CFD setup

Highlighted Results for showcase:

Obtained at speed 80 kph = 22.2222 m/s , density of 1.162 kg/m^3 , reference/ frontal area = 0.29 m^2 . Main aspects of car (nosecone + side panels)

Net total drag force = 60.7 N

Net Total drag coefficient= 0.7289

Net total downforce = 28.5 N

Net total downforce coefficient = 0.3429

L/D = 0.47

Downforce generated by nosecone = 9.0196 N , note that nosecone is the only frontal aerodynamic component that generates downforce

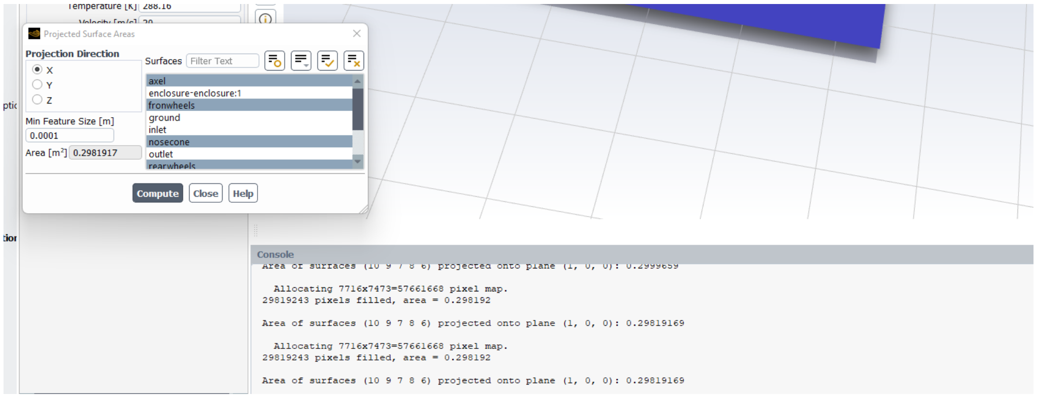
% front down force (over the front axle) = (down force of nose cone / total down force)*100%

= (9.0196 / 28.5)*100% = 31.65 %

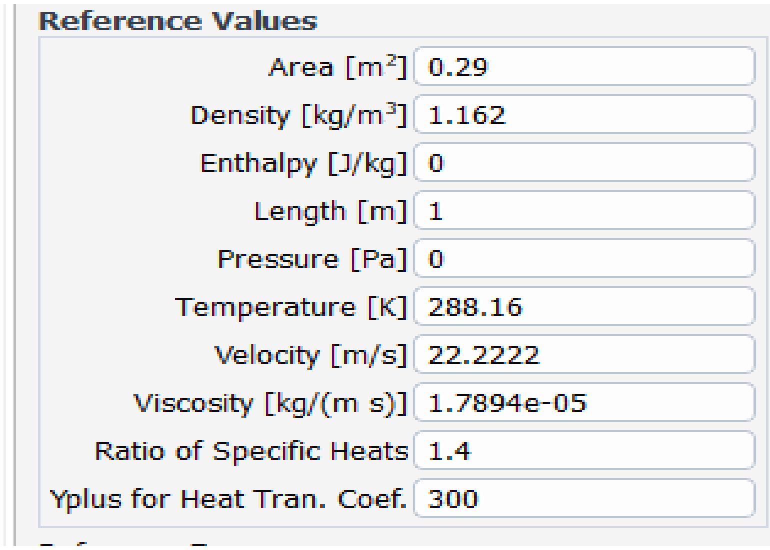
- Check Mesh Quality

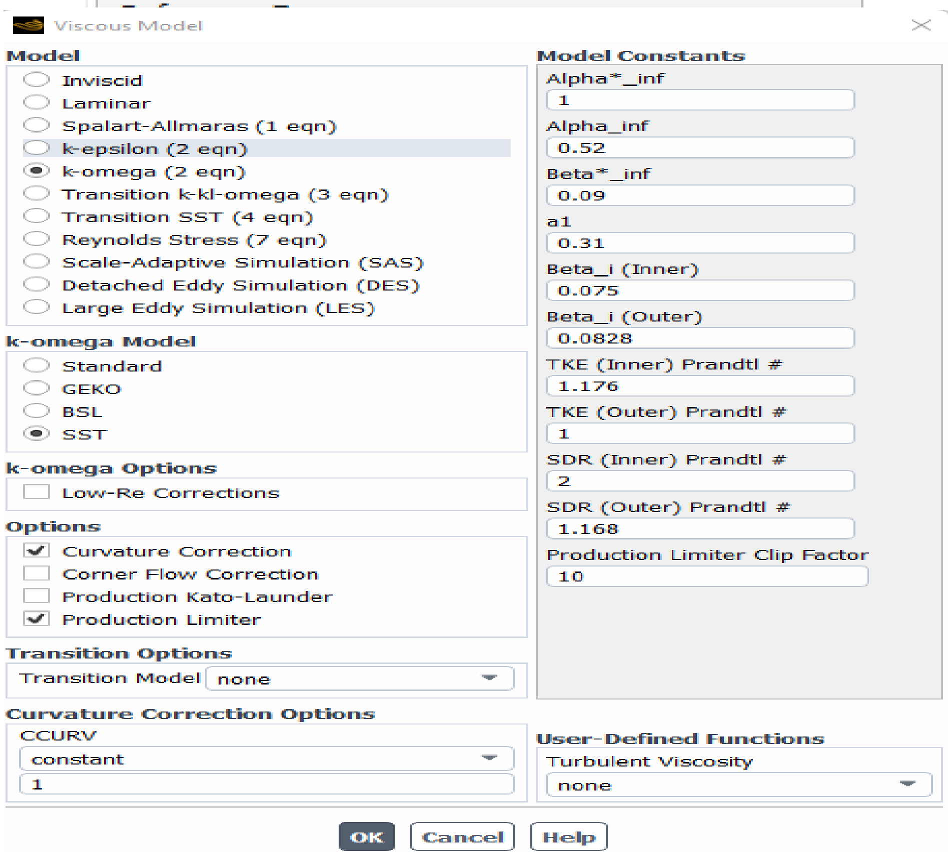
```
Mesh Quality:

Minimum Orthogonal Quality =  1.00154e-01 cell 448646 on zone 3754 (ID: 1170250 on partition: 1) at location ( 1.81738e+00,  4.11892e-01,  2.68951e-01)

Maximum Aspect Ratio =  6.15272e+02 cell 117729 on zone 3754 (ID: 271213 on partition: 0) at location ( 1.82014e+00,  4.32322e-01,  2.70841e-01)
```

- Effective Frontal Area



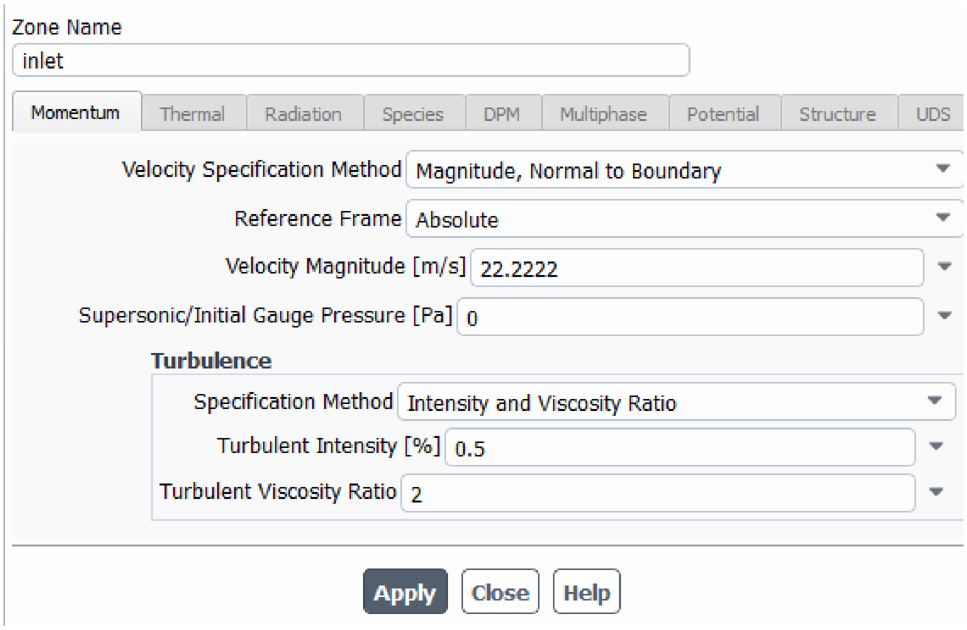
- Reference values and model selection:



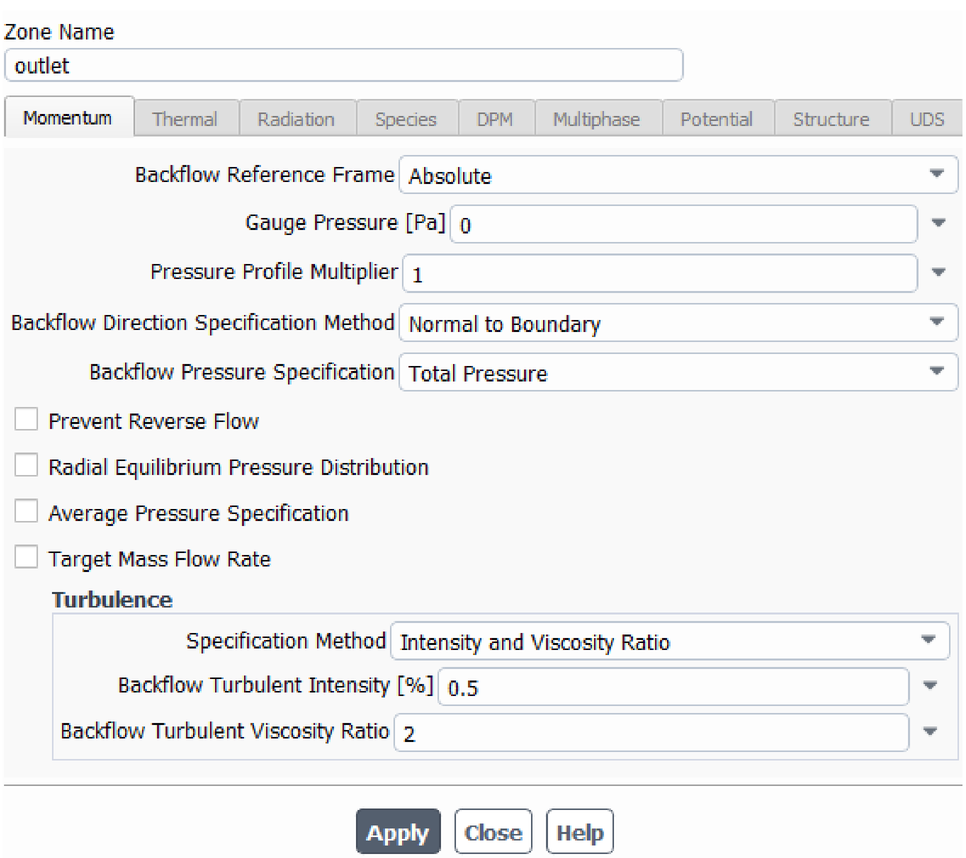


Note: The Reynolds number based on car length is about 4 million, so we will assume the flow to be fully turbulent. Therefore, k-omega SST model is used for this simulation. Also, the curvature correction option is activated to consider the streamline curvature and system rotation.

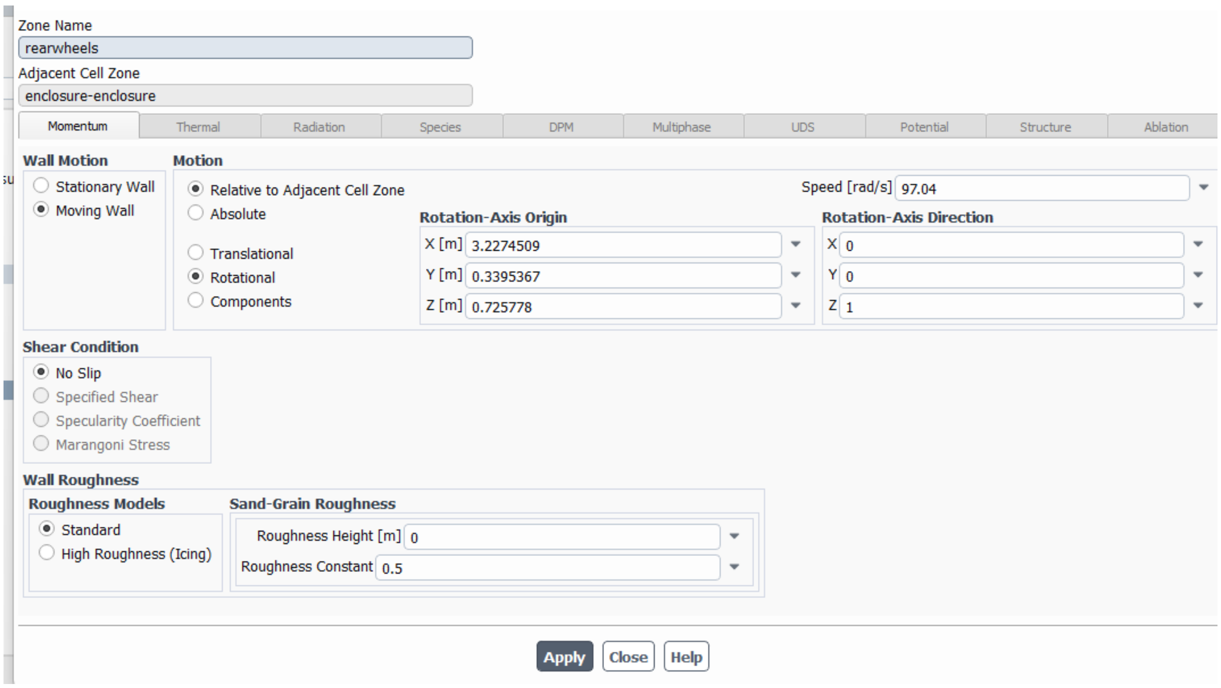
- Boundaries set-up

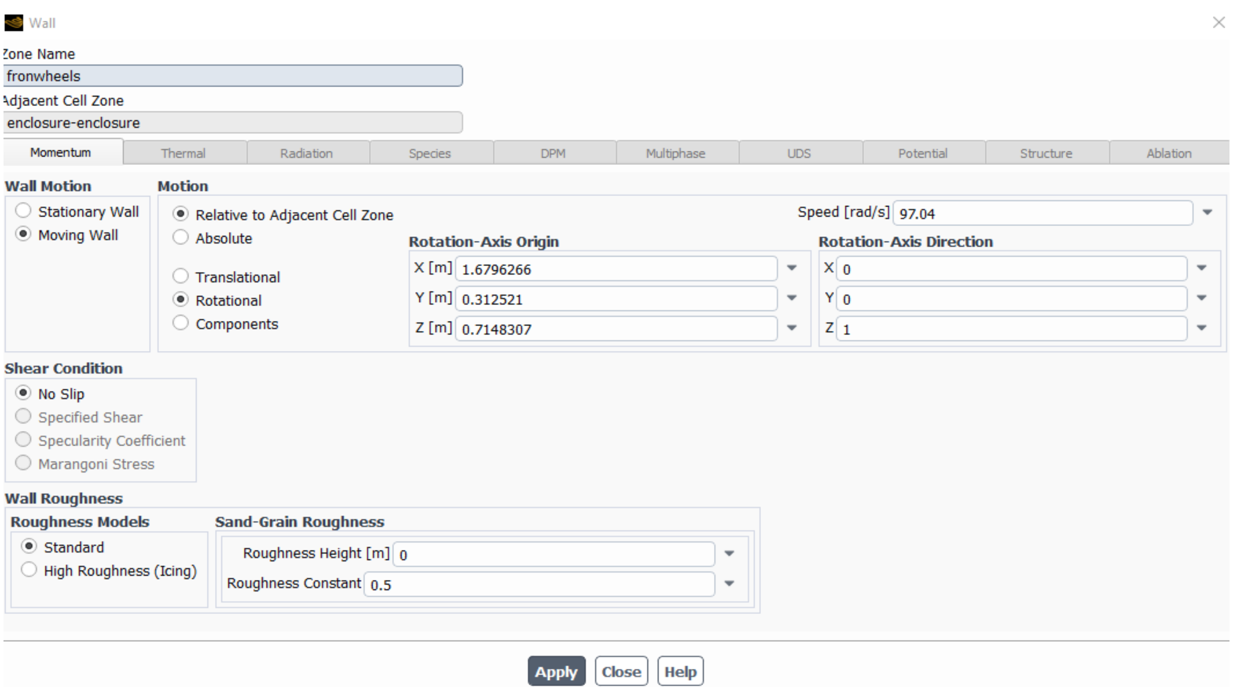


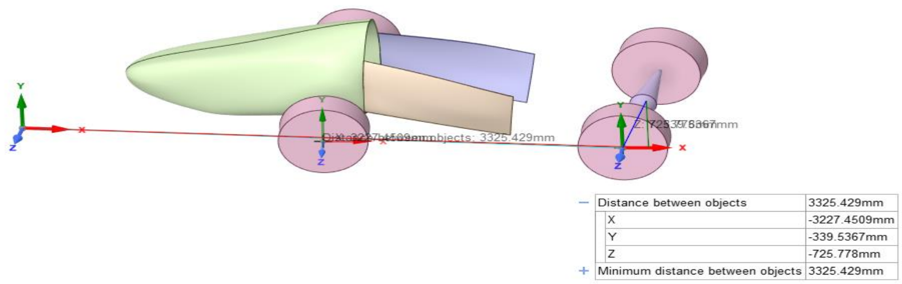
Note: The turbulent intensity at the wind tunnel inlet is usually very low, so it will be set at 0.5

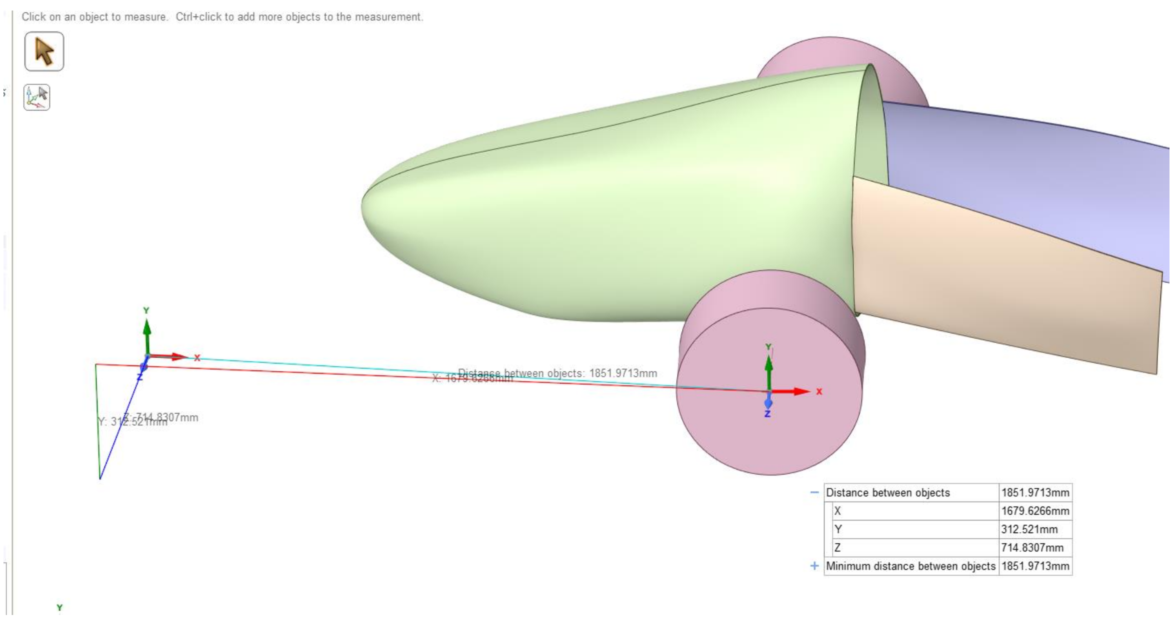


Note: The outlet is set to zero-gauge pressure because it's exposed to the Ambiant atmospheric pressure, and the turbulent intensity is set at 0.5 as well in case of any reversed flow





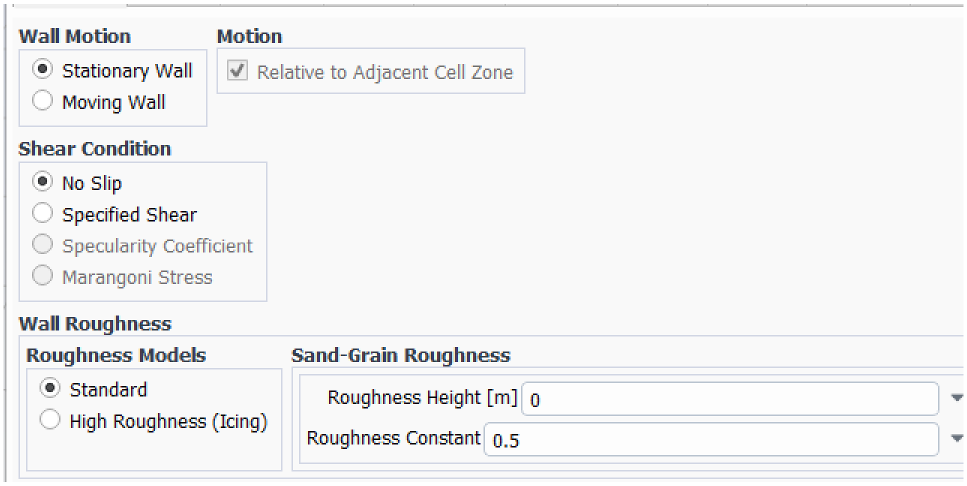




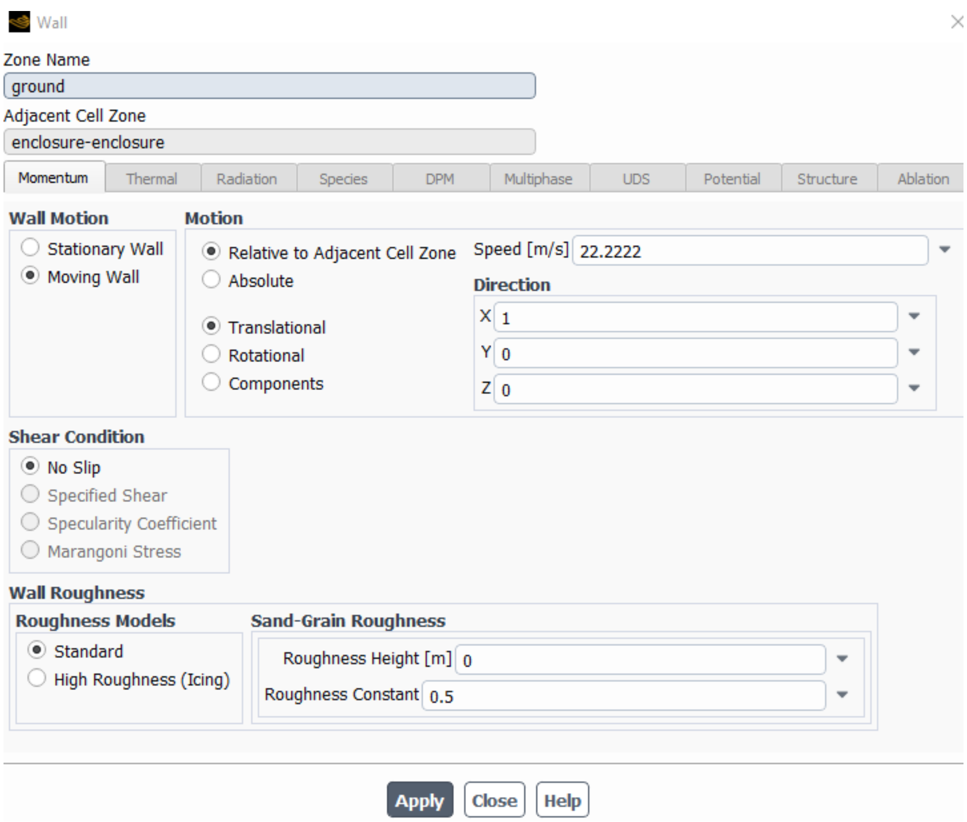
Note: For the front and rear wheels, the rotation axis origin is set.

The angular speed of the wheels, omega = v/r_wheel = 22.2222/ 0.229 = 97.04 rad/s

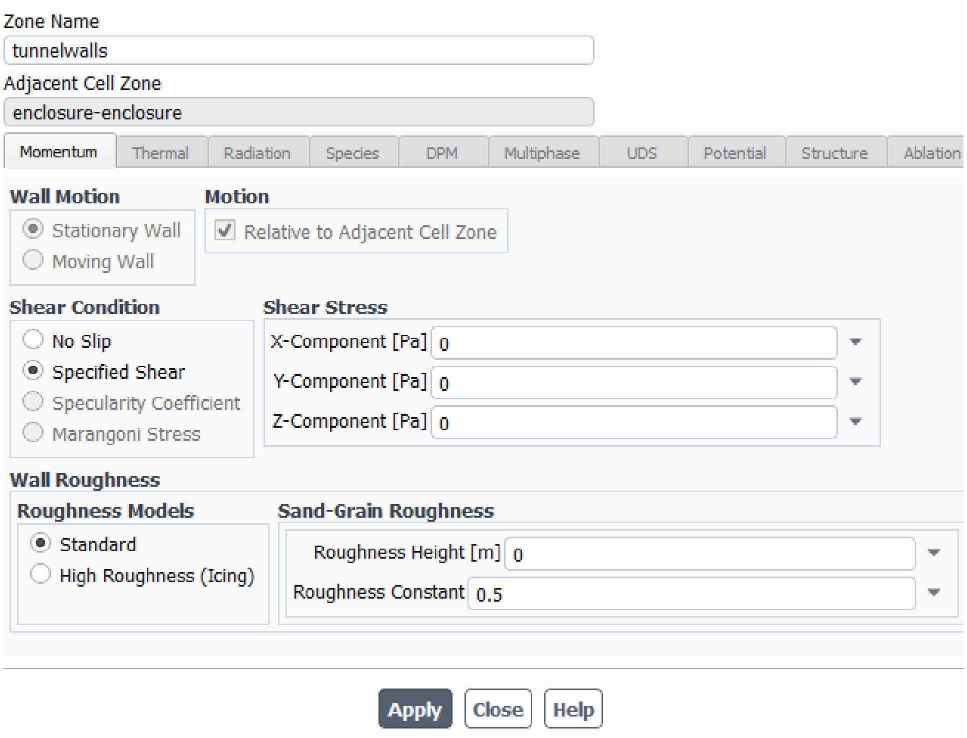
The rotation of axis is in the z direction according to the right-hand rule



Note: All car walls are set to no slip stationary walls

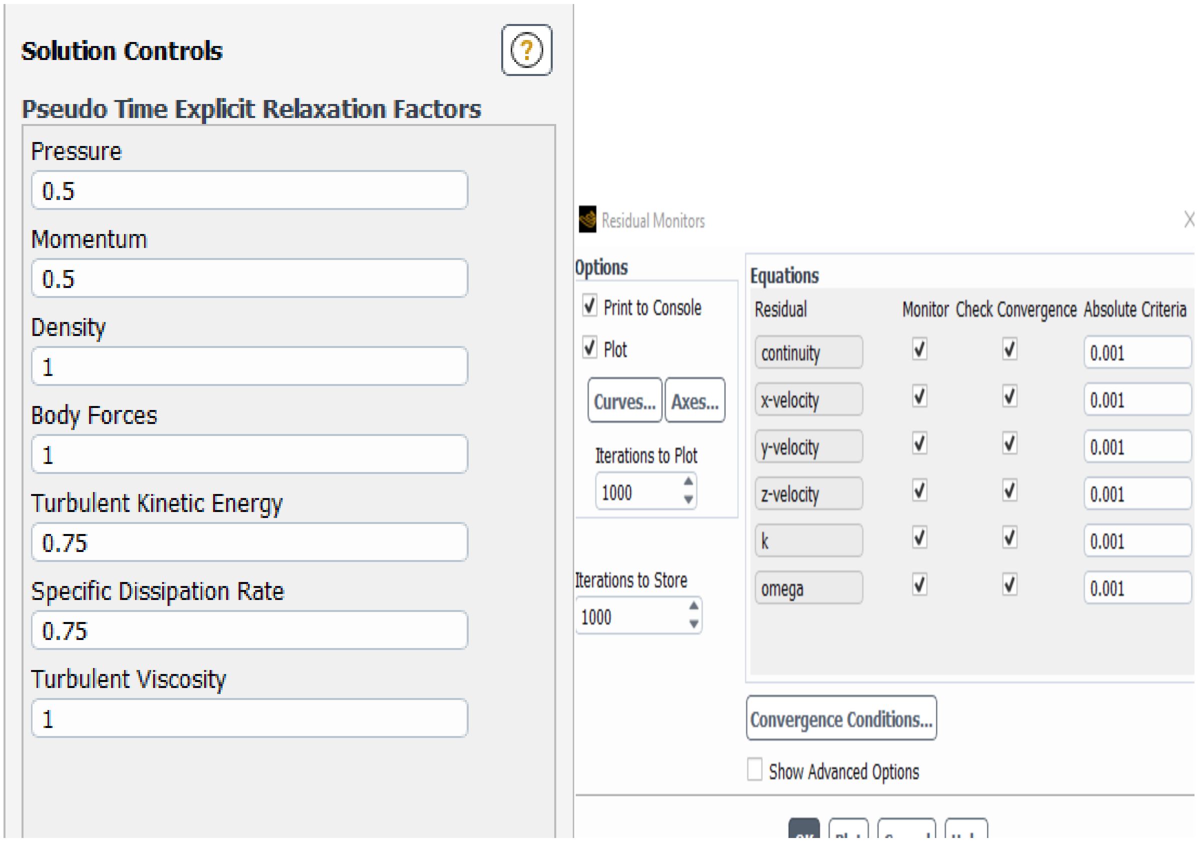


Note: The ground is set as a moving wall with a 22.2222 m/s translational speed as it will be moving with respect to the car

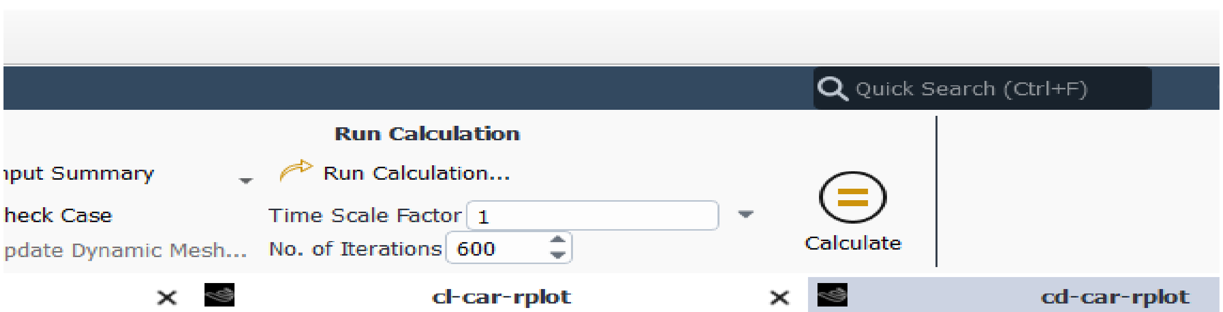


Note: The tunnel walls are set as a zero specified shear to simulate a free slip wall

- Solutions

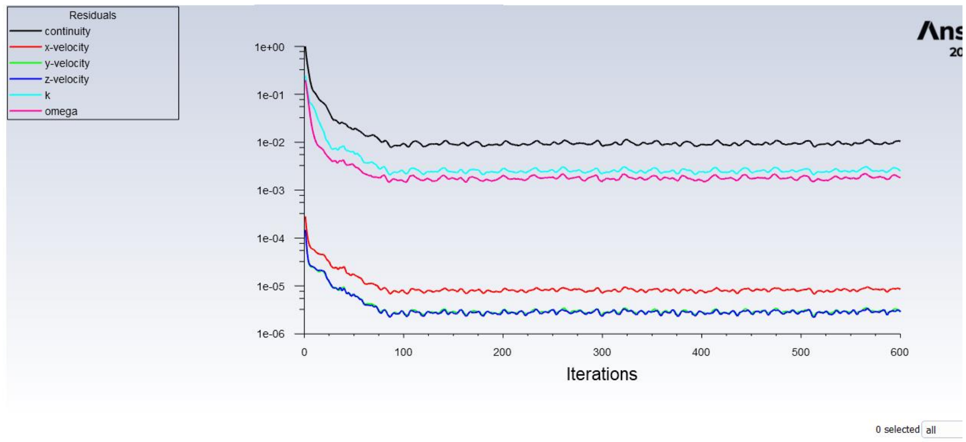


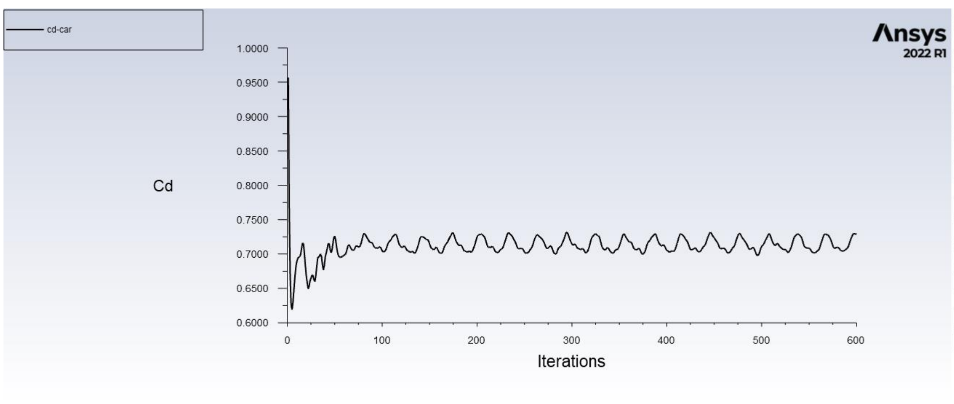
Note: Solutions controls, and convergence conditions are set at the software default value

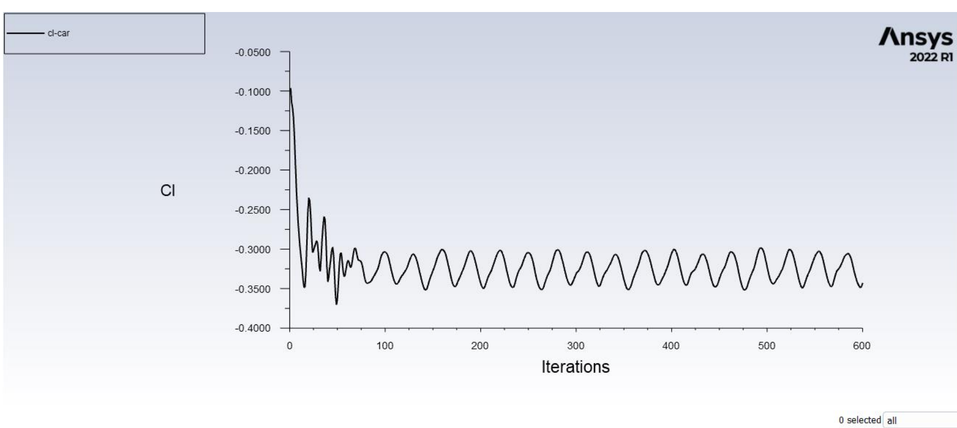


Note: The simulation is run for 600 iterations, and it’s estimated to be completed in 10 hours.

➢ **Results:**







Note: Global residuals and drag and lift monitors are oscillating which is due to the vortex shedding caused by the interaction of the car and the air. The latter is an expected behavior as this an inherently unsteady flow problem. The plots of drag and lift coefficient seem to have stabilized past 200 iterations and oscillate around ana average value.

- **Post-Processing & analysis**
  - **Estimated total net drag and lift forces & coefficients**

1) Average total and local drag forces:

Forces - Direction Vector (1 0 0)

	Forces [N]			Coefficients		
Zone	Pressure	Viscous	Total	Pressure	Viscous	Total
axel	5.3381396	0.11466207	5.4528017	0.064156655	0.0013780709	0.065534726
fronwheels	20.157536	0.26675361	20.424289	0.24226419	0.0032059894	0.24547018
nosecone	16.469415	1.2522173	17.721632	0.19793835	0.015049827	0.21298818
rearwheels	15.445095	0.33275901	15.777854	0.18562752	0.0039992782	0.1896268
sidepanel	1.0811278	0.19770524	1.278833	0.01299358	0.0023761287	0.015369708
Net	58.491313	2.1640973	60.65541	0.7029803	0.026009294	0.72898959

2) Average total and local lift forces:

Forces - Direction Vector (0 1 0)

	Forces [N]			Coefficients		
Zone	Pressure	Viscous	Total	Pressure	Viscous	Total
axel	0.32545197	0.0059812523	0.33143323	0.0039114582	7.1885932e-05	0.0039833442
fronwheels	-9.0791262	0.10362401	-8.9755022	-0.10911786	0.0012454095	-0.10787245
nosecone	-9.0583903	0.038770433	-9.0196198	-0.10886864	0.00046596408	-0.10840268
rearwheels	-11.309894	0.1114858	-11.198409	-0.13592844	0.0013398968	-0.13458854
sidepanel	0.35999986	-0.033267018	0.32673284	0.0043266734	-0.00039982105	0.0039268523
Net	-28.761959	0.22659448	-28.535365	-0.34567681	0.0027233352	-0.34295348

Discussion Note:

that the nosecone and wheels, especially the front wheels contribute significantly to the overall drag.

The total lift forces as well as the corresponding lift coefficients have a negative sign , which means that the car is experiencing a net force in the negative y direction (downforce). This force act to keep the car on the ground at this speed.

Net total drag force = 60.7 N

Net Total drag coefficient= 0.7289

Net total downforce = 28.5 N

Net total downforce coefficient = 0.3429

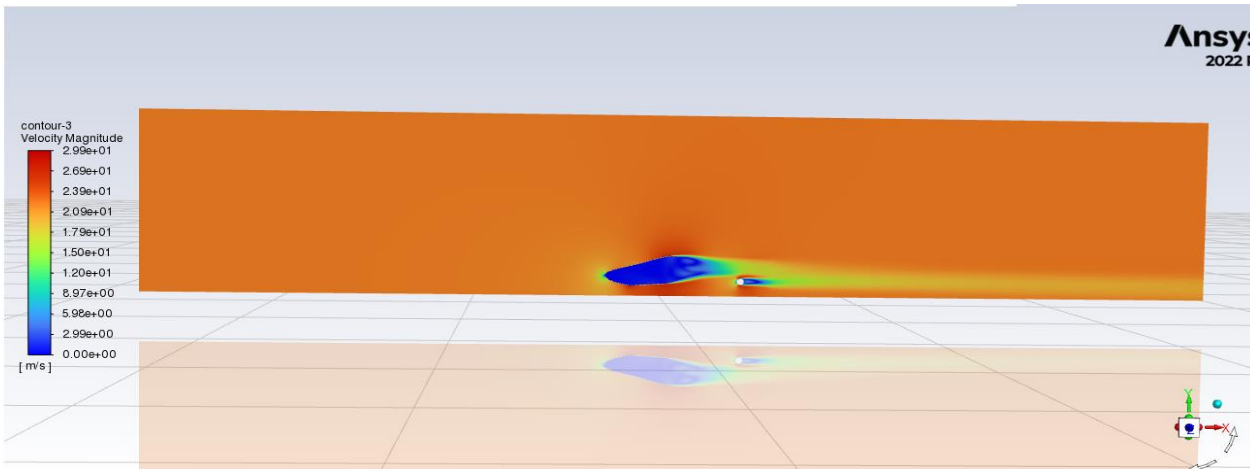
L/D = 0.47

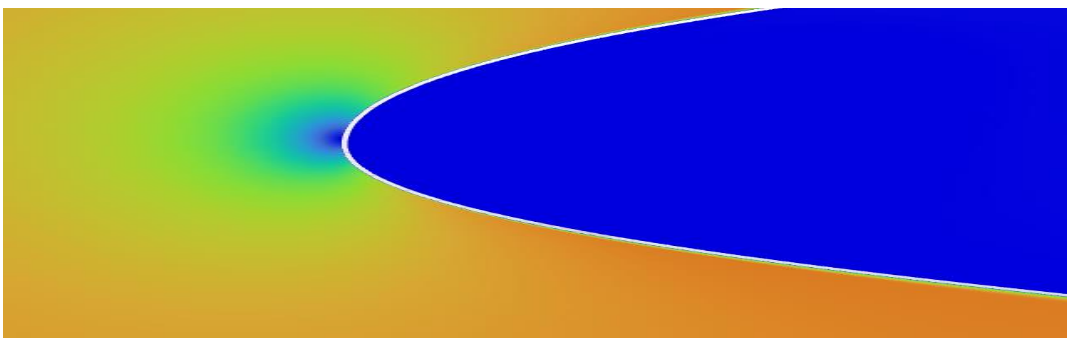
- **Contour Plots**

Contour plots are important to understand the general flow filed around the car

1) Velocity plot

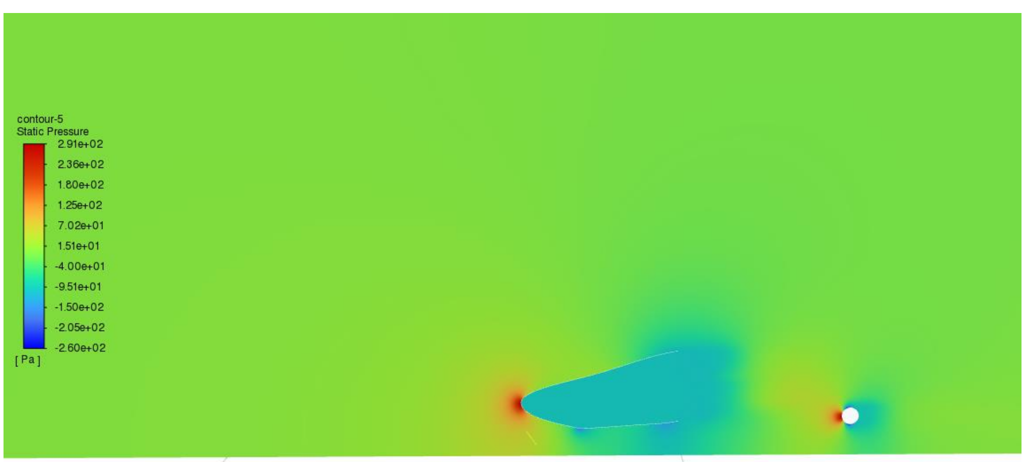
This contour plot helps us identify the low and high velocity regions





We can see that the velocity at the at the front of the car decelerates sharply to zero. This is called a fluid stagnation point. Also, low velocity region is created behind the car which is referred as wake.

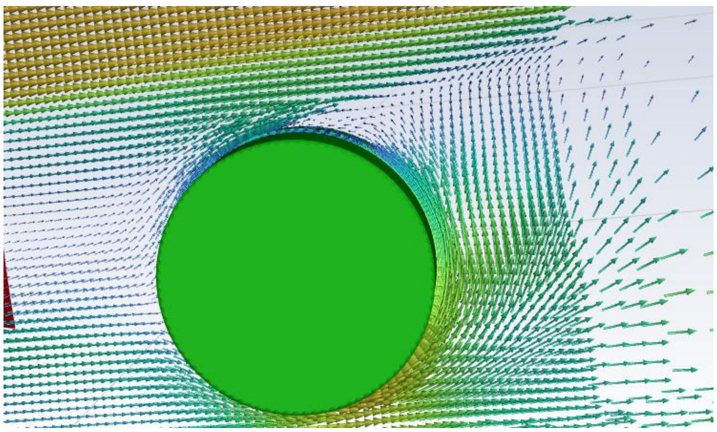
2) Static Pressure plot



Nota that there is a high pressure region at the nose and allow pressure region behind the car . The high pressure in front of the car is due to flow stagnation and the low pressure region in the wake is due to the flow separation and subsequent flow reversal behind the car. Note that there is a low pressure region in nose cone follow floor which is lower than the pressure in the upper part. The latter is what creates the downforce due to venturi effect

- Vector Plots

1) Velocity vector plot



Because of the rotational motion of the wheels, we see that that the air flow near the wheels has a strong rotational component. Furthermore, flow vortices can be observed which are region of rotating flow