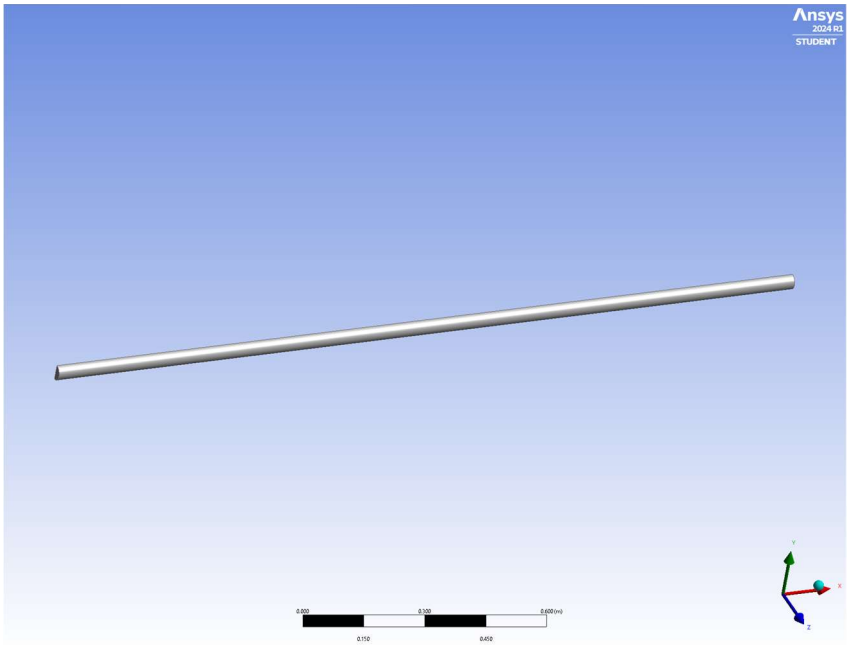
# Project 2: Laminar and Turbulent Flows in a Smooth Pipe

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**Problem Description**

Geometry

The structure is a smooth cylindrical pipe, diameter of 0.04m, length of 2m, with fluid flowing going in the positive x-direction with a symmetry line being placed on the XY plane.




Fluid Properties

The fluid for this project is Air, chemical formula $O_2$ with relevant properties as follows:

Density – 1.2 kg / $m^3$

Viscosity – 1.8 x $10^{-5}$ kg / m * s

(No Energy required for this project)

Flow Conditions

There will be 2 flow conditions for this project, Laminar and Turbulent:

Laminar Flow – Inlet Velocity U = 0.02 m/s

Laminar Viscous Model

Turbulent Flow – Inlet Velocity U = 2 m/s

At both Inlet / Outlet:

Turbulent Intensity I = 5 %

Hydraulic Diameter D = 0.04 m

K-epsilon Viscous Model

**Method**

Mesh

There will be two different meshes for this project, to examine if the velocity profile at the outlet is mesh independent.

Body Sizing = 0.003 m, 469,484 cells

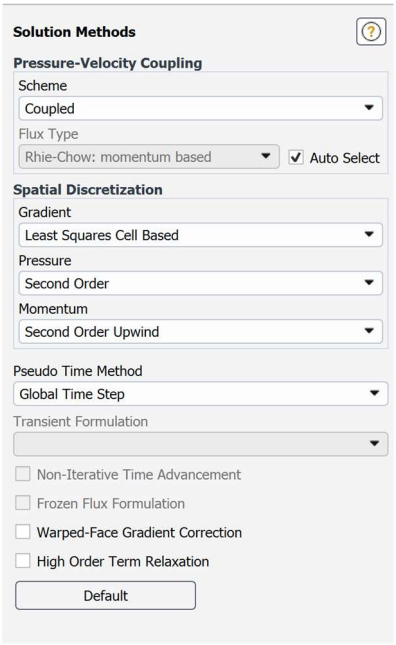
Body Sizing 2 = 0.005 m, 114929 cells

Equations

Laminar uses Laminar viscous model, as well as 0.02 m/s velocity

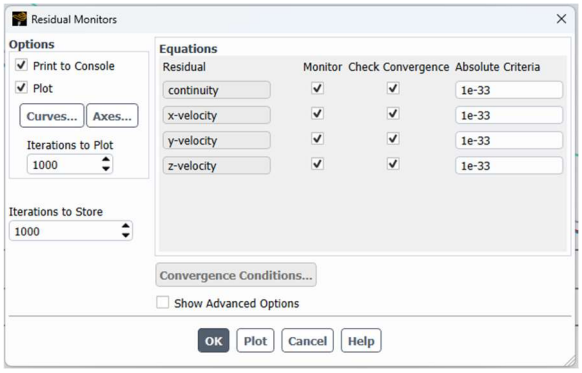
Turbulent uses k-epsilon

## Spatial Discretization Methods

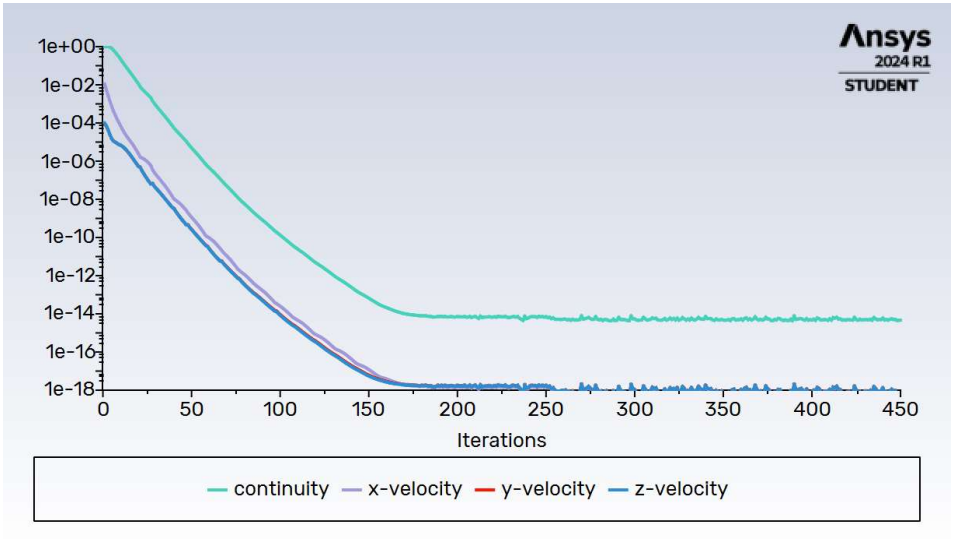


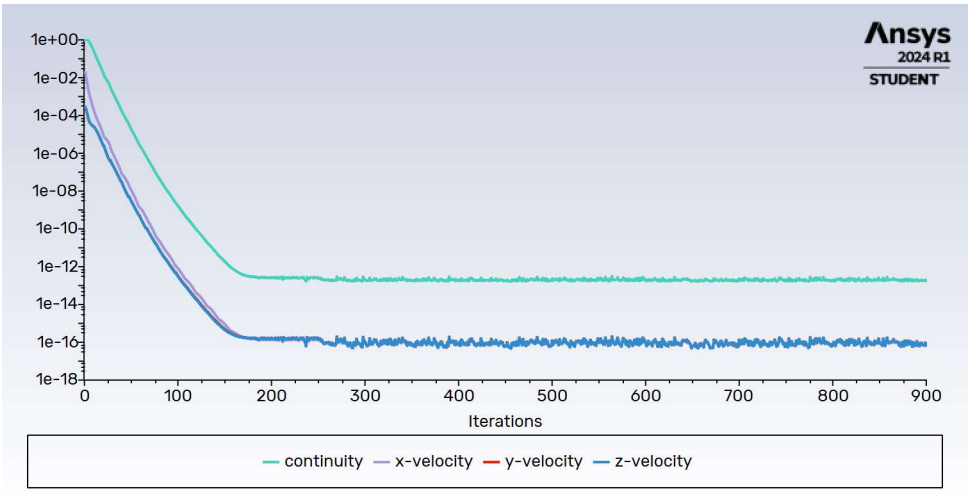

## Residual Values

The residual monitors used for all case is as follows:

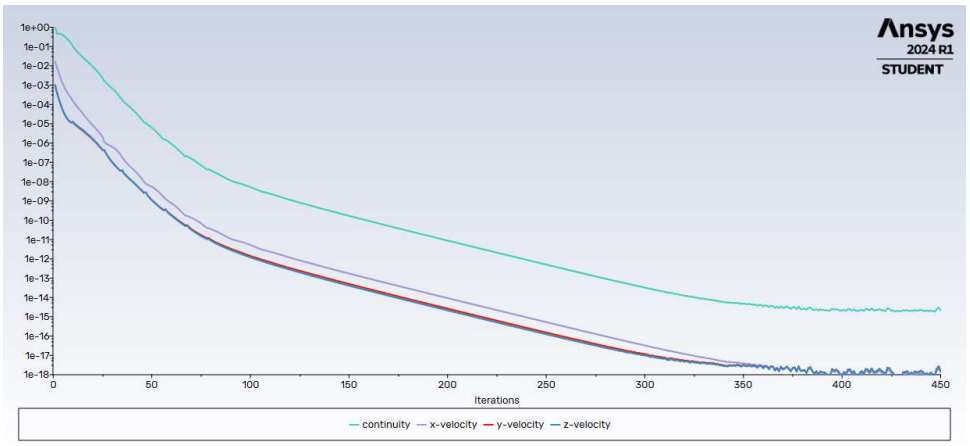


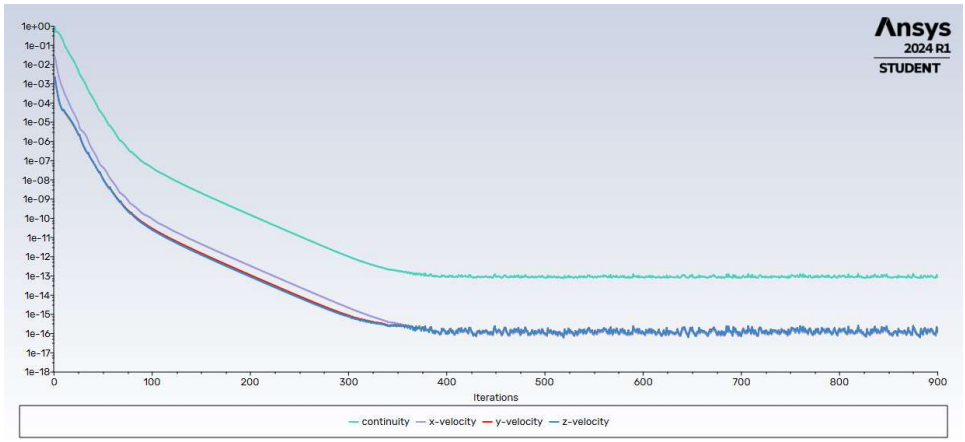
The Scaled Residual for 0.003m Laminar testing at 450 and 900 iterations is as follows:



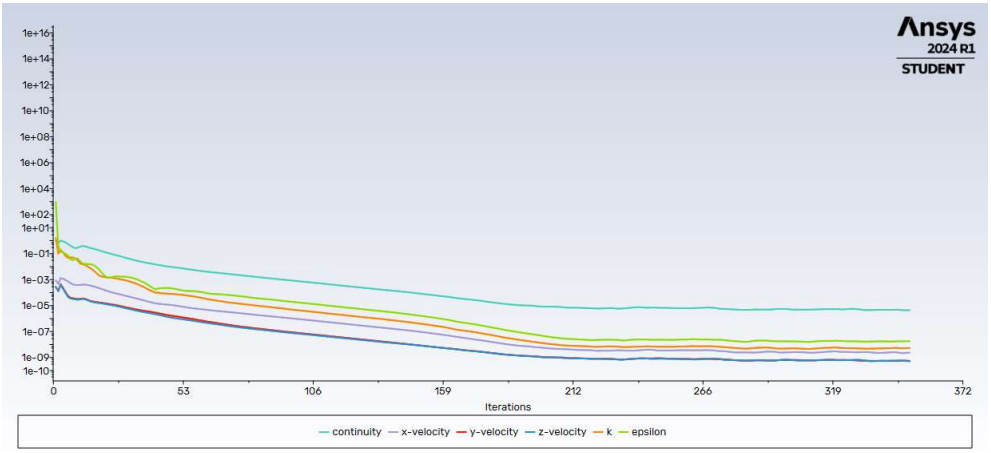



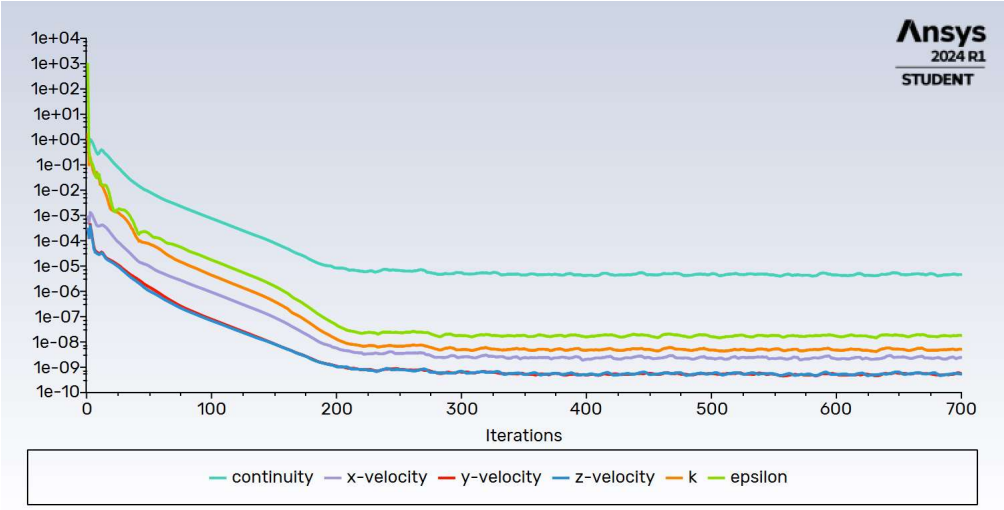
The Scaled Residual for 0.005m Laminar testing at 450 and 900 iterations is as follows:



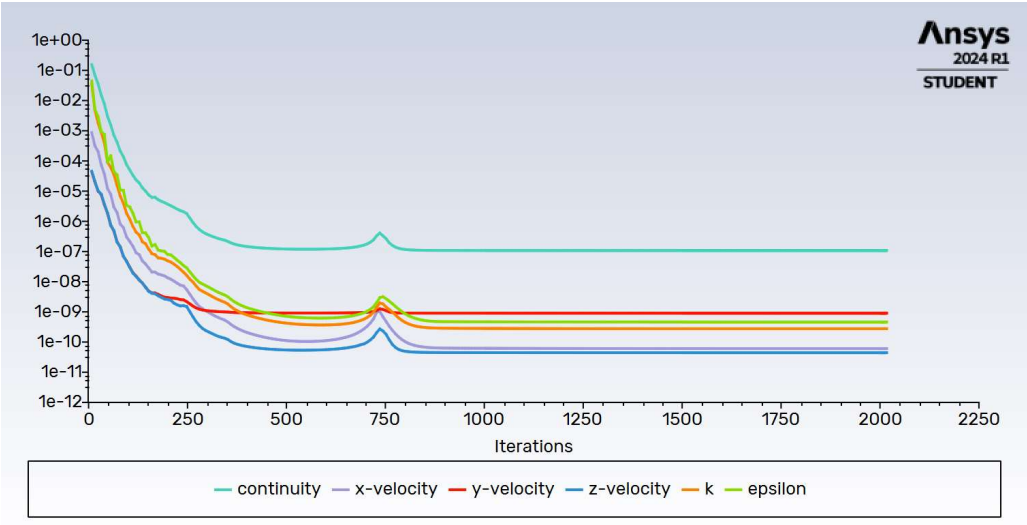




The Scaled Residual for 0.003m Turbulent testing at 350 and 700 iterations is as follows:



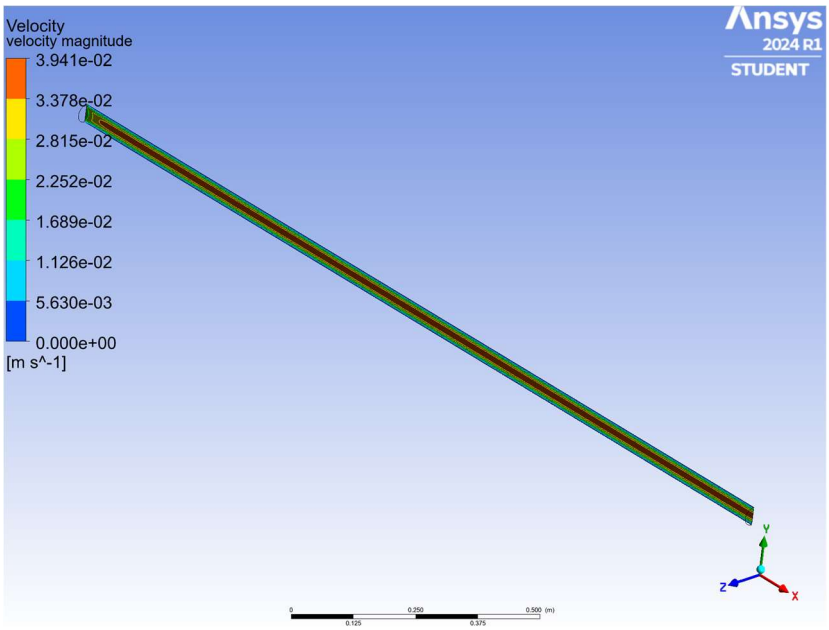



The Scaled Residual for 0.005m Turbulent testing at 1000 and 2000 iterations is as follows:

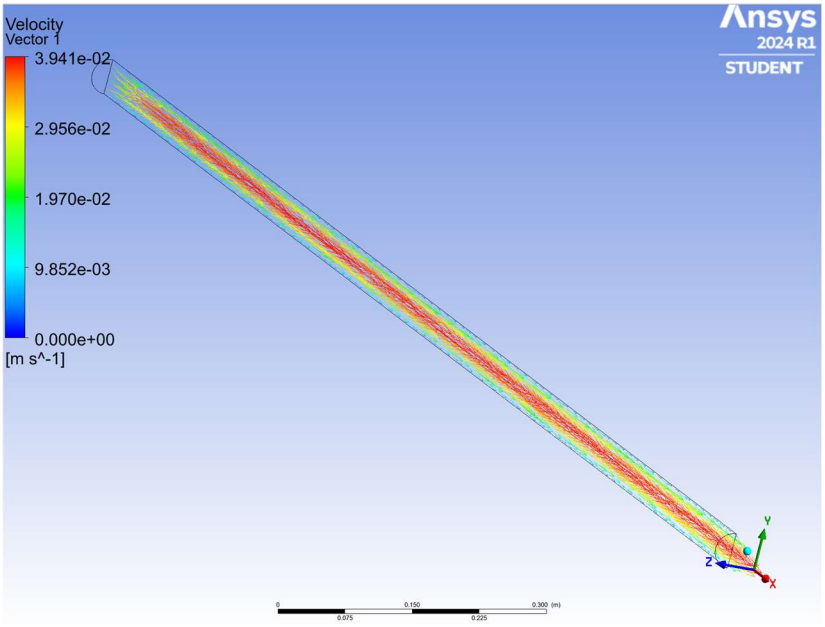


**Results**

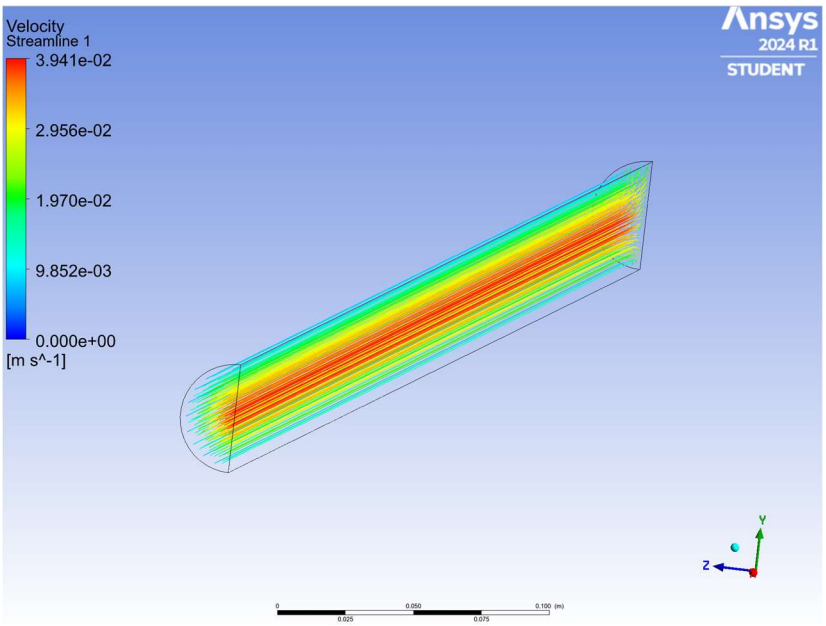
Velocity Magnitude plot for Laminar – 0.003



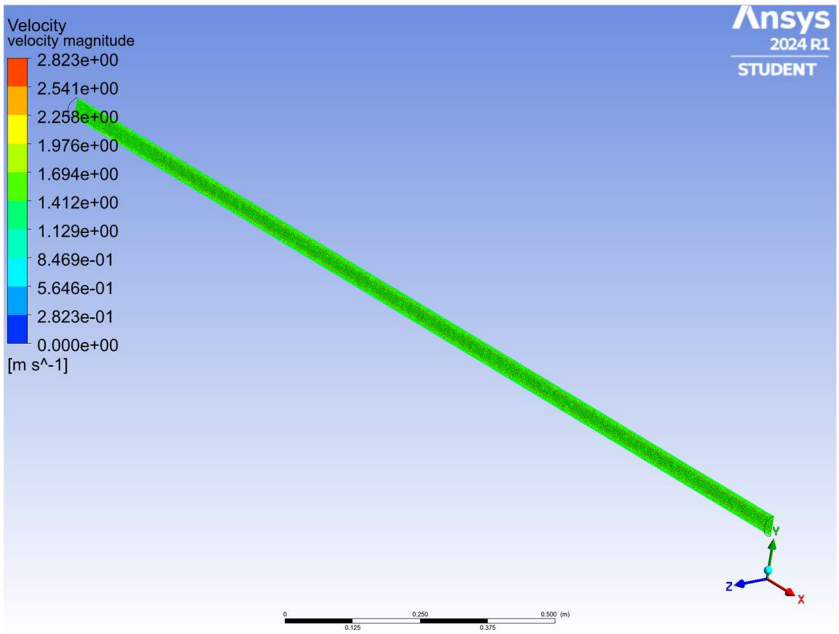

Vector Plot for Laminar – 0.003



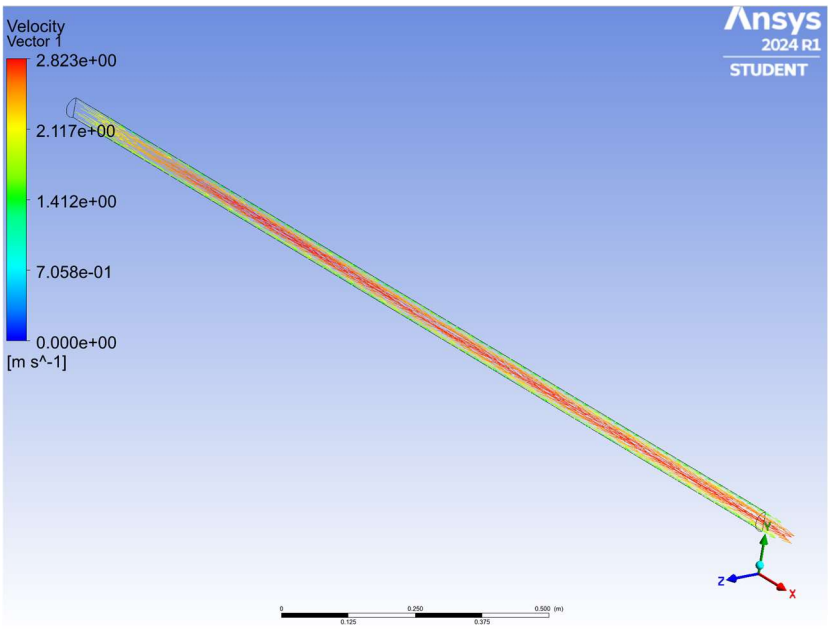
Pathlines Plot for Laminar – 0.003



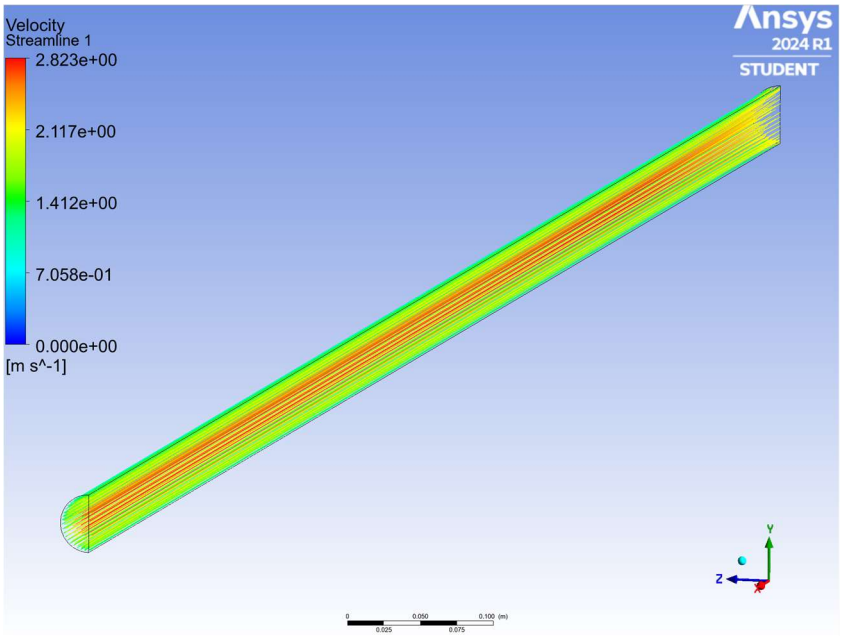

Velocity Magnitude plot for Turbulent – 0.003



Vector Plot for Turbulent – 0.003



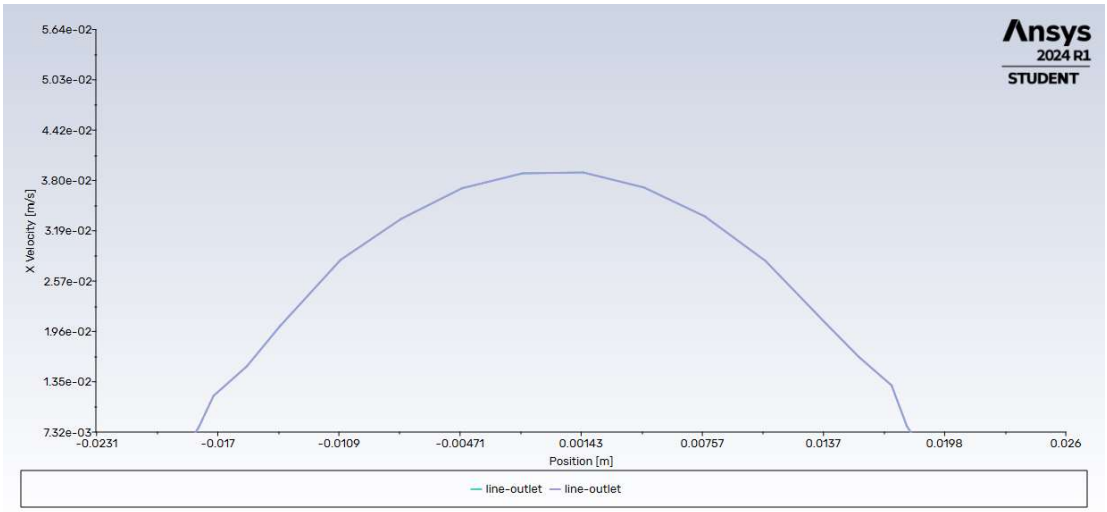

Pathlines Plot for Turbulent – 0.003



# Task 1:

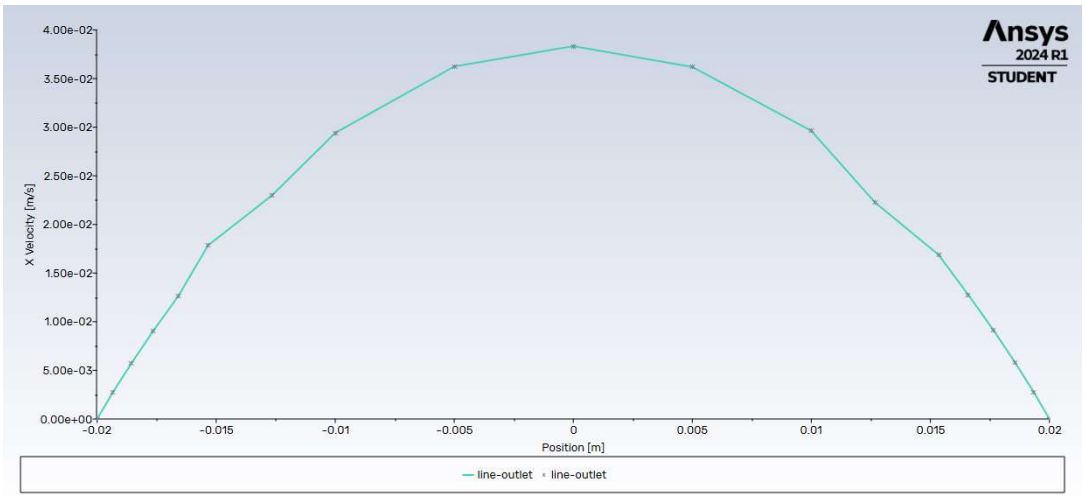
Laminar – 0.003

The teal line is representative of 341 iterations, the darker blue line is representative of 691 iterations. As shown in this plot, iteration beyond 341 iterations proves to not change the solution significantly.



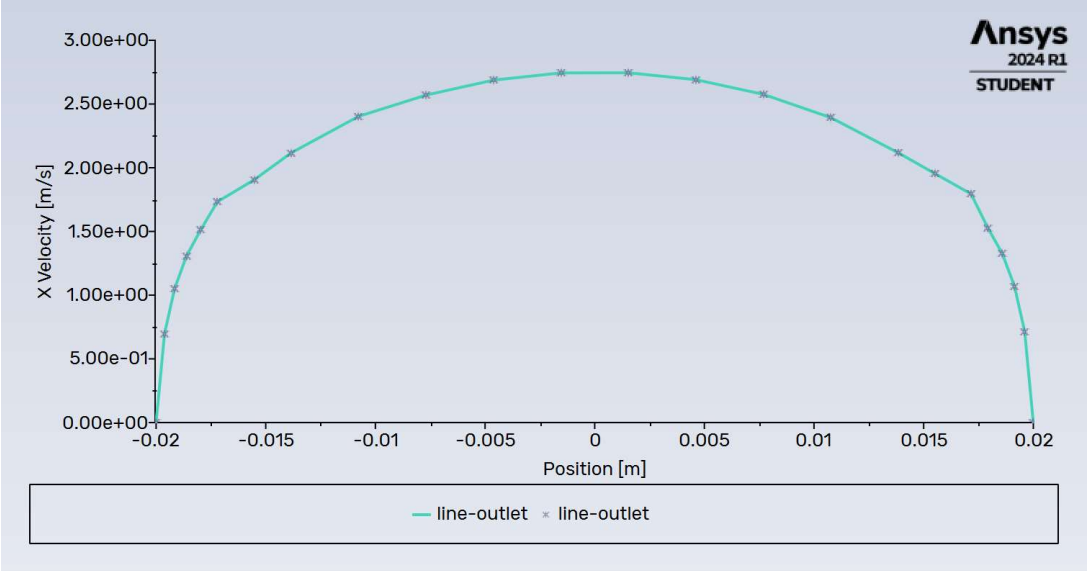

Laminar – 0.005

The teal line is representative of 450 iterations, the asterisks are representative of 900 iterations. As shown in this plot, iteration beyond 450 iterations proves to not change the solution significantly.



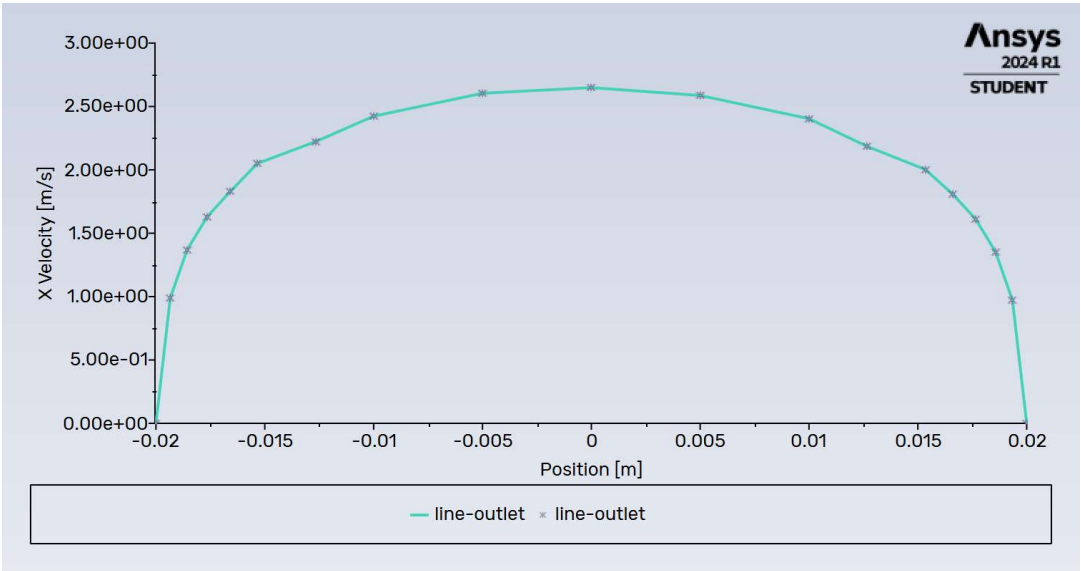
Turbulent – 0.003

The teal line is representative of 350 iterations, the asterisks are representative of 700 iterations. As shown in this plot, iteration beyond 350 iterations proves to not change the solution significantly.




Turbulent – 0.005

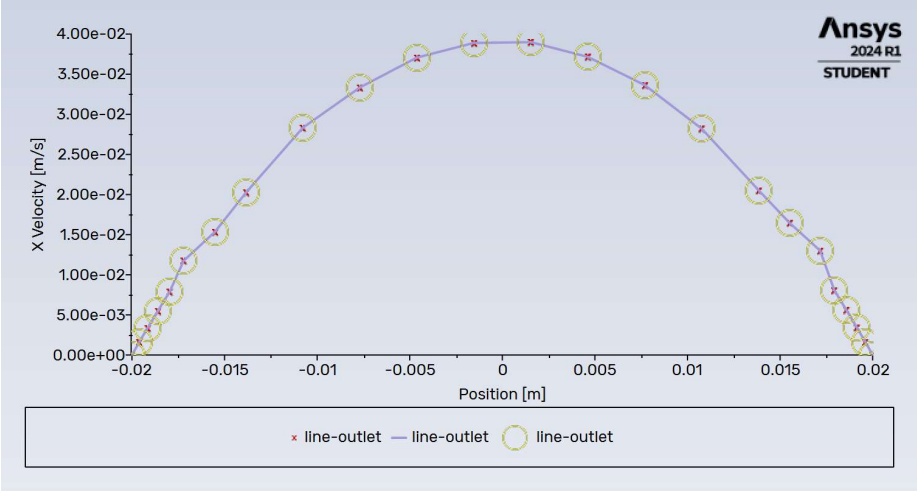
The teal line is representative of 450 iterations, the asterisks are representative of 2000 iterations. As shown in this plot, iteration beyond 450 iterations proves to not change the solution significantly.



# Task 2:

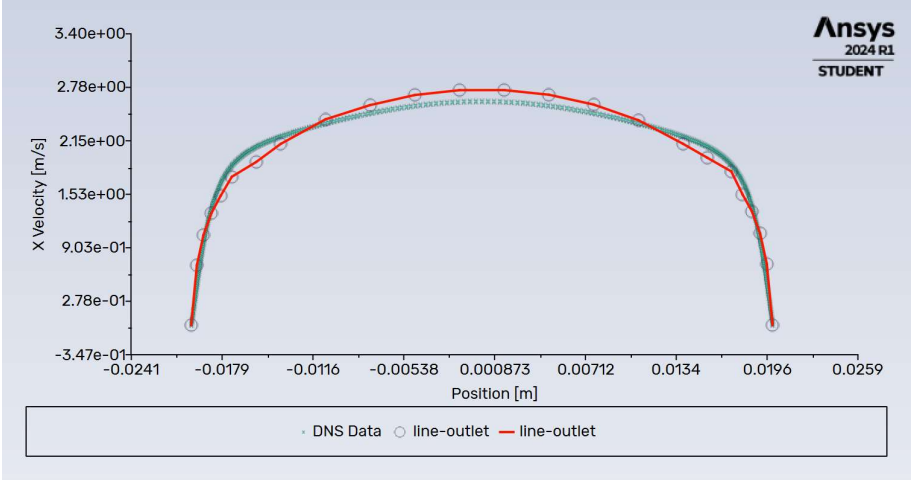
Laminar – 0.003

The yellow markers are representative of 341 iterations, the red x marks are representative of 691 iterations, the lavender line is representative the provided analytical/modeling data. As shown in this plot, iteration beyond 341 iterations proves to be significantly similar to the provided analytical/modeling data.




Turbulent – 0.003

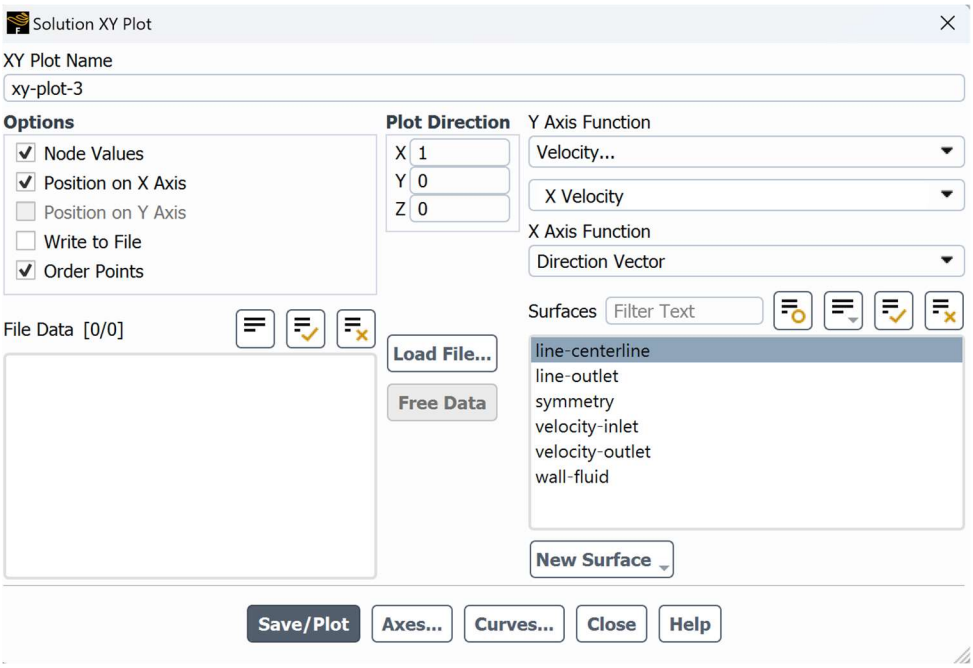
The teal x marks are representative of the provided analytical/modeling data, the grey circles are representative of 350 iterations, the red line are representative of 700 iterations. As shown in this plot, the calculated values strayed away from the provided analytical/modeling data at some points but still shows a fairly accurate approximation.

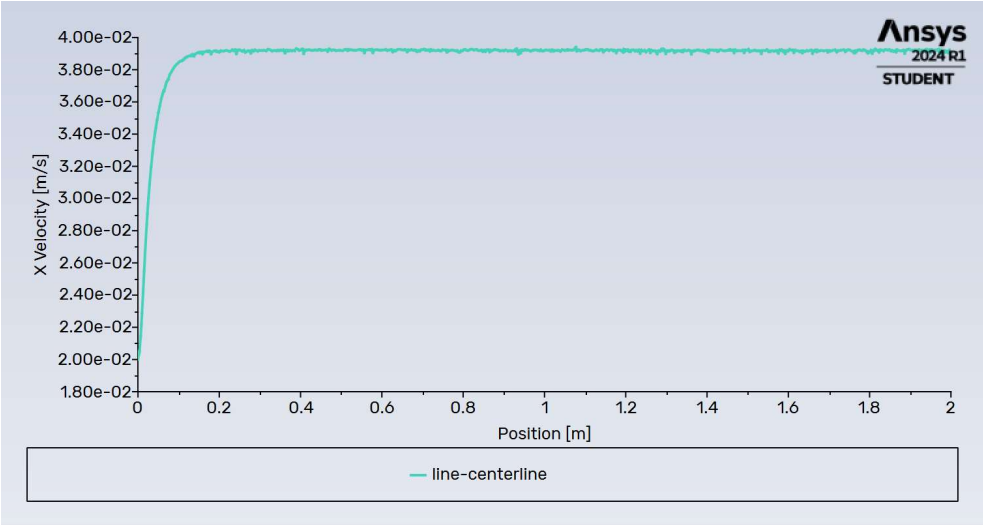


# Task 3:

Laminar – 0.003

Based on the X-velocity plot below the velocity does not change significantly after 0.2 meters for Laminar test using our 0.003 mesh.



Turbulent – 0.003

Based on the X-velocity plot below the velocity does not change significantly after 1 meter for Turbulent test using our 0.003 mesh.

