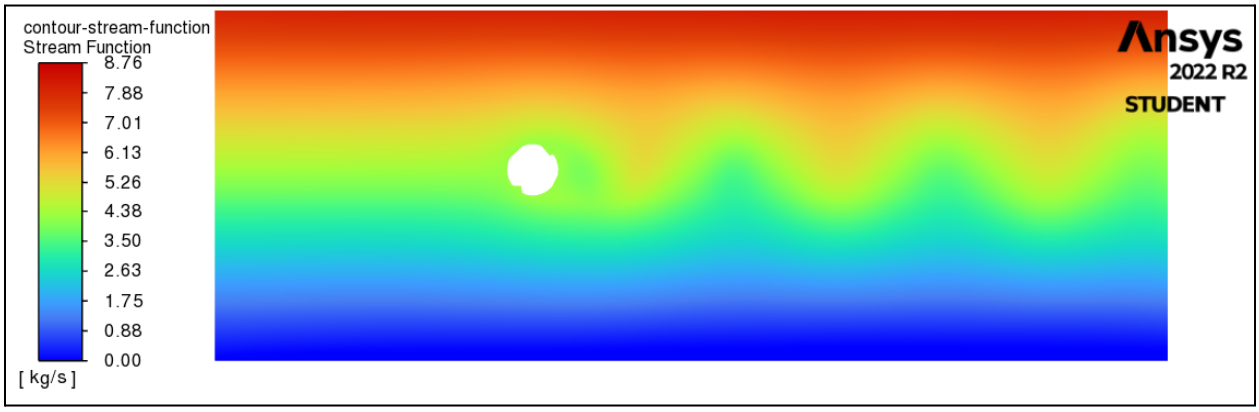

Figure 21. Asymmetric Cylinder 1 Stream Function Unadjusted Range

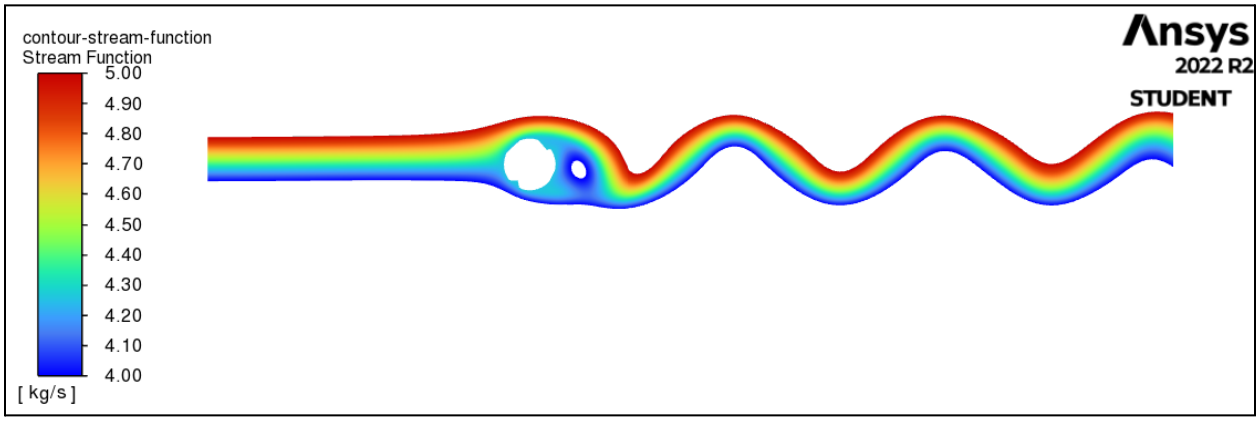

Figure 22. Asymmetric Cylinder 1 Stream Function Adjusted Range

(D11.1)

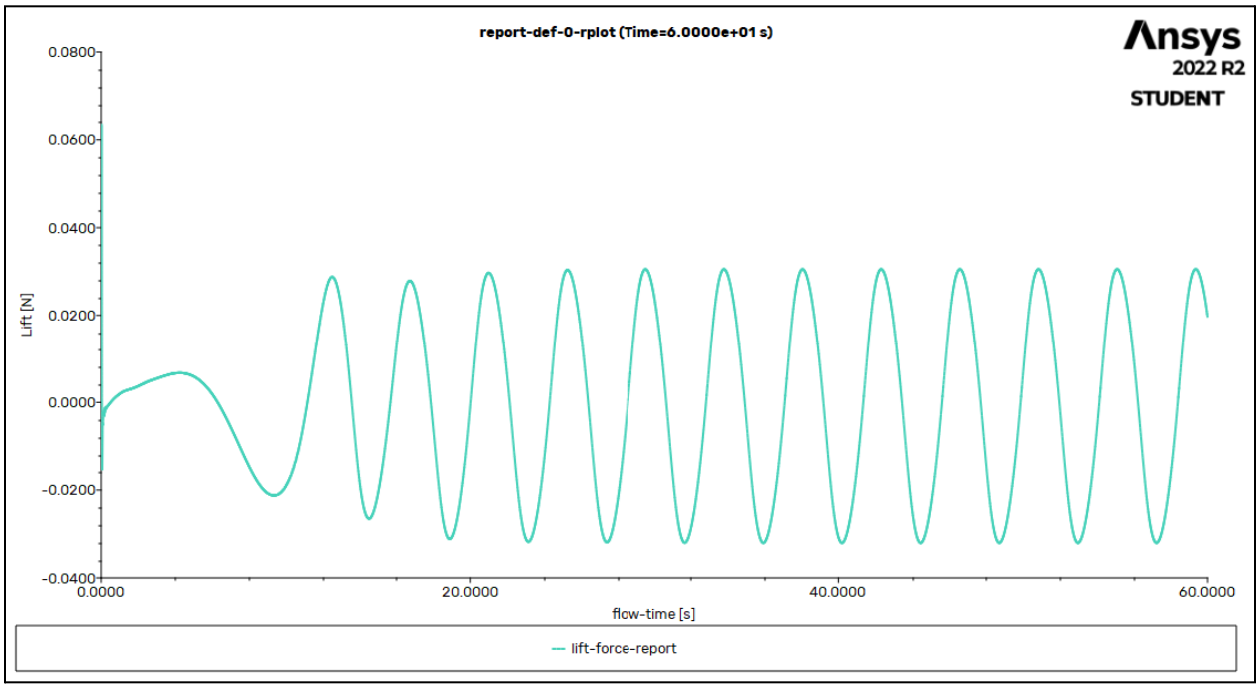

Figure 23. Lift Force on Asymmetric Cylinder 1

(D10.2)

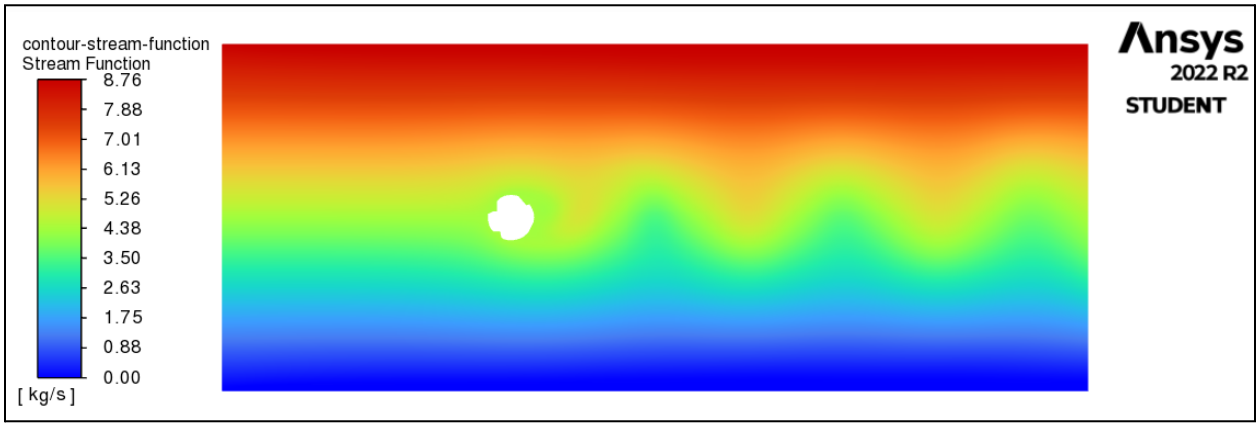

Figure 24. Asymmetric Cylinder 2 Stream Function Unadjusted Range

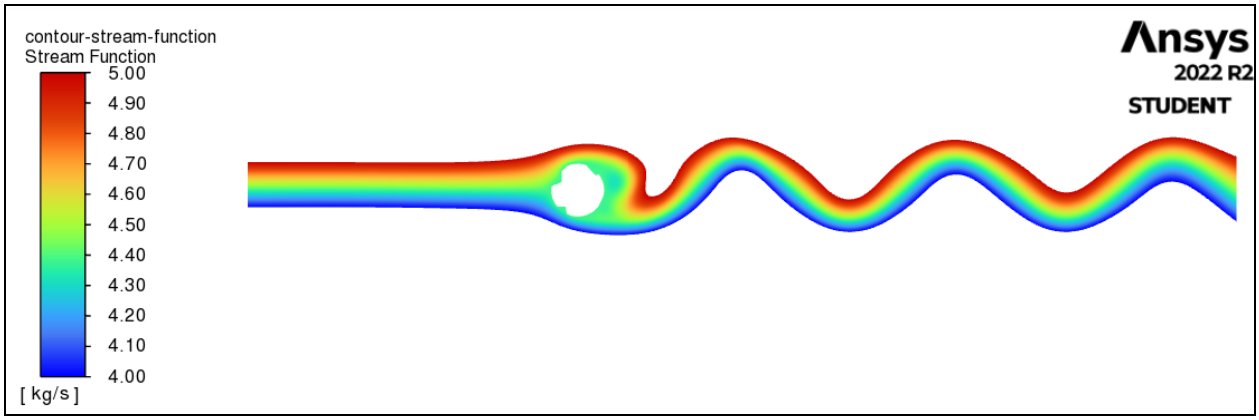

Figure 25. Asymmetric Cylinder 2 Stream Function Adjusted Range

(D11.2)

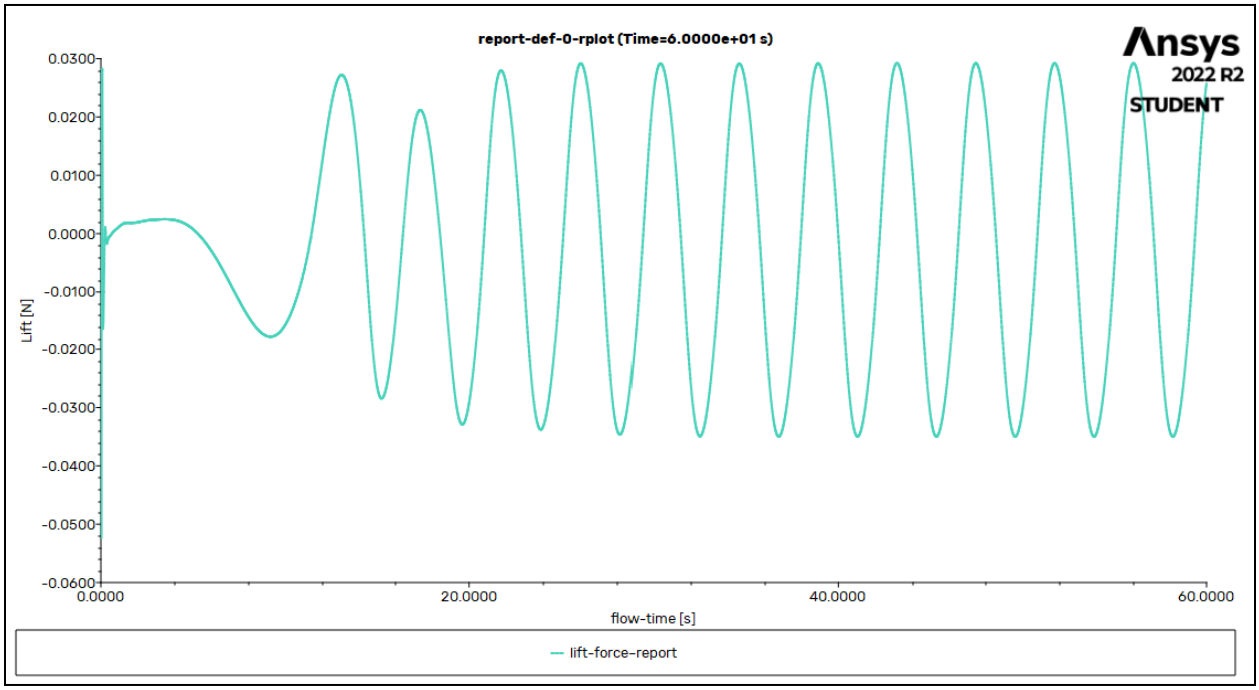

Figure 26. Lift Force on Asymmetric Cylinder 2