FEYNMAN AEROSPACE

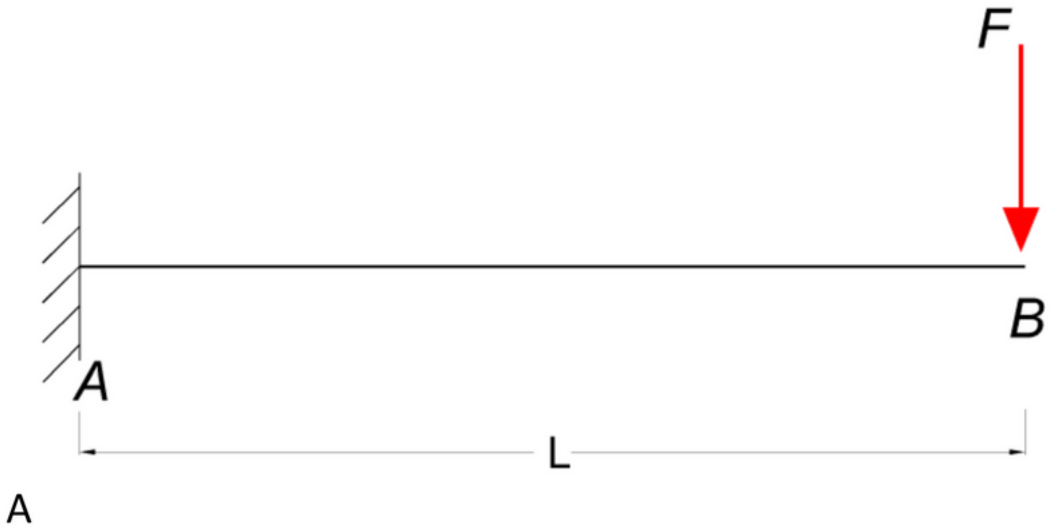
FEA & CFD Internship

Presented By
SYED SADAAN HASAN
sshasan620@gmail.com
ADHIYAMAAN COLLEGE OF ENGINEERING
HOSUR

Index

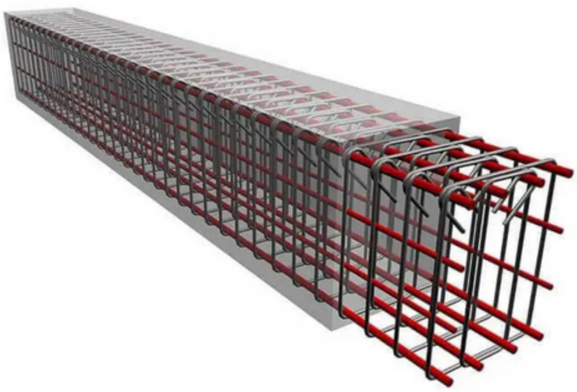
Problem 1

A Cantilever beam has a length L: 5000mm. The beam has a rectangular cross-section with dimensions Length x Breadth: 600mm, Force (F) of 40 kN acting at one end and the other is fixed. Material: Structural Steel.
Perform 1D as well as 3D Static Structural Analysis.
Find Total Deformation and maximum Stress.



Static Structural Analysis on Beam

Description:
A beam is a horizontal or inclined structural member that is designed to support loads and transfer them to vertical supports, such as columns or walls, in a building or structure. Beams are essential components of the framework that provide stability, strength, and integrity to a structure. They are used to distribute the various loads, such as the weight of the structure itself, occupants, furniture, and environmental forces, safely and effectively to the supports.



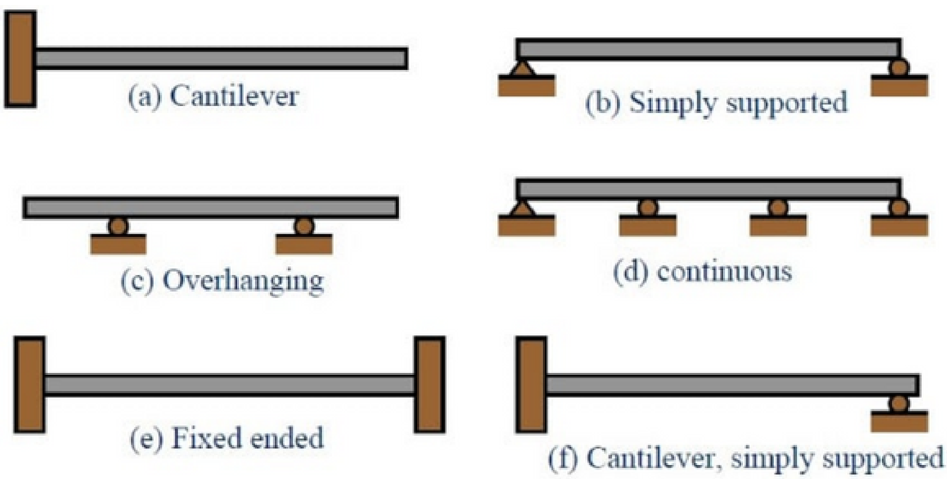
Beams are responsible for carrying and transferring loads from above to the supports below. These loads can be both vertical (gravity loads) and horizontal (lateral loads, like wind or seismic forces).

Beams are typically made from materials with high strength-to-weight ratios, such as steel, wood, or reinforced concrete. The choice of material depends on factors like structural requirements, aesthetics, and environmental conditions.

Common beam shapes include I-beams (also known as H-beams), C-beams, and rectangular or square sections. The shape and dimensions of the cross-section influence the beam's load-carrying capacity and stiffness.

Types of Beam

1. Simply Supported Beam: A simply supported beam is one that is supported at its ends, allowing it to freely rotate and move vertically at the supports. This type of beam is often used in basic spans where the load is primarily transferred vertically to the supports.
2. Cantilever Beam: A cantilever beam is a type of beam that is anchored at one end and extends freely beyond its support. This configuration is often used for balconies, overhangs, and structures where one end must remain unsupported.
3. Continuous Beam: A continuous beam is supported by more than two points along its length, creating multiple spans. This type of beam can distribute loads and moments more effectively, leading to reduced deflections and larger load-carrying capacity.
4. Fixed Beam (Rigid Beam): A fixed beam is one that is rigidly connected or fixed at its supports, preventing rotation and horizontal movement at those points. Fixed beams can resist both vertical and lateral forces, making them suitable for resisting bending and torsional moments.
5. Simply Supported-Cantilever Beam: This type of beam combines the characteristics of a simply supported beam and a cantilever beam. It is supported at one end while extending beyond the support at the other end.
6. Overhanging Beam: An overhanging beam is supported at one or both ends, and it has a portion that extends beyond its support points. It combines the characteristics of a cantilever and simply supported beams.



For this analysis, we are going to perform Static Structural Analysis on a Cantilever beam.

Objective of Analysis

The primary objective of this analysis is to comprehensively assess the structural behaviour of a cantilever beam through both one-dimensional (1D) and three-dimensional (3D) static structural analyses. The cantilever beam, composed of a rectangular cross-section made of a specified structural material, is subjected to defined boundary conditions and an applied load.

Given Data:
Cantilever Beam
Length: 5000mm
Cross-section: 600mm x 600mm
Material: Structural Steel

Analysis Condition:
Force acting downward at the free end
Magnitude: 40kN

To find:
Deformation Analysis:

- Evaluate the total vertical deformation and displacement of the free end of the cantilever beam in response to the applied load.

Stress Distribution and Concentration:

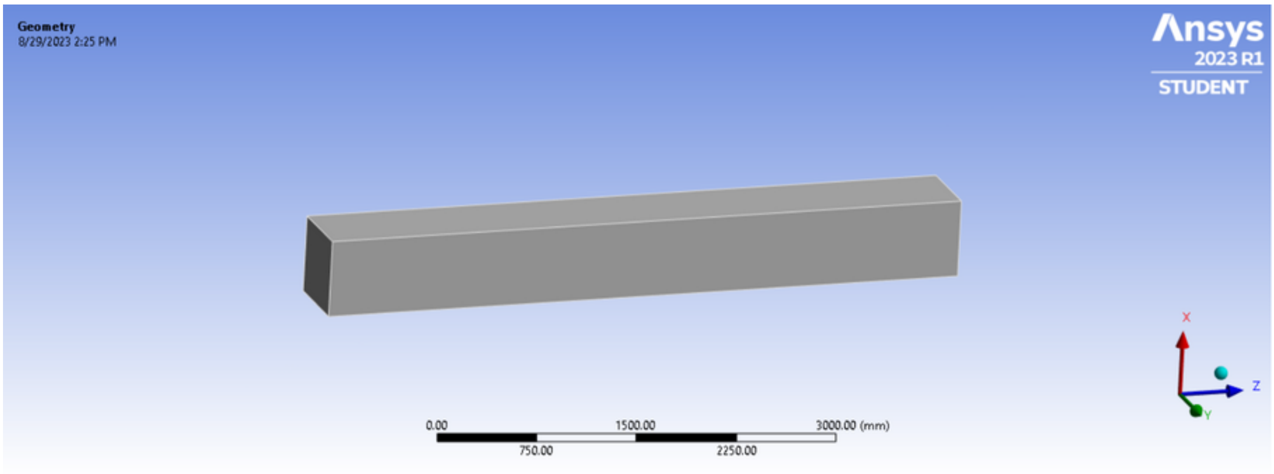
- Analyze the stress distribution along the length of the cantilever beam under the applied load.

Design Focus

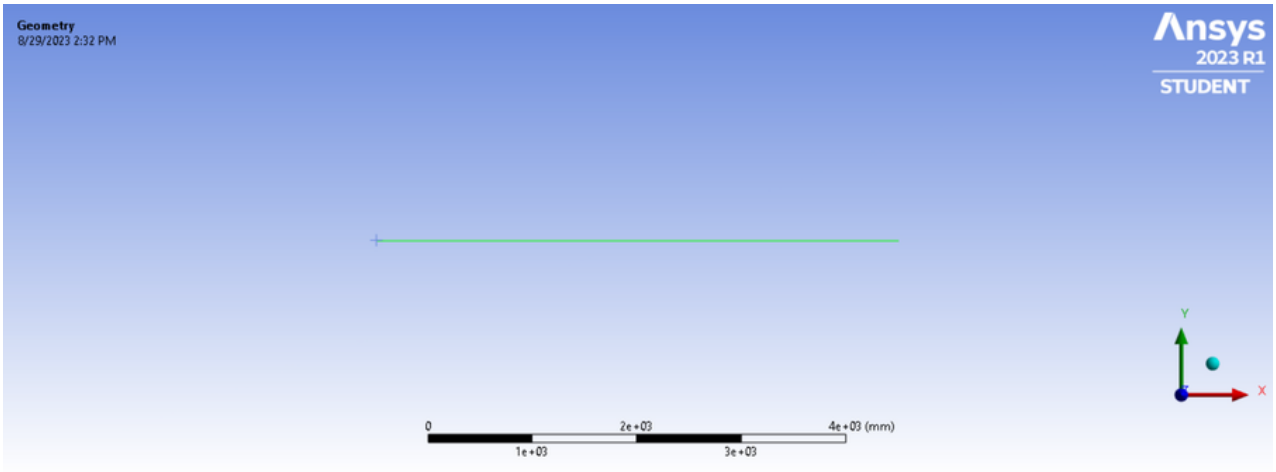
The beam has a 600mm x 600mm square cross-section and a 5000mm span. To ensure its ability to safely carry loads, maintain stability, and prevent excessive deflection or failure. This involves selecting suitable materials, calculating load-bearing capacity, addressing deflection, ensuring structural stability, adhering to codes, and optimizing for economic efficiency. The goal is to create a strong, stable, and durable beam that meets safety standards and supports the intended structural purpose effectively. The material of the beam chosen for the analysis was structural steel, which gives high strength, toughness, ductility, and durability. The beam can withstand high loads without having much deformation.

Design Model

Design Model for 3D analysis:



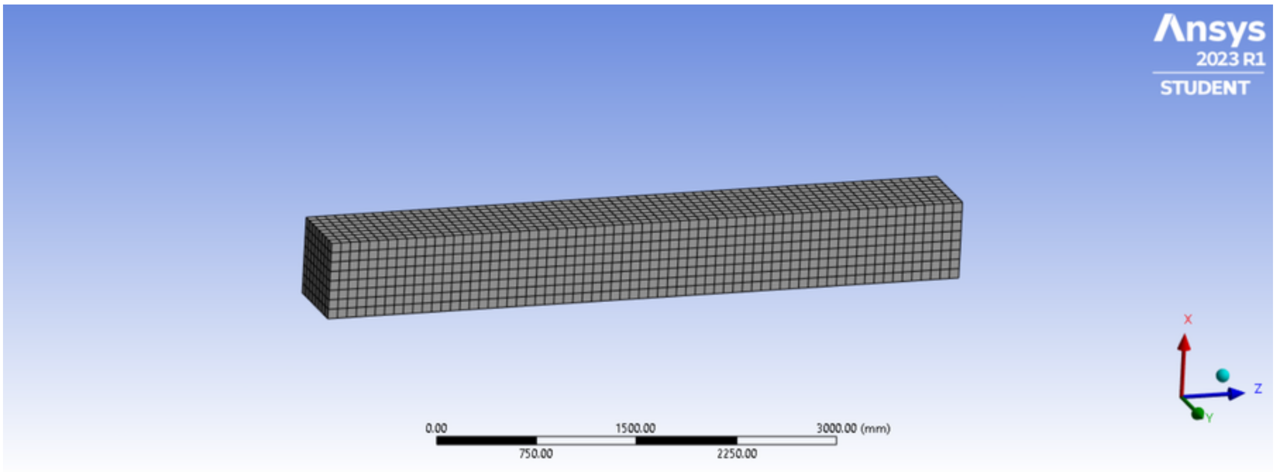
Design Model for 1D analysis:



Meshing

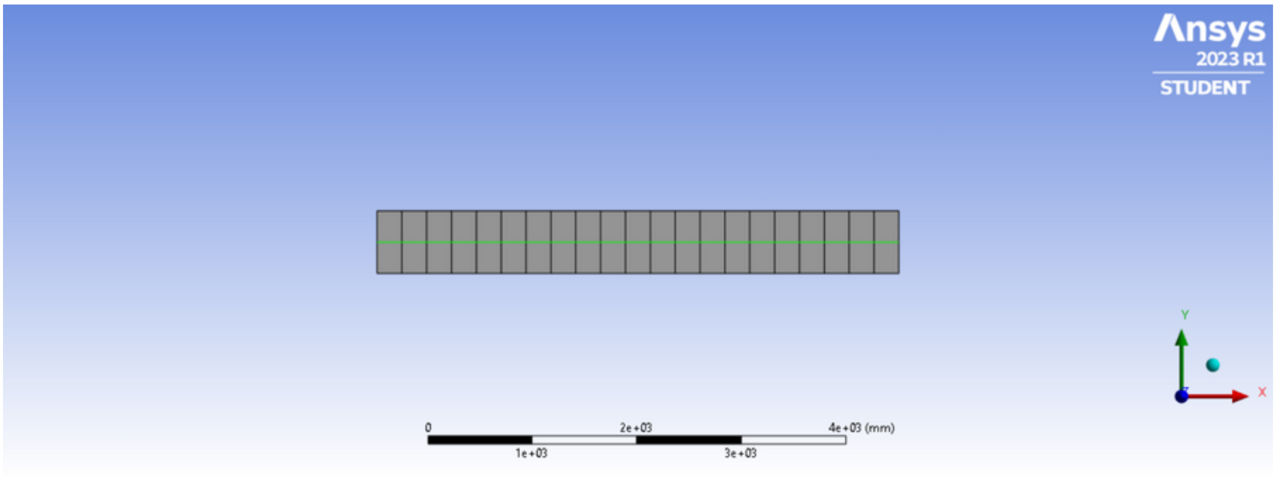
For the 3D analysis the meshing was done in Static Structural analysis with an element size 75mm. The adaptive sizing method was used at default settings with medium smoothing.
The following are the meshing results:

- Nodes: 20727
- Elements: 4288

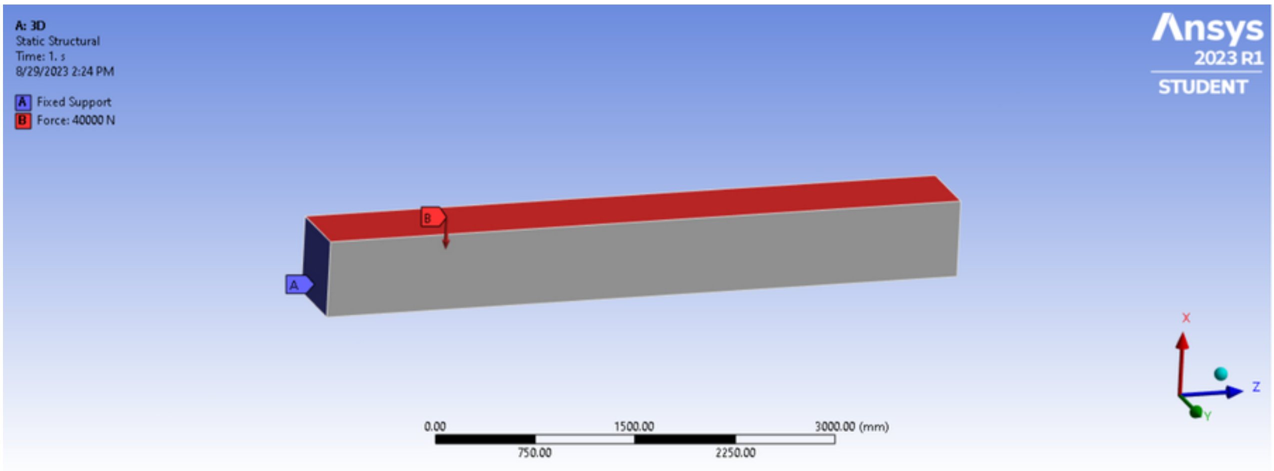


For 1D analysis, the same settings were used and the result is as follows:

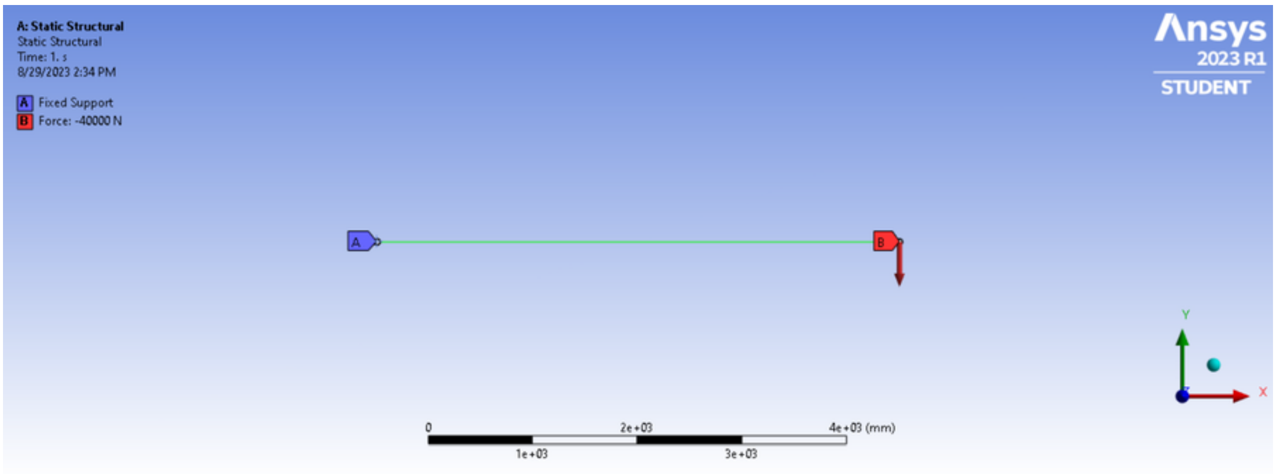
- Nodes: 43
- Elements: 21



Analysis - 3D

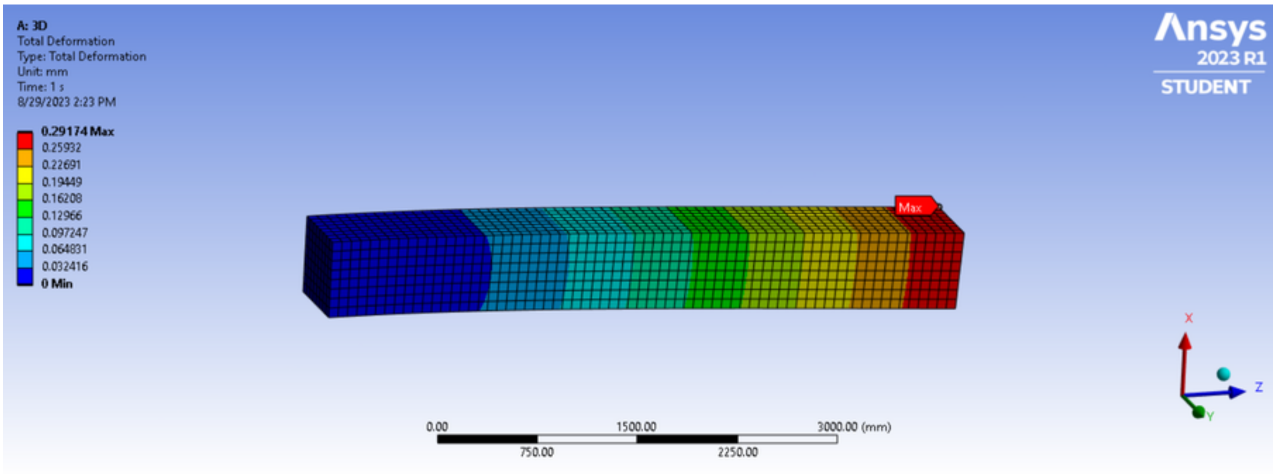


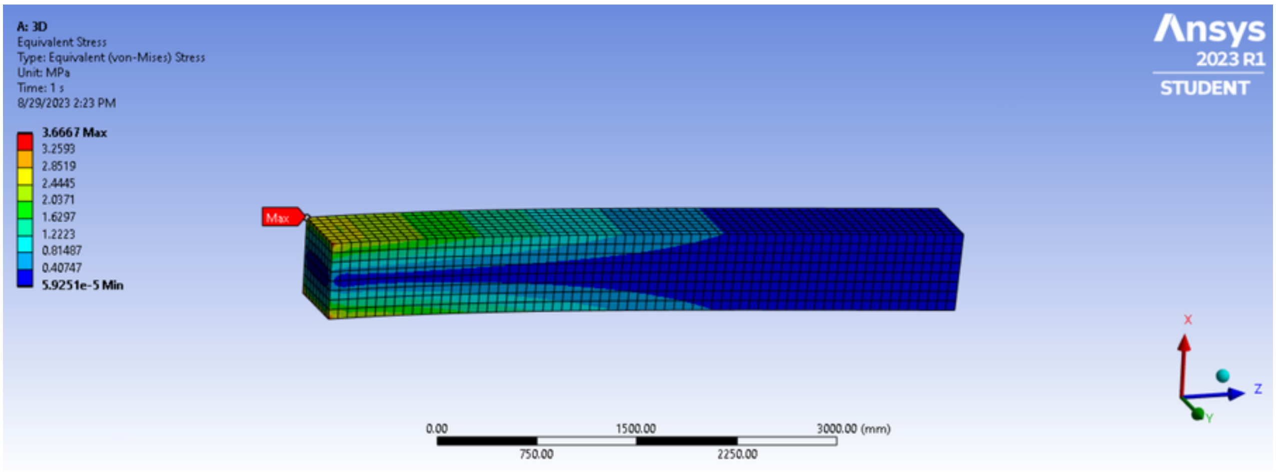
Analysis - 1D



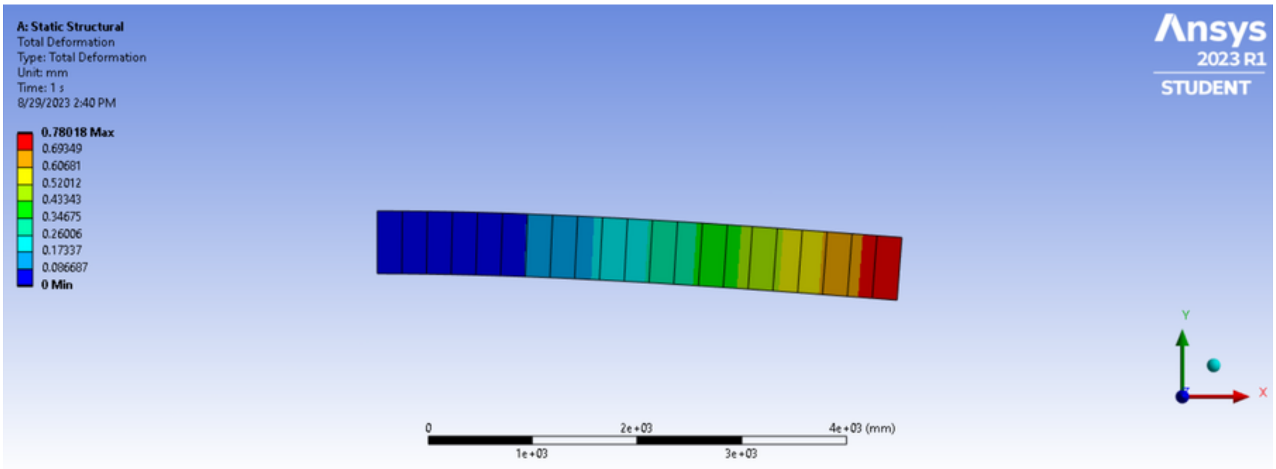
The figure shows the fixed end and the force component on the beam acting downwards.

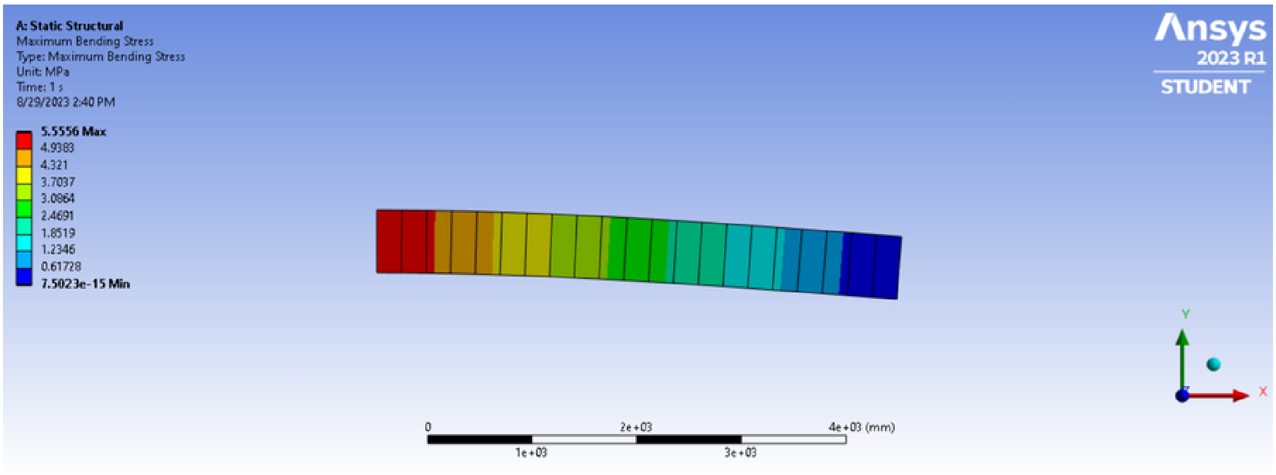
Solution 3D





Solution 1D





Result

For 3D Analysis

Total Deformation	0.2917 mm
Maximum Stress	3.6666 MPa

For 1D Analysis

Total Deformation	0.78018 mm
Maximum Stress	5.5556 MPa

Conclusion

The maximum deformation on the beam takes place at the free end and the maximum stress occurs at the fixed end of the beam.

Problem 2

Perform Steady State Thermal Analysis on Aircraft Wing.
Material: Titanium Alloy
Temperature at Leading Edge: 60°C
Analysis Type: 3D
Define Convection
Find: Temperature Distribution and Heat Flux

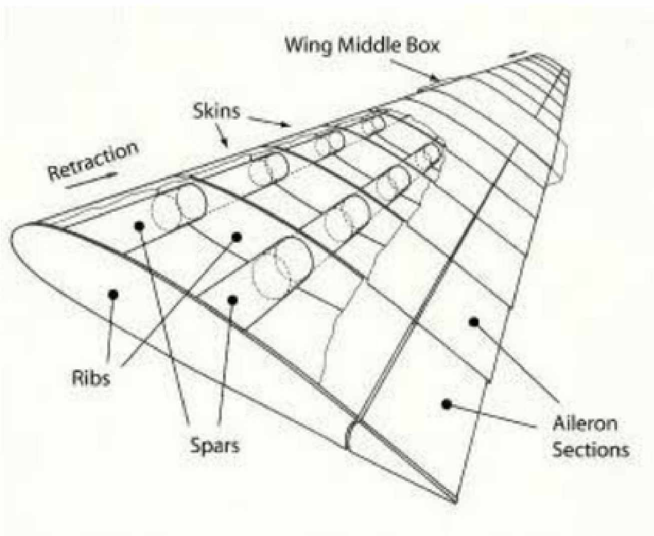
Steady State Thermal Analysis on Wing

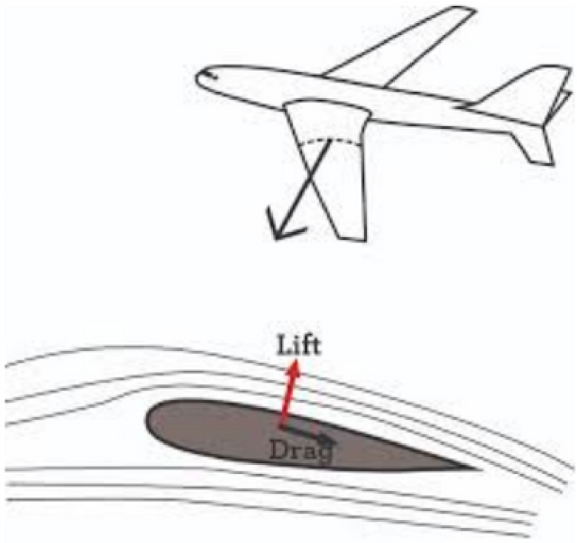
Description:

An aircraft's wing stands as a pivotal constituent responsible for generating lift, while also facilitating controlled banking during flight. These wings come in a diverse array of forms, each distinct in dimensions and shape. Comprising ribs and spars interconnected by stringers, they ensure uniform load distribution while in flight.

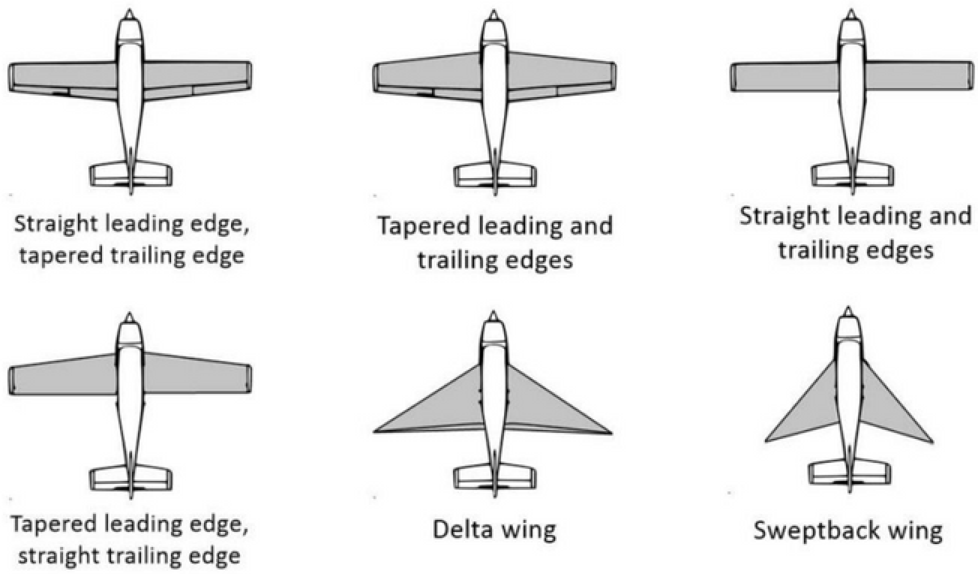
Wing configurations encompass a spectrum, spanning rectangular, tapered, swept-back, and delta designs. The specific type chosen hinges upon the aircraft's classification. Commercial aircraft favour swept-back wings, while military jets opt for the efficiency of delta wings.

To preserve structural integrity, Steady State Thermal Analysis is employed to scrutinize the wing's thermal behaviour. This meticulous assessment aims to ascertain the wing's upper-temperature threshold or heat flux, thus mitigating any risk of structural deterioration resulting from excessive temperatures.





Types of Aircraft Wings:



For this analysis, we are going to consider a Swept-back Tapered Leading edge, straight trailing edge wing.

Objective of Analysis

The objective of the steady-state thermal analysis is to identify and quantify the highest temperature or heat flux generated by the wing during operation, ensuring that it remains within safe operational limits and avoids structural damage due to elevated temperatures. This analysis aims to provide insights into thermal behavior critical for maintaining the wing's structural integrity and performance.

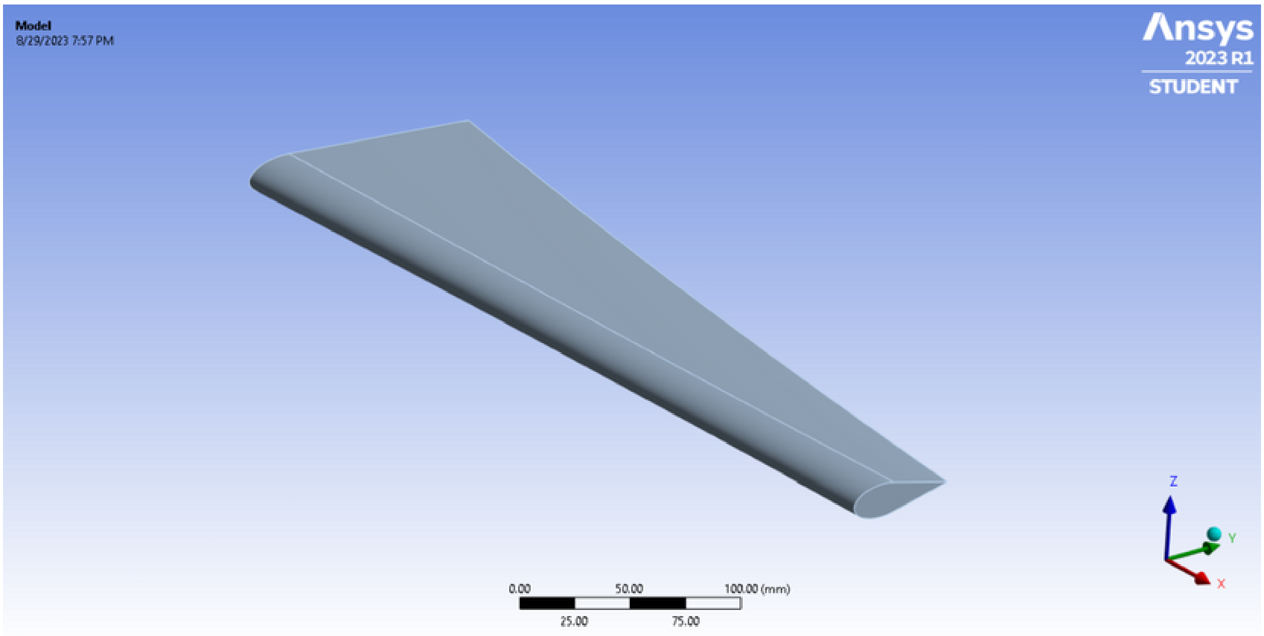
Wing Structure:
Swept-back Tapered Leading edge, straight trailing edge wing
Thick Airfoil section
Material: Titanium Alloy

Analysis Condition:
Initial Temperature: 22˚C
Temperature at the Leading edge: 60˚C
Type: Convection
Film Coefficient: 15 W/mm2˚C

Design Focus

In this design process, the primary objective is to comprehensively analyze and map out the distribution of temperatures as well as calculate the cumulative heat flux experienced uniformly across the entirety of the wing's surface

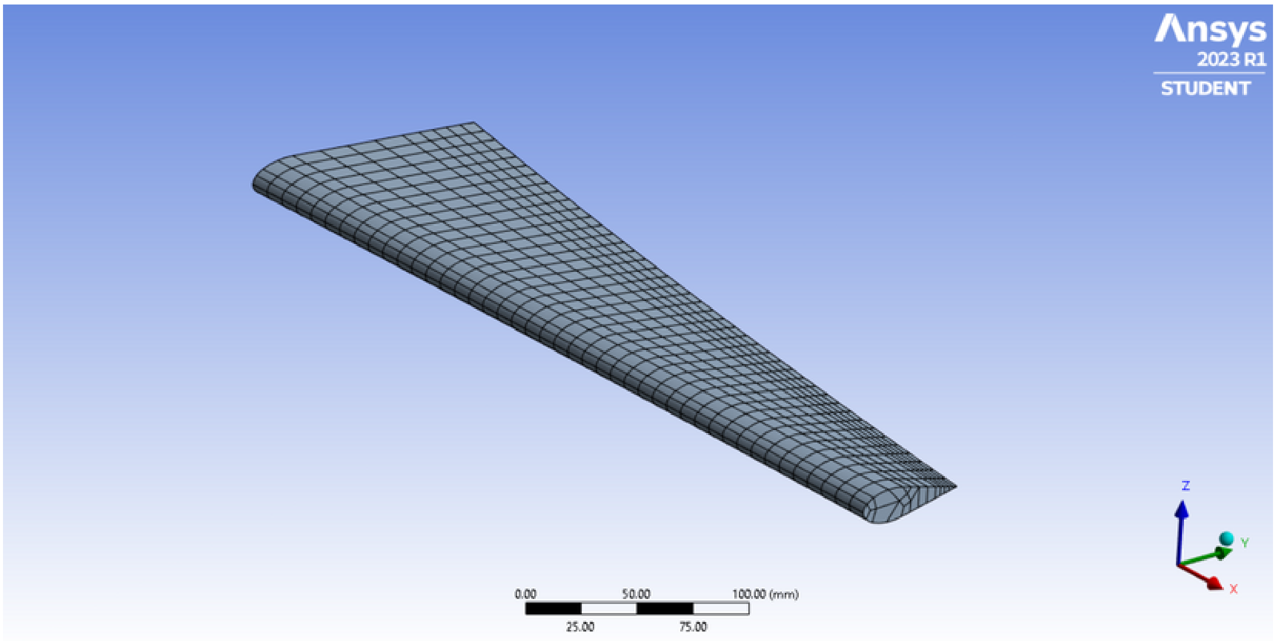
Design Model



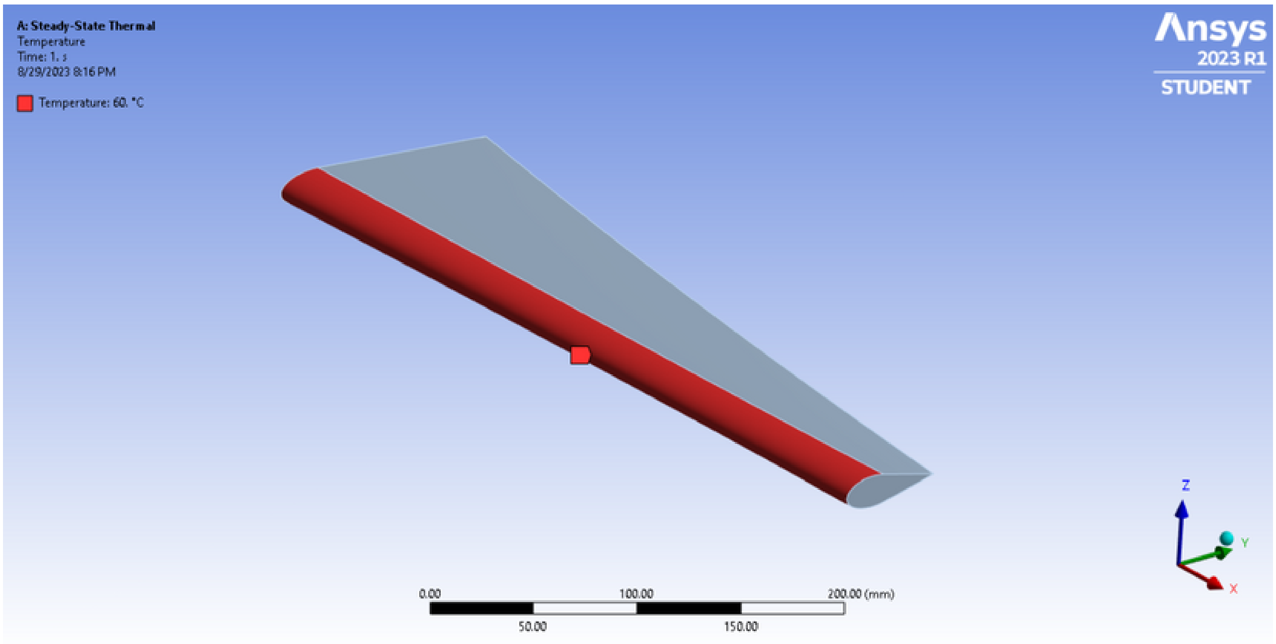
Meshing

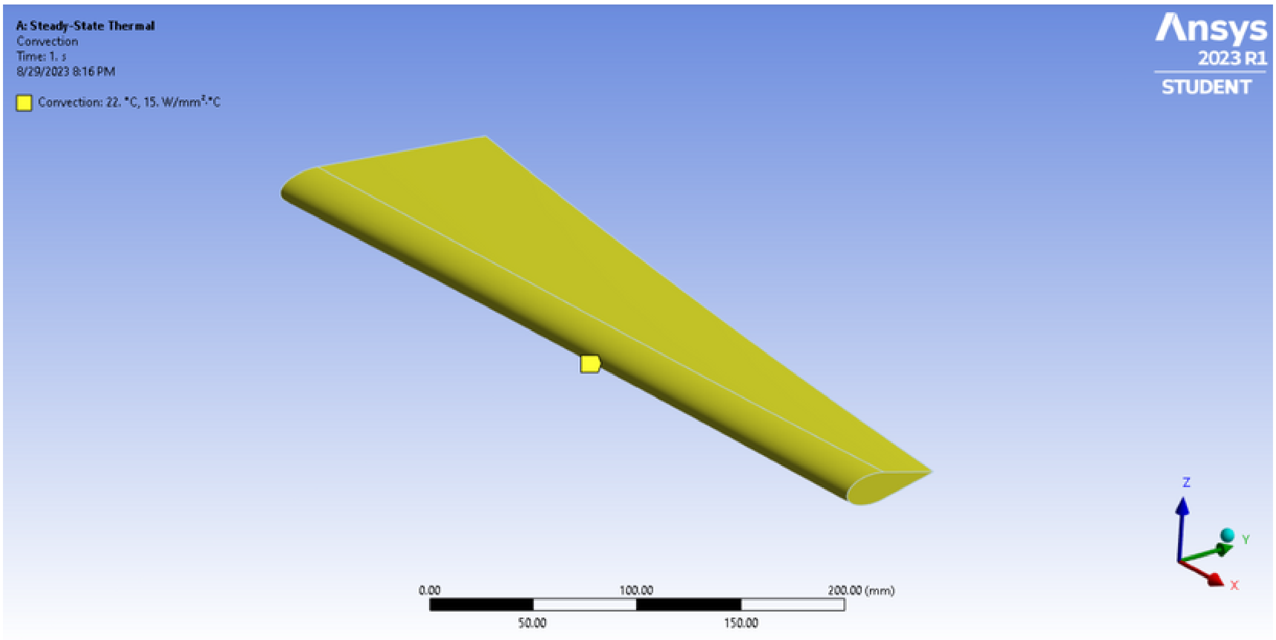
For the analysis, the meshing was done in Steady State Thermal analysis with an element size 10mm. The adaptive sizing method was used at default settings with medium smoothing. The following are the meshing results:

- Nodes: 4984
- Elements: 817



Analysis



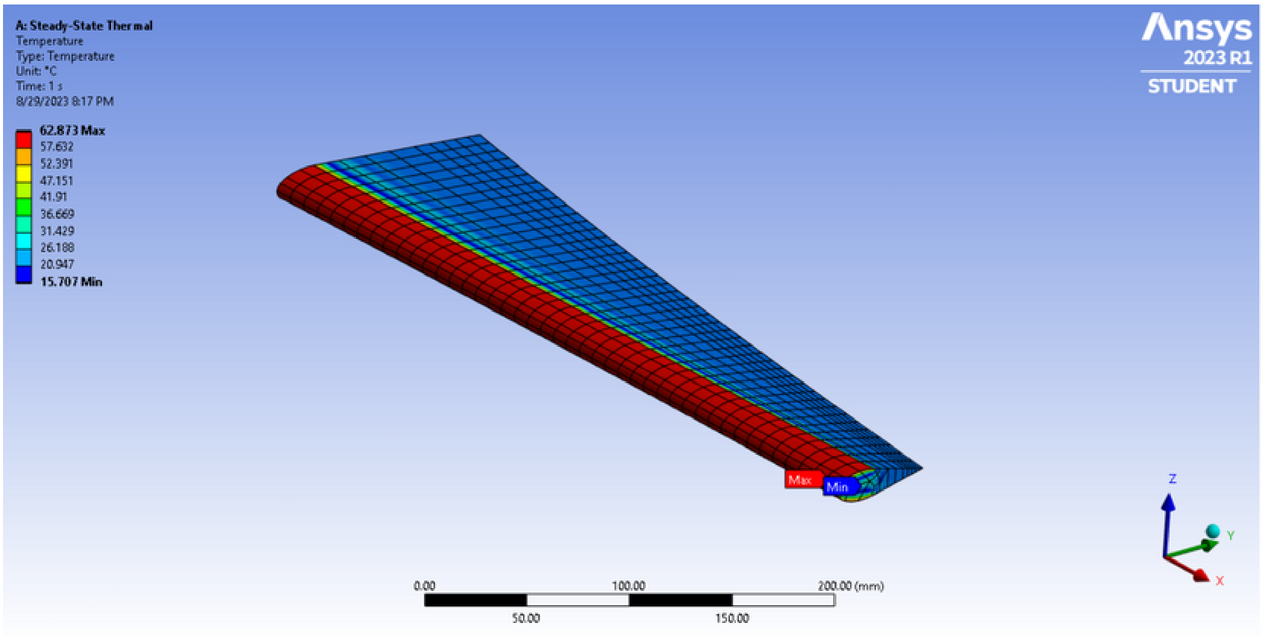


Temperature at Leading edge: 60˚C
Convection over the wing surface with film coefficient 15 W/mm^2 ˚C

Solution

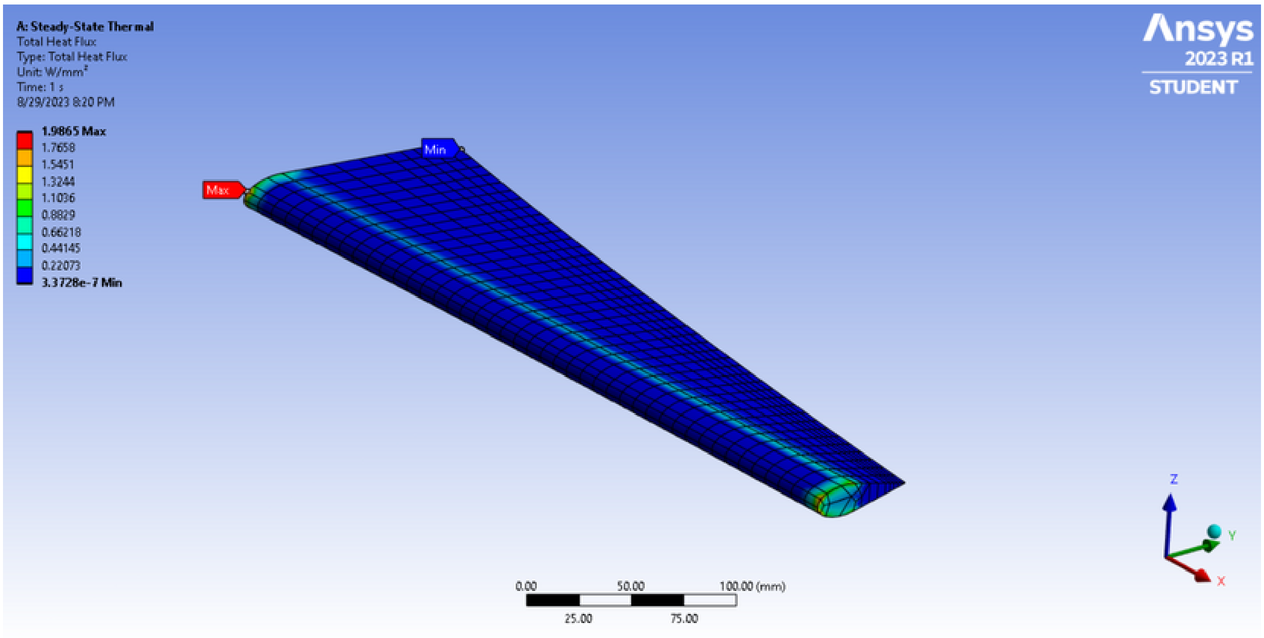
Temperature Distribution:

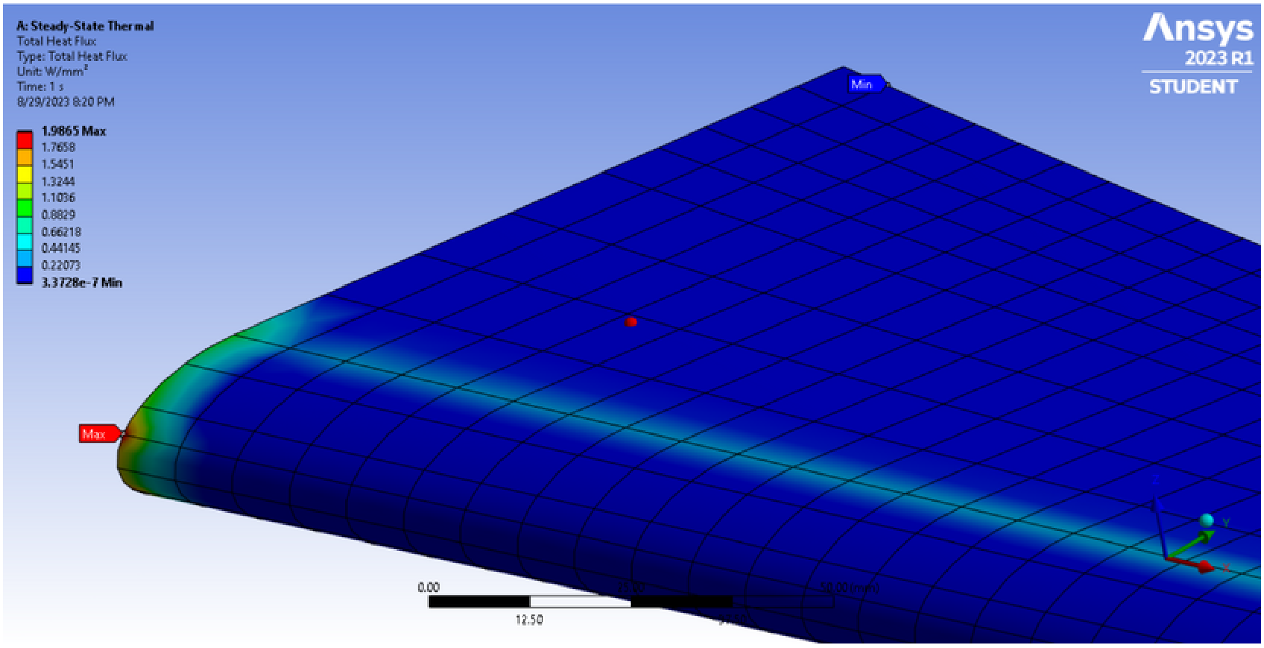
The maximum temperature was 63.83˚C



Total Heat Flux:

Maximum Heat flux is 1.98 W/mm^2





Result

Total Temperature	63.83˚C
Total Heat Flux	1.98 W/mm^2

Conclusion

The maximum temperature is found to be at the tip of the leading edge of the wing. The maximum heat flux occurs at the root of the leading edge of the wing.

Problem 3

Perform CFD Analysis
Model F-16 Fighter
Aircraft Inlet Velocity: 80 m/s
Operating Conditions: Default
Material: Air
Find Coefficient of Lift & Drag, Lift Force, Drag Force.

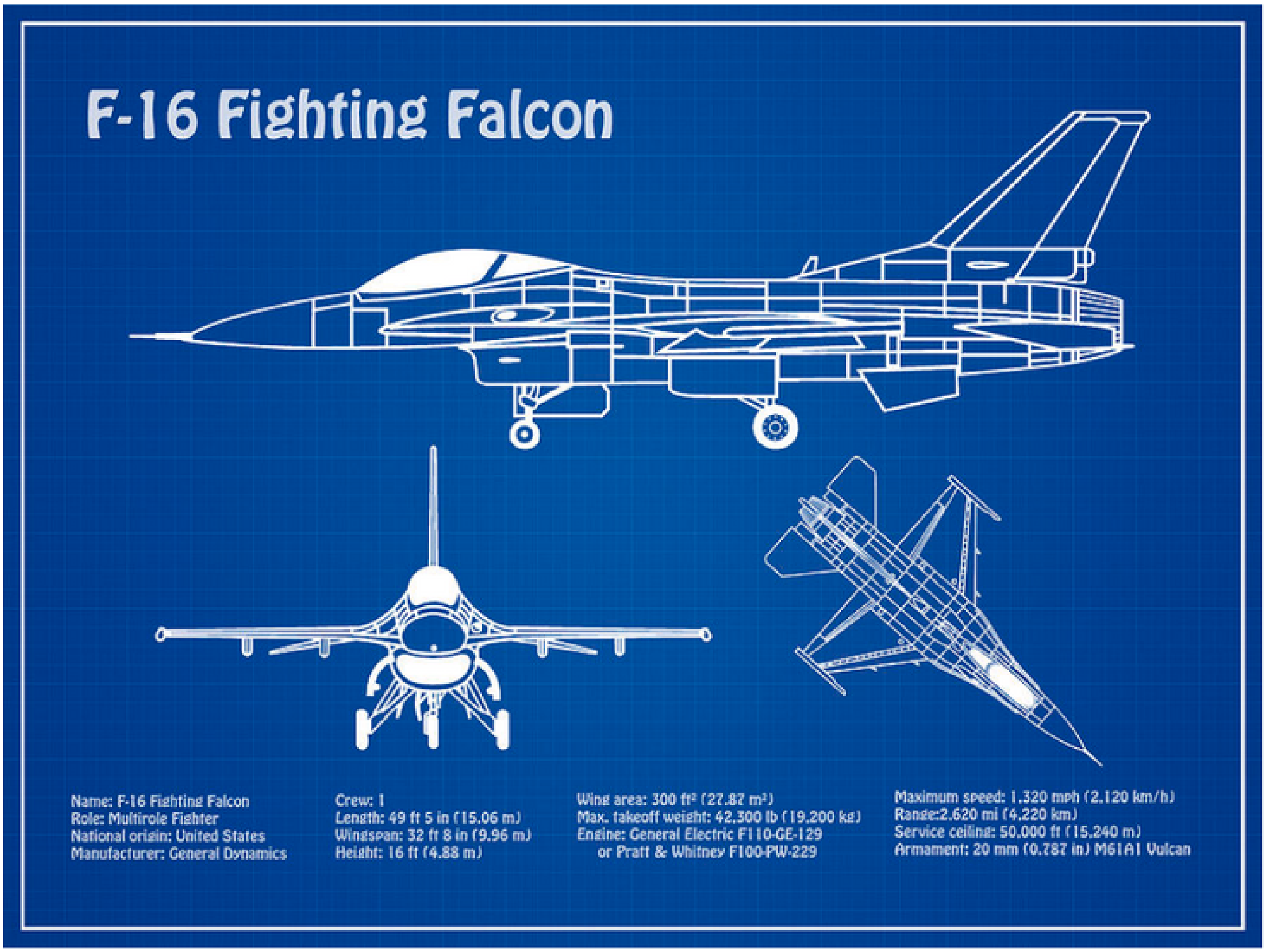
CFD Analysis on F-16 Fighter Aircraft

Description:

The F-16 Fighter Jet, also known as the "Fighting Falcon," is a versatile and widely-used multirole aircraft in military aviation. Renowned for its agility and performance, the F-16 is characterized by a sleek design, advanced avionics, and a powerful engine. It can engage in various roles, including air superiority, ground attack, reconnaissance, and more. Its design emphasizes manoeuvrability, making it capable of executing complex aerial manoeuvres. The F-16 has served as a cornerstone of many air forces worldwide, contributing to their tactical capabilities across a range of mission profiles.

The F-16, developed by General Dynamics, was introduced into service in 1978, the F-16 became a symbol of innovation and adaptability. It rapidly gained popularity due to its fly-by-wire control system, compact design, and impressive performance characteristics. Over the years, the F-16 has undergone various upgrades, evolving into different versions like Block 30, Block 50, and more. Its successful track record in air combat and its ability to integrate advanced weaponry and avionics has cemented its role as a versatile and enduring fighter jet employed by numerous countries worldwide.

The F-16 continues in service worldwide, with various versions optimized for different tasks, showcasing agility, speed, and adaptability in combat situations.



Objective of the Analysis

The Objective of this analysis is to perform Computational Fluid Dynamics on F-16 Fighter Aircraft.

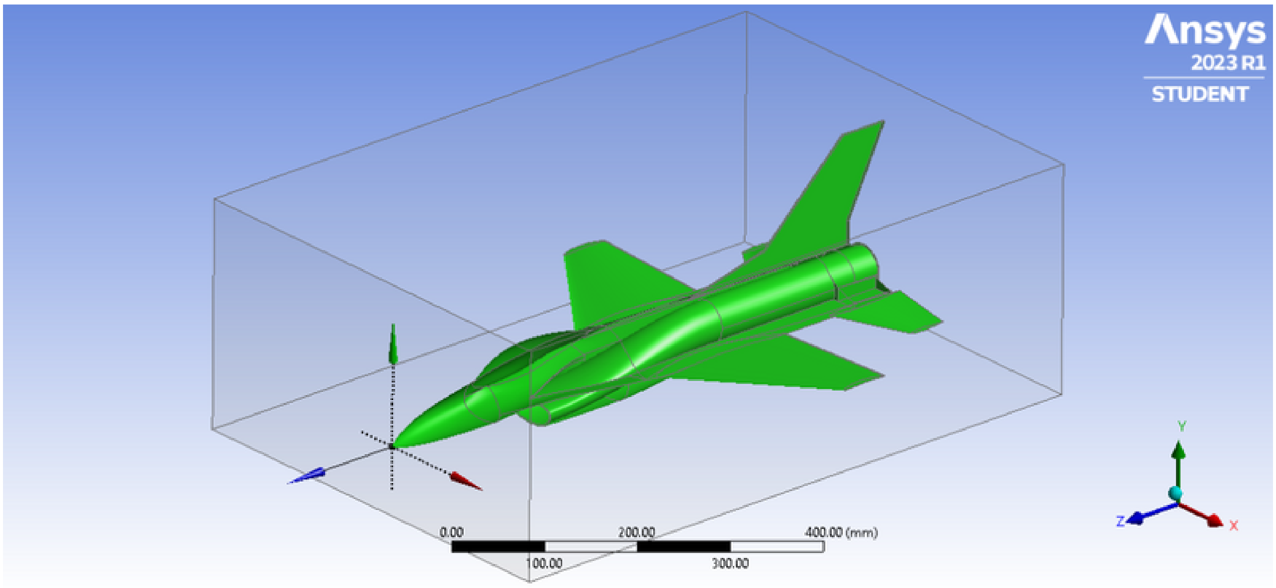
Given Data:
Inlet velocity: 80 m/s
Fluid material: Air
Operating conditions: Default

To find:
Lift Coefficient
Drag Coefficient
Lift Force
Drag Force

Design Focus

The design focus for the CFD analysis of the F-16 fighter jet aims to evaluate lift and drag forces, and lift and drag coefficients. This involves simulating the aircraft's aerodynamic behavior under various conditions, optimizing wing and body design to enhance lift-to-drag ratio, minimize drag, and achieve optimal aerodynamic efficiency for improved overall performance and fuel efficiency.

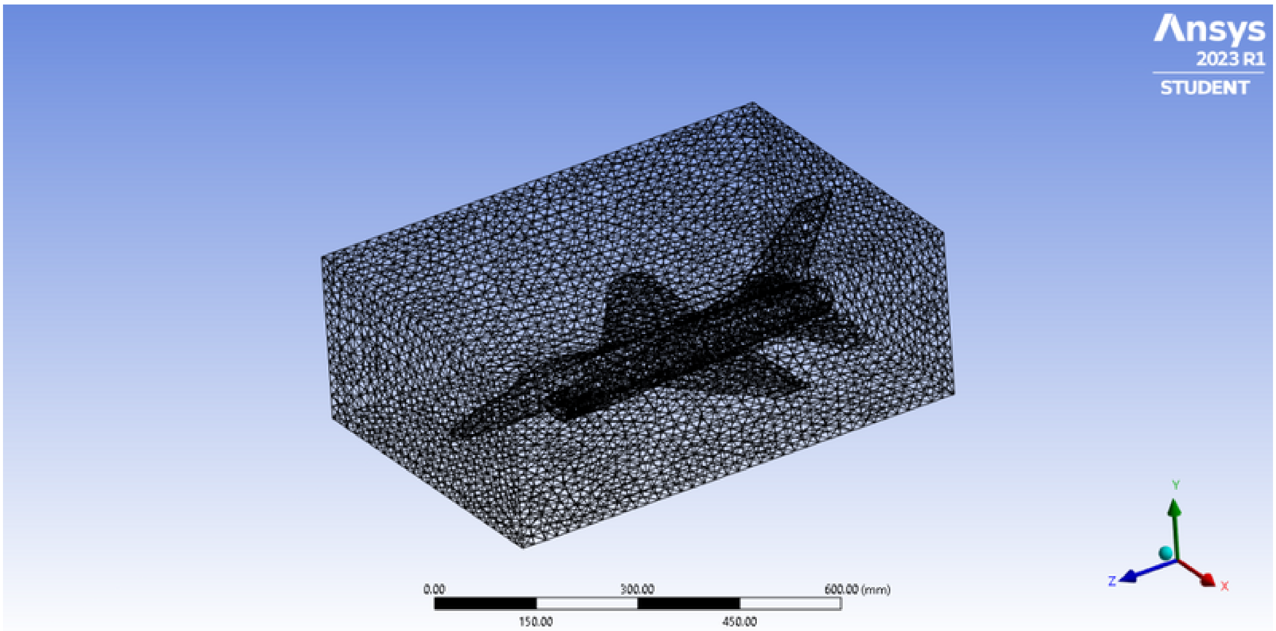
Design Model



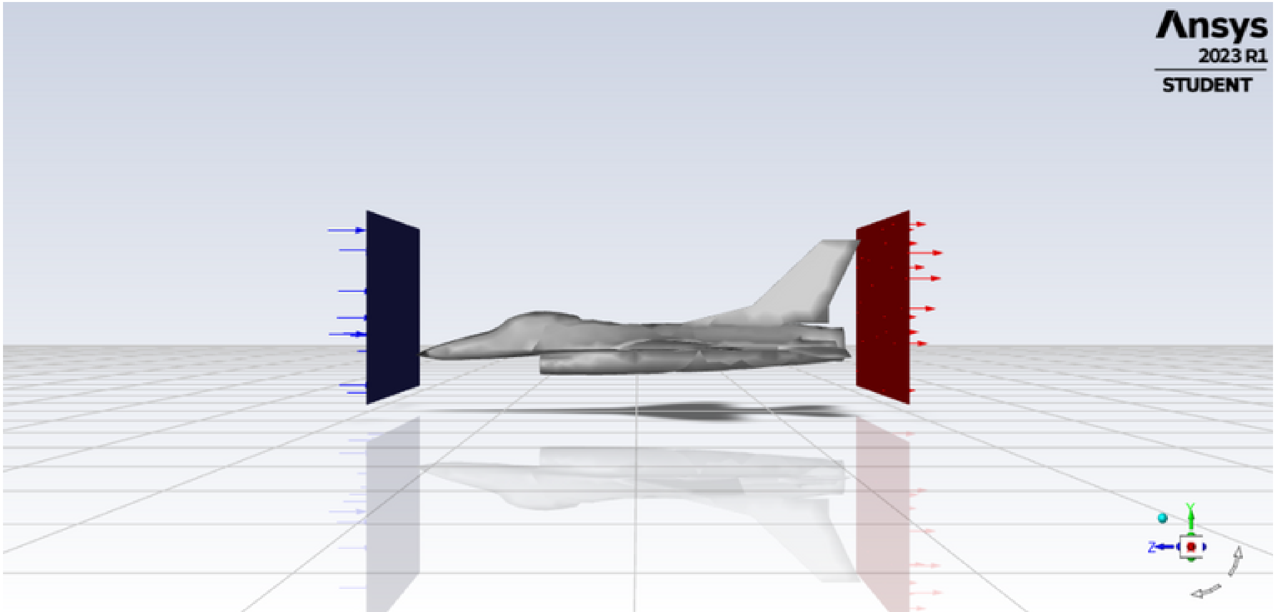
Meshing

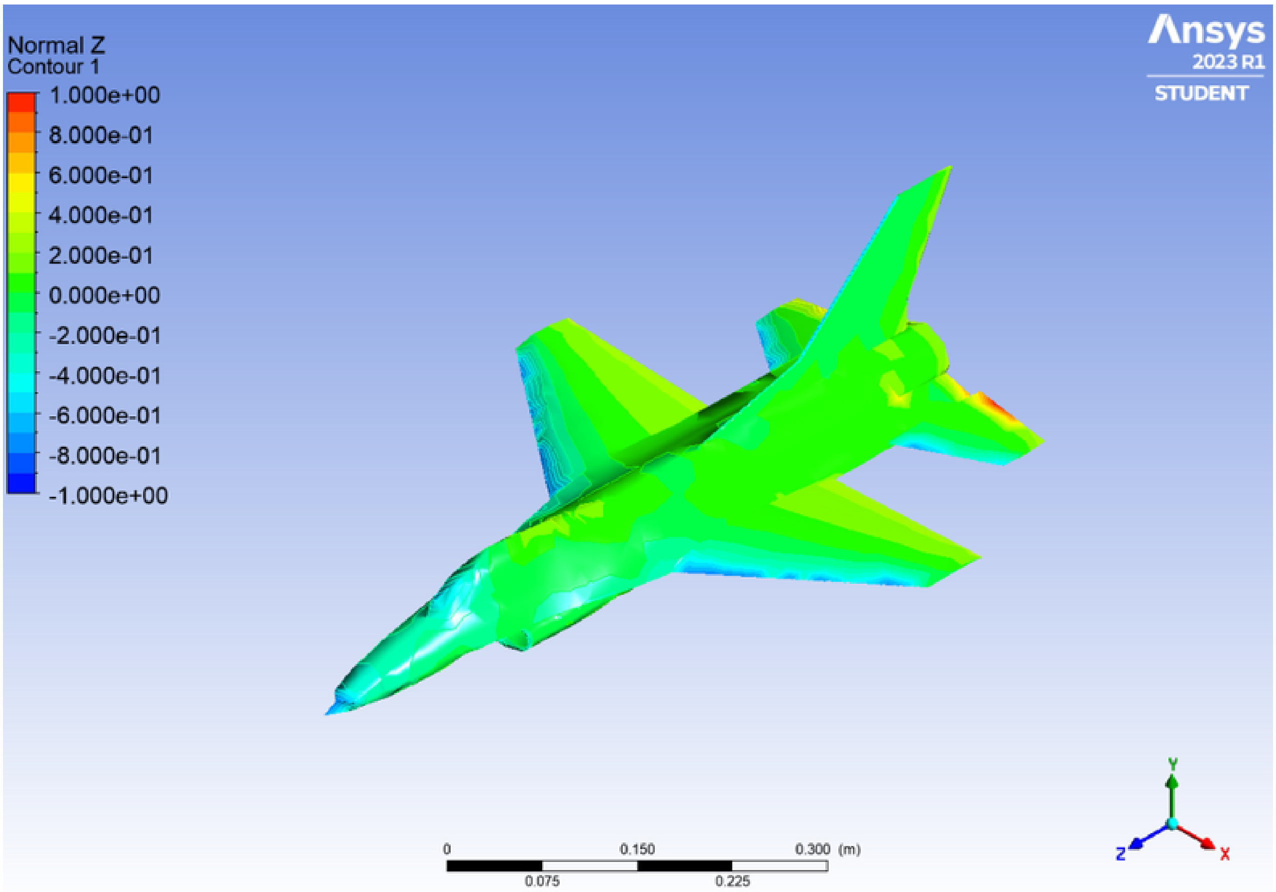
For the CFD analysis the meshing was done in Fluid FLow (FLUENT) with an element size 20mm. Sizing with growth rate of 1.6 was used at default settings with medium smoothing.
The following are the meshing results:

- Nodes: 12287
- Elements: 57453



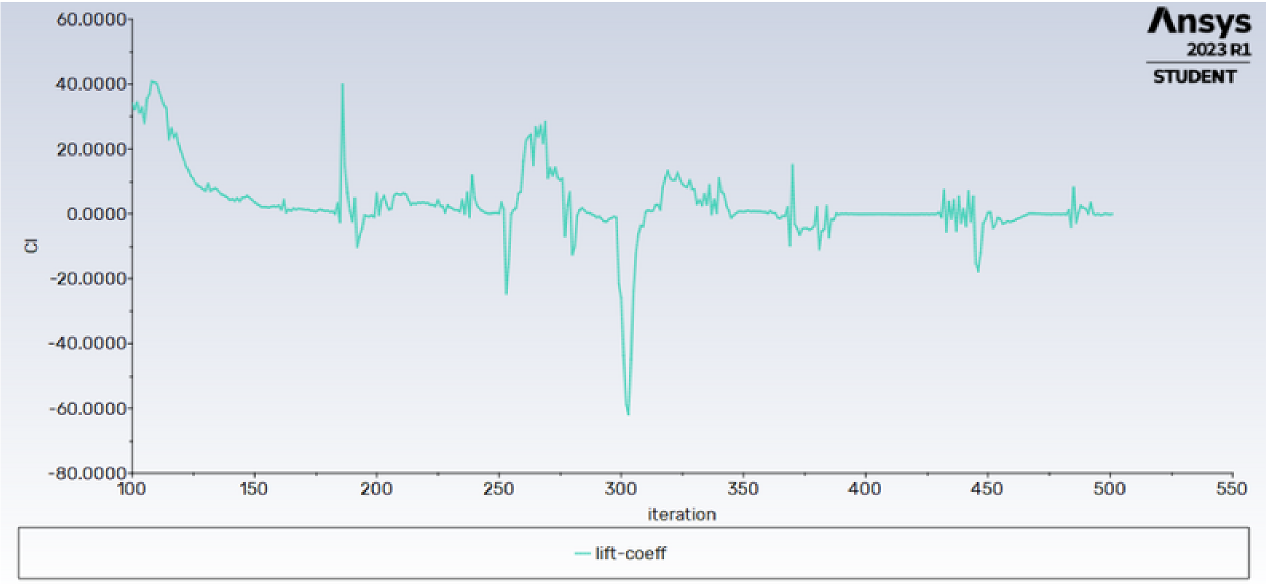
Analysis

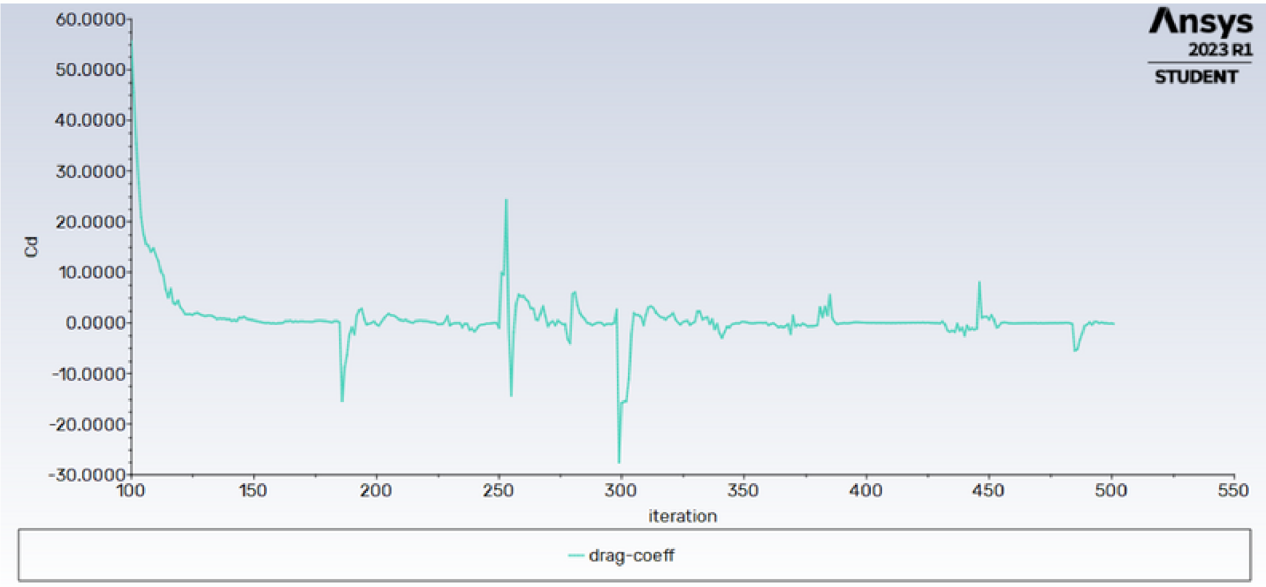

Ansys
2023 R1
STUDENT


Normal Z
Contour 1
1.000e+00
8.000e-01
6.000e-01
4.000e-01
2.000e-01
0.000e+00
-2.000e-01
-4.000e-01
-6.000e-01
-8.000e-01
-1.000e+00
Ansys
2023 R1
STUDENT
0
0.150
0.300 (m)
0.075
0.225

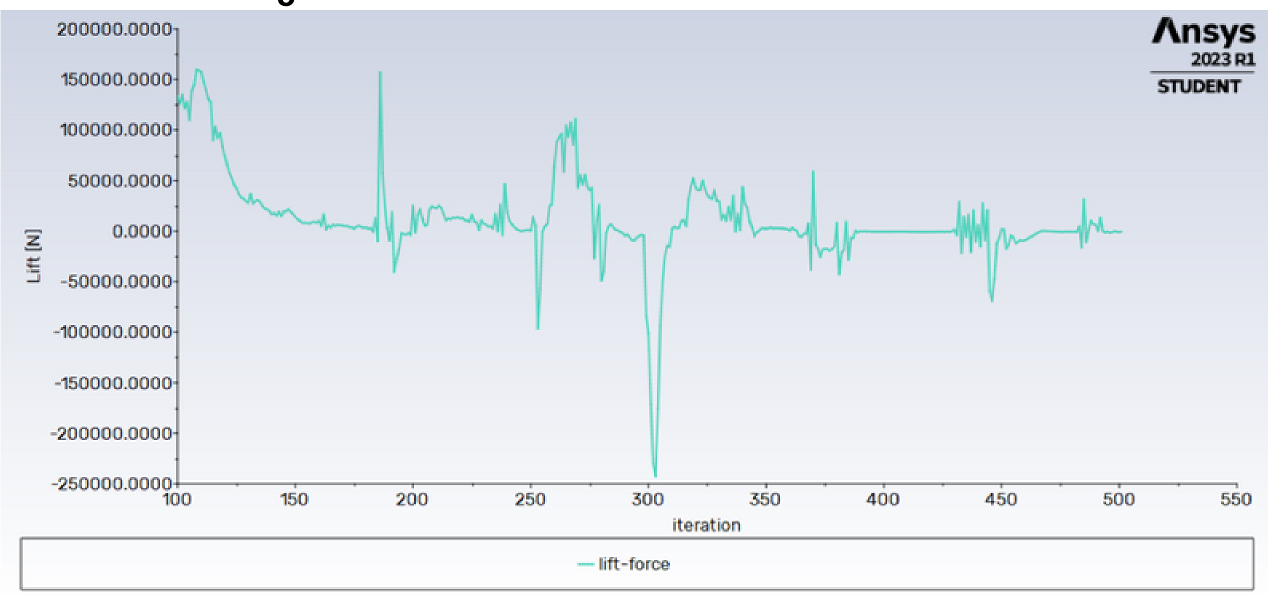
Solution

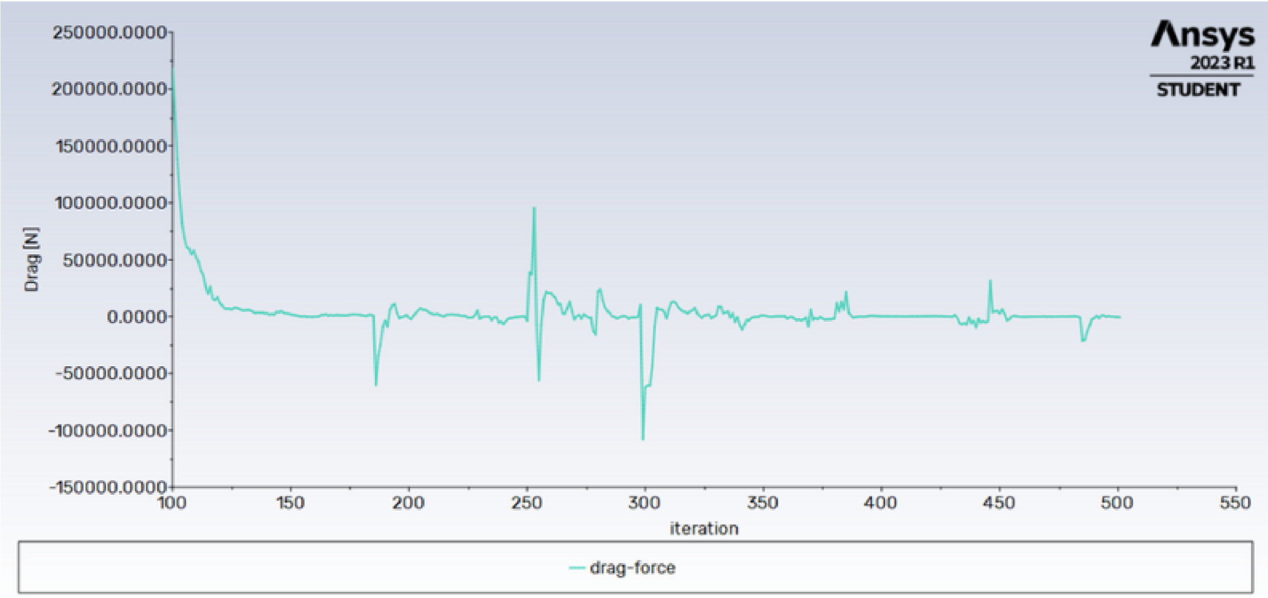
Lift Coefficient and Drag Coefficient





Lift Force and Drag Force





Result

Lift Coefficient	0.1194	**Lift Force**	468.211 N
Drag Coefficient	0.0309	**Drag Force**	121.192 N

Conclusion

The F-16 Fighter jet has a lift-drag ratio of 3.86. This suggests that the aircraft is capable of generating a substantial amount of lift while maintaining relatively low drag, which is favourable for achieving greater fuel efficiency and longer gliding distances.