MAE 560 Fall 2020

Project 3

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Statement of Collaboration:

Name of Collaborator: None	
Tasks, specific detail	Contribution to collaborative effort
N/A	N/A

Task 1:

A) I) Estimate of Reynolds Number

An estimate of the Reynolds number can be solved using the Eq. (1) below.

$$Re = \frac{\rho V_\infty D}{\mu} \tag{1}$$

Using the givens from the problem and the material properties in Ansys, the following are known quantities.

From Ansys $$\rho = 998.2 \frac{kg}{m^3}$$

From Setup $$V = 0.04 \frac{m}{s}$$

From Setup $$D = 0.08\, m$$

From Ansys $$\mu = 0.001003 \frac{kg}{m\, s}$$

And so, the Reynold's number can be estimated below.

$$Re = 3184.685$$

II) Contour plots of static pressure, y-velocity and stream function @ t = 3 min

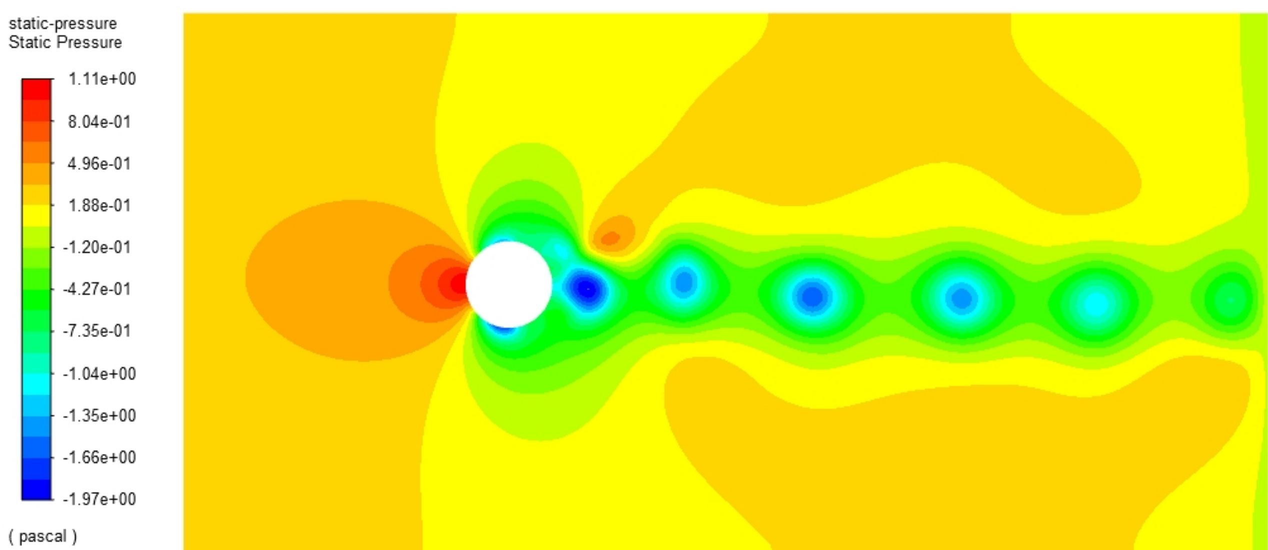

Figure 1 Static Pressure over Circle in Flow

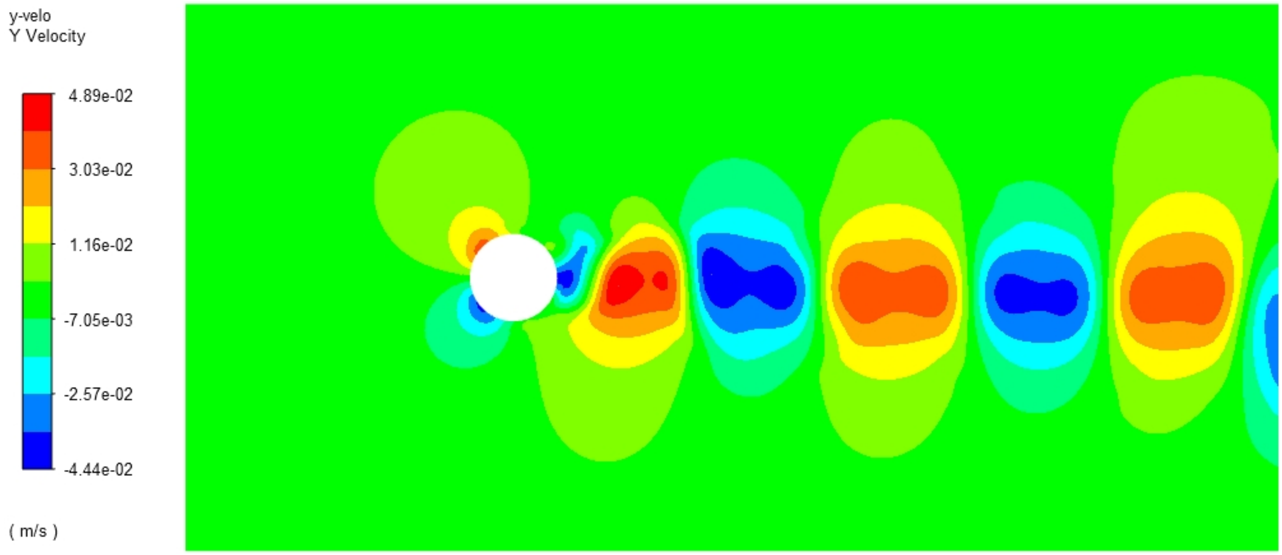

Figure 2 Y Component of Velocity over Circle in Flow

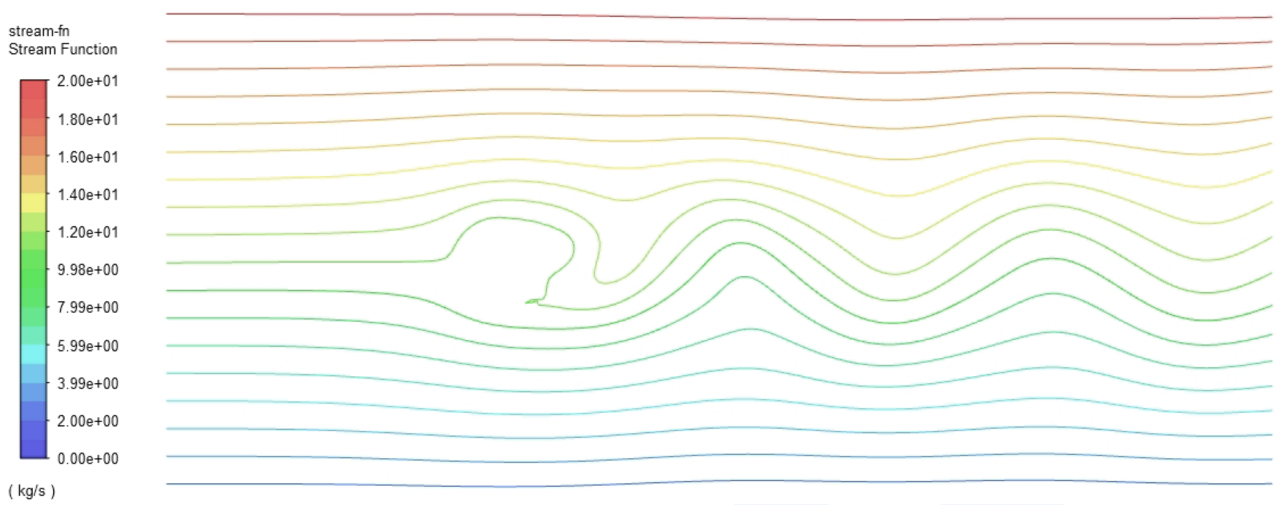

Figure 3 Stream function of Circle in Flow

III) Line plots of Lift force over Time for each scenario @ 3 min.

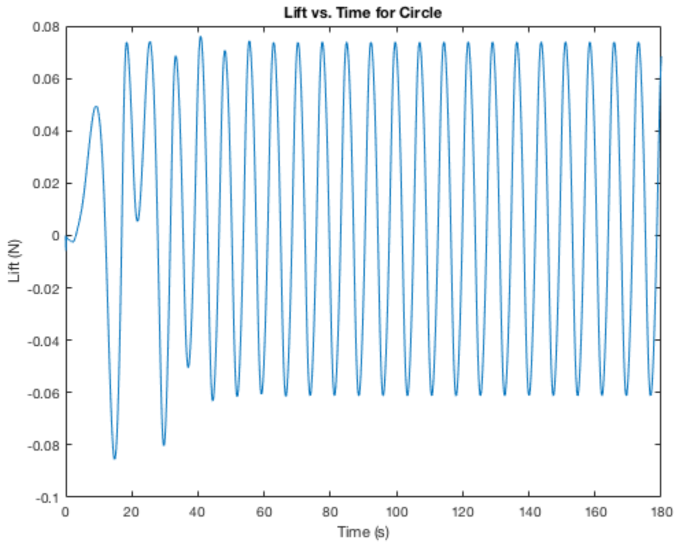

Figure 4 **Lift vs. Time for Circle in Flow**

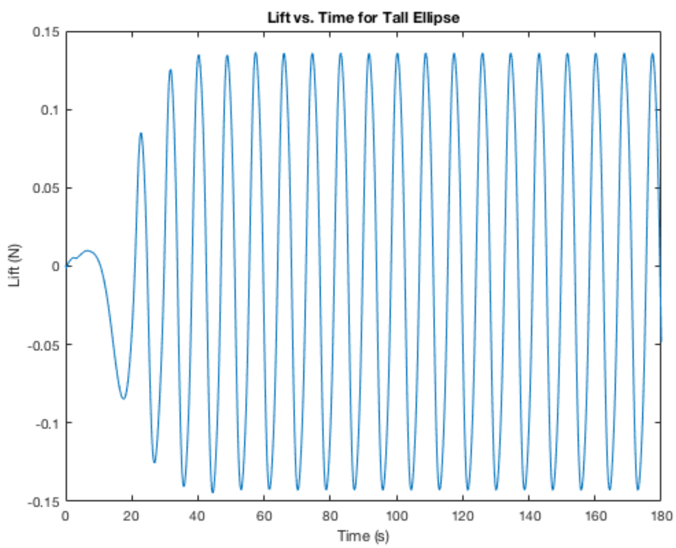

Figure 5 **Lift vs. Time for Tall Ellipse in Flow**

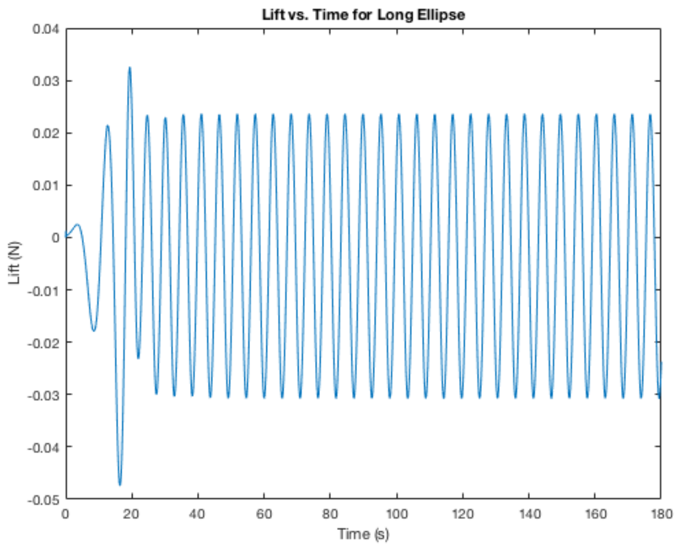

Figure 6 Lift vs. Time for Long Ellipse in Flow

The plots above were utilized to find the amplitudes and periods of oscillation. The MATLAB code used is in the Appendix.

IV) Comparison of Amplitude and Period of Shapes in Flow

Table 1 Lift and Period of Oscillation of Bodies in Flow

Lift, Period	Amplitude of Lift (N)	Period (s)
Circular Cylinder	0.067525	7.3
Elliptical Cylinder Tall	0.13935	8.6
Elliptical Cylinder Long	0.027145	5.4

It is clear to see that the shape of the object has both an effect on the period of oscillation and the amplitude of the lift being generated. As is expected, the Tall cylinder, which has a larger surface area perpendicular to the flow generates a larger period. The smallest is directly proportional to the smallest surface area in the flow, or the more aerodynamic shape in the long ellipse. The amplitude is counter to my instinct given I would expect the more aerodynamic shape in the long ellipse to generate more lift. However, I think this lifting force is caused by the void formed on the back surface of the object which would point to a larger magnitude being generated from the Tall Ellipse.

Task 2:

Flying Saucer at different Angles of Attack

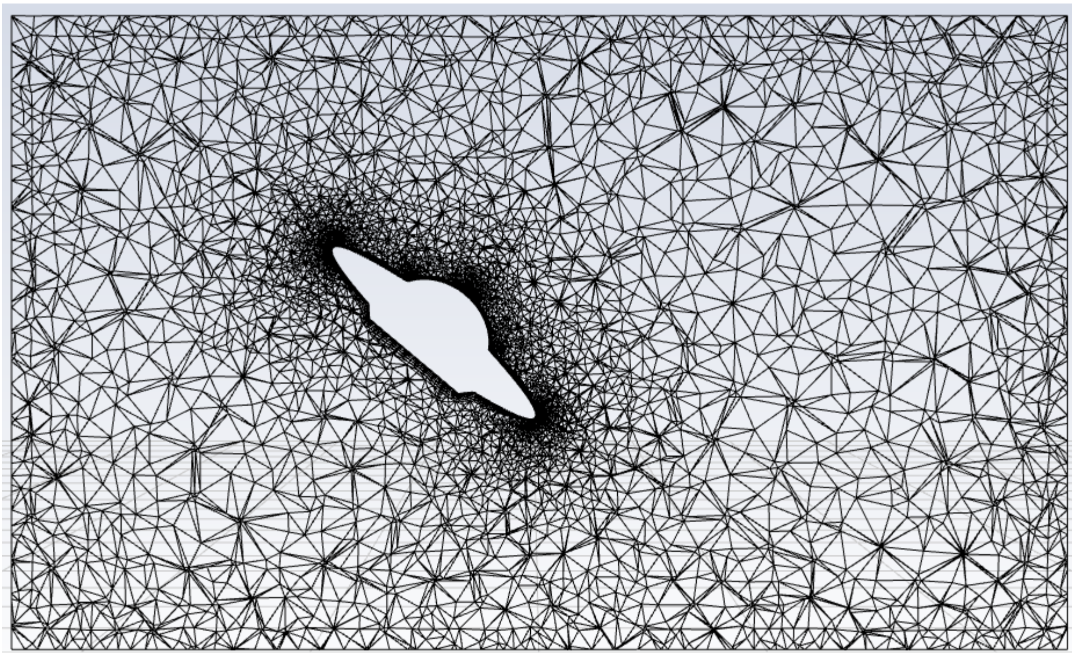

Figure 7 Mesh along plane of symmetry with Angle of Attack @ 40 Degrees

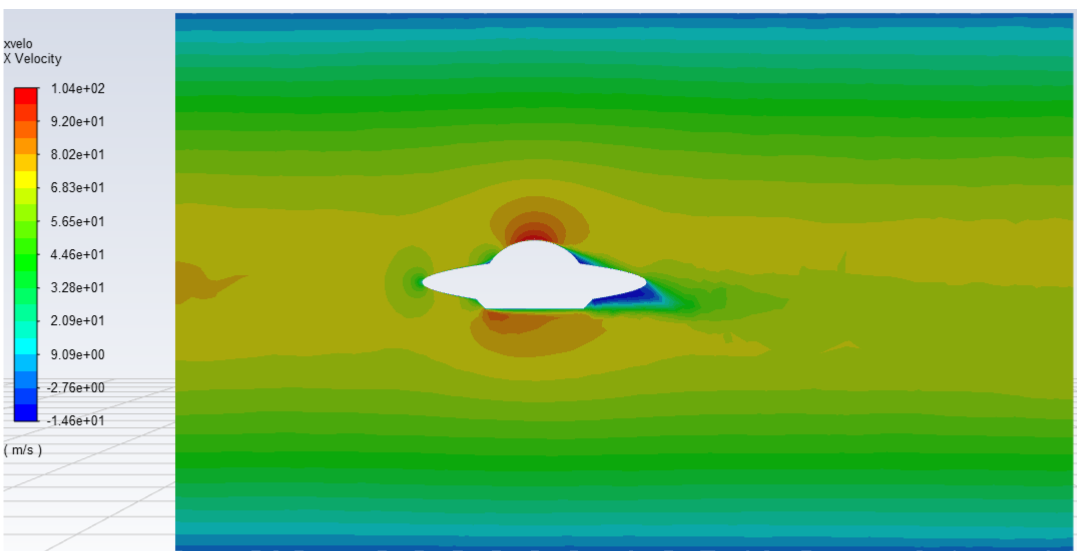

Figure 8 X Velocity @ 0 degree Angle of Attack

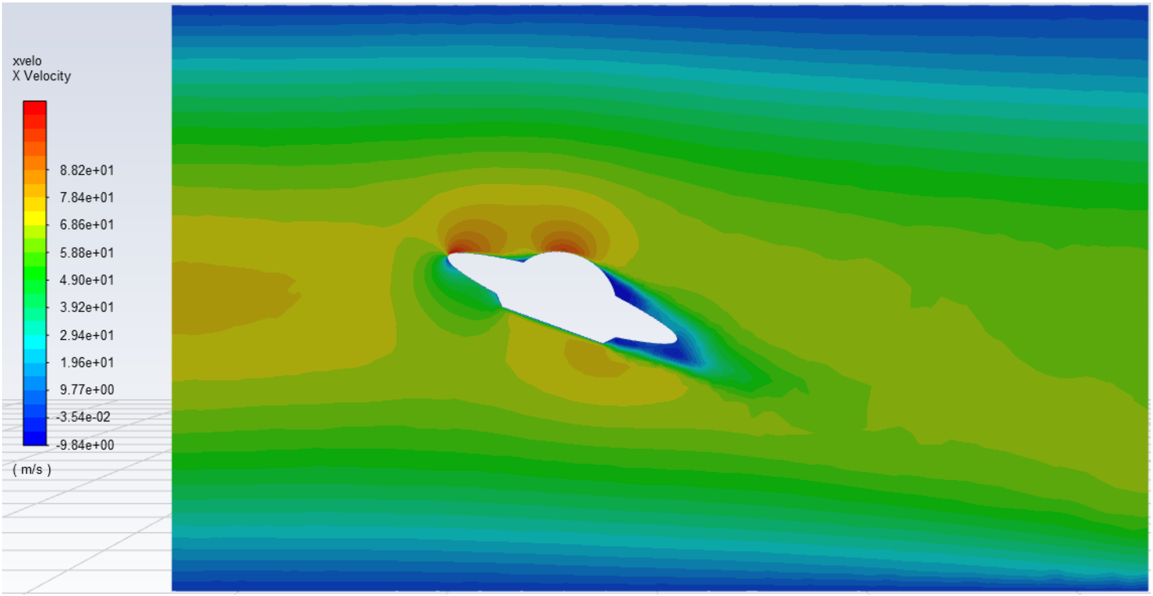

Figure 9 X Velocity @ 20 degree Angle of Attack

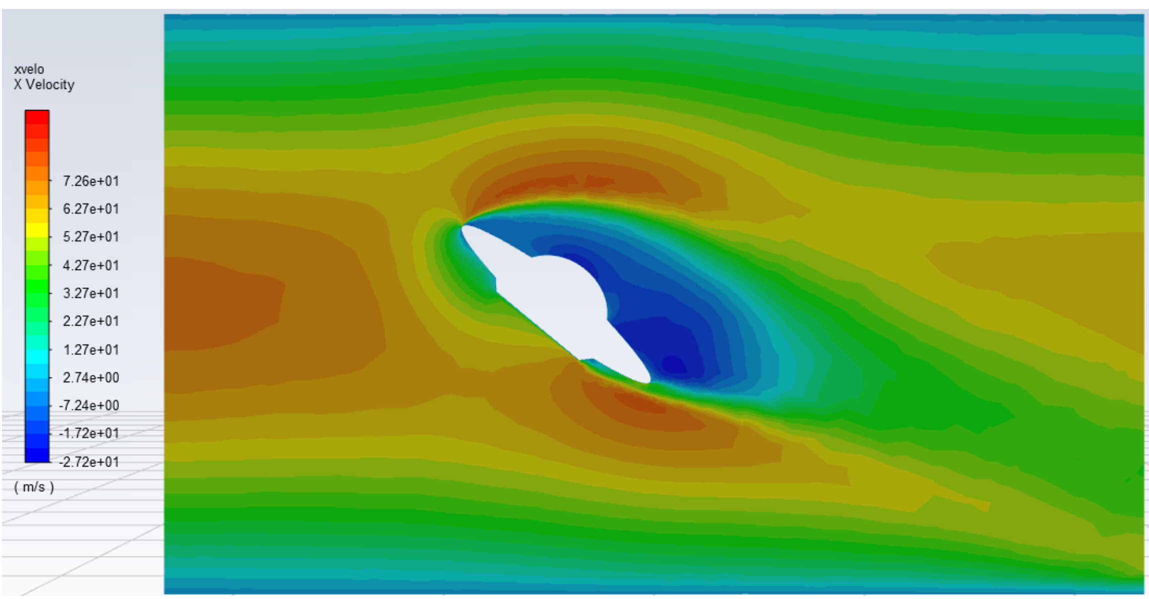

Figure 10 X Velocity at 40 degree Angle of Attack

Table 2 Lift and Drag Forces for Various Angles of Attack

	Lift Force (N)	Drag Force (N)
$\theta = 0°$	5.8246	5.2487
$\theta = 20°$	65.906	19.382
$\theta = 40°$	53.661	62.888

Task 3:

Pentagon Shaped Building in freestream flow. The first set has the flow moving from bottom to top and the second set has the flow moving top to bottom.

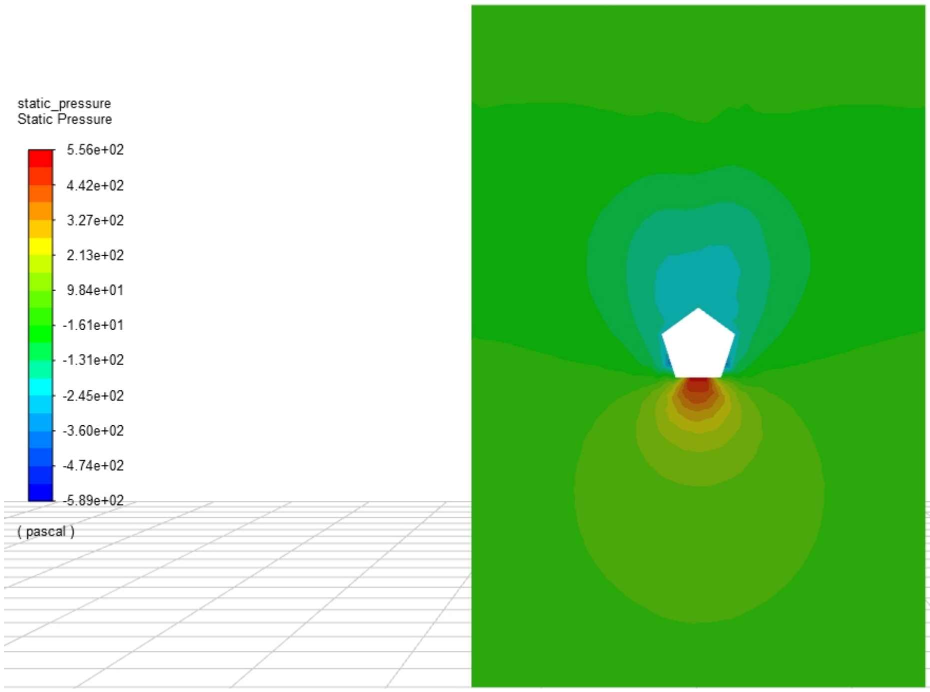

Figure 11 Static Pressure on Horizontal Plane Flat Side

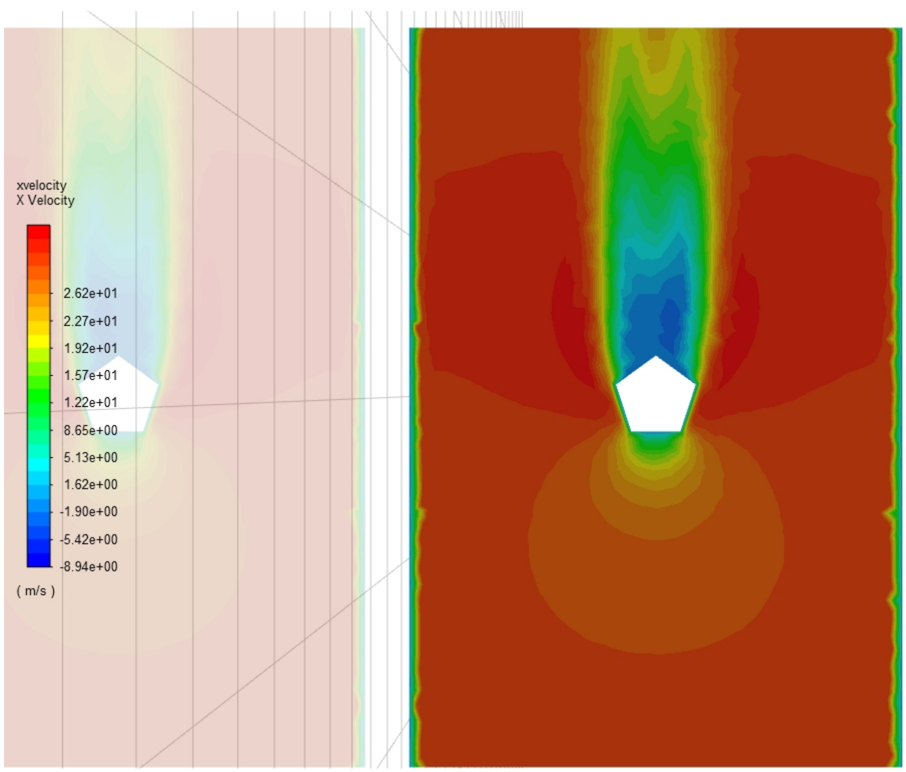

Figure 12 Velocity on Horizontal Plane Flat Side

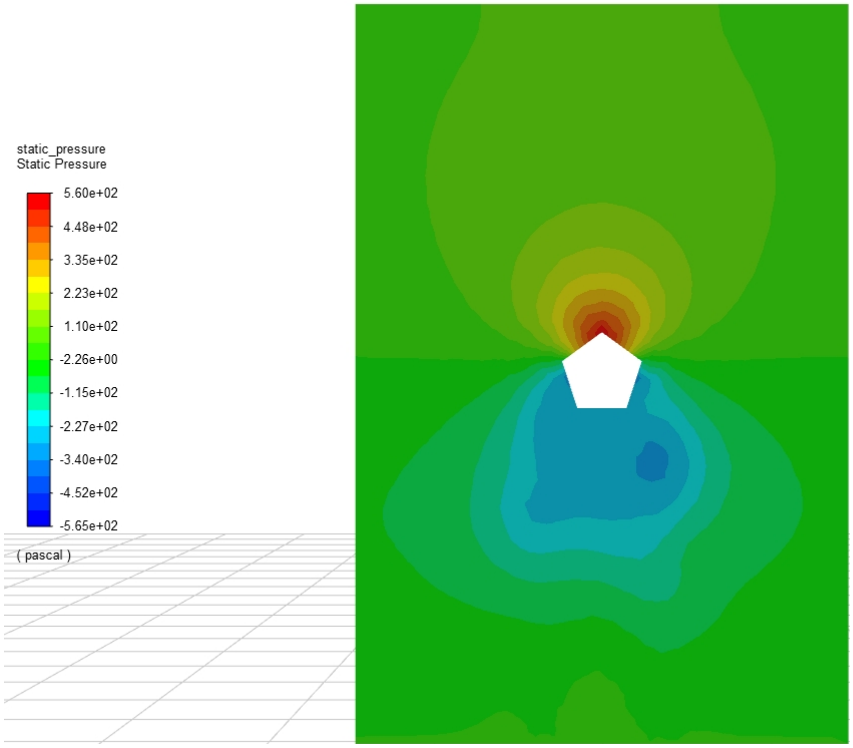

Figure 13 Static Pressure on Horizontal Plane Pointed Side

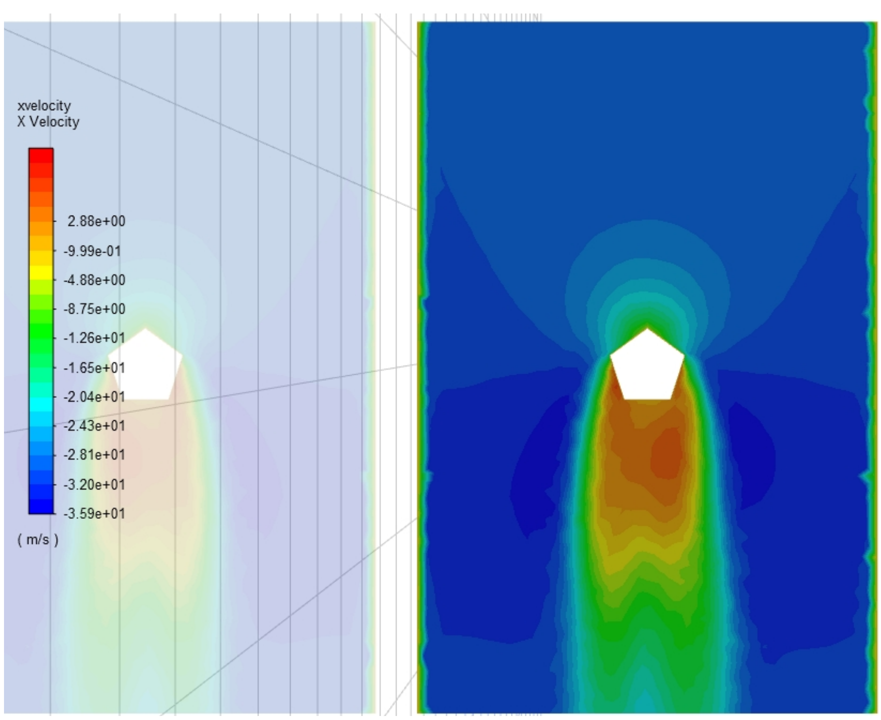

Figure 14 Velocity on Horizontal Plane Pointed Side

Table 3 Drag Forces

	Total Drag (N)	Pressure Drag (N)	Viscous Drag (N)
Case 1 Flat Side	755.901	754.879	1.0219
Case 2 Pointed Side	1164.04	1163.70	0.3327

The general expectation was that the flat side of the pentagon would generate more drag given it is more of a bluff body, but this was not the case. By looking at the drag table, it is clear that the pointed side facing into the wind led to a higher magnitude of drag. We can then analyze this in the pressure and velocity plots above. In Fig. 13, it can be seen that there is a much larger low pressure region than there is in Fig. 11 behind the pentagon. This low pressure region has a direct effect on the drag being generated on the structure. In addition, when comparing Fig. 12 and 14, it can be seen that the velocity in the system is lower in magnitude, thus generating more drag which slows the entire system down. This is similar to what you see in wind tunnels when an airfoil changes angle of attack, the entire flow through the tunnel slows down. It seems that the pointed side of the pentagon creates a sort of fast-back design, where the flow is more gradually returned to the flow over the back surface of the pentagon, thus reducing the drag on the object. This type of design can be seen most notably on cars as well as supercritical airfoils. The more abrupt back surface creates a very turbulent region on the back side of the pentagon, thus greatly increasing the drag.

Appendix

MATLAB Code

```
%Luca Robbins
%1210910620
clear

%Load Data
Circle=importdata('Lift_time_circle.txt');
Tall=importdata('Lift_time_Tall.txt');
Long=importdata('Lift_time_Long.txt');

%Plot Lift and Time
Lc=Circle.data(:,3);
Lt=Tall.data(:,3);
Ll=Long.data(:,3);

Tc=Circle.data(:,2);
Tt=Tall.data(:,2);
Tl=Long.data(:,2);

figure(1)
plot(Tc,Lc)
xlabel('Time (s)')
ylabel('Lift (N)')
title('Lift vs. Time for Circle')

figure(2)
plot(Tt,Lt)
xlabel('Time (s)')
ylabel('Lift (N)')
title('Lift vs. Time for Tall Ellipse')

figure(3)
plot(Tl,Ll)
xlabel('Time (s)')
ylabel('Lift (N)')
title('Lift vs. Time for Long Ellipse')
```