TECHNICAL UNIVERSITY OF LIBEREC

**Faculty of Mechatronics,
Informaticsand Interdisciplinary
Studies**

Modeling & Simulation of Aircraft Wing to Study Fluttering Phenomenon

Simulation of electromechanical Systems
Semester Thesis

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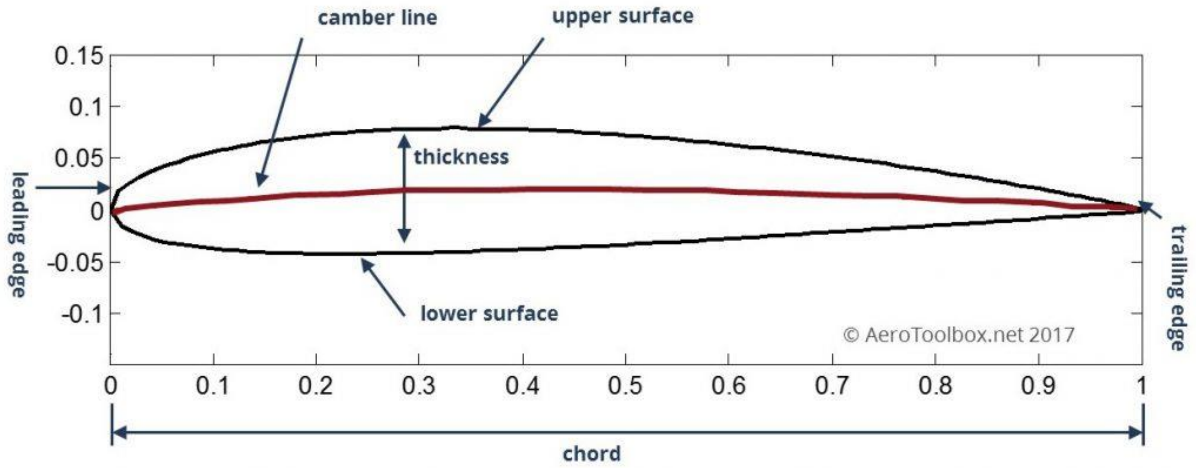
MODELING AND STRUCTURAL ANALYSIS OF AIRCRAFT WING

The aircraft wing, which is responsible for the take-off of the aircraft. Initially running on the runway, the angle of attack is 0 for gaining the momentum to fly. After certain distance covered and momentum gain angle of attack become (theta) and create high pressure and low-pressure areas at the bottom and upper side of the wing. Which helps to the aircraft to lift in the air. This analysis would be focusing on the accidental failures occur due to the engineered fluttering effects encountered in aircraft wings. This can be found out by carrying out stress-strain static analysis via Ansys by finding out natural frequencis and modelling in solid Edge.



Objective

To analyze the fluttering phenomenon of aircraft wing and impact on different stages of flights such as: Take-off, Hovering & Landing by calculating the different natural frequencies which usually encounter during flutter effect and causes aircraft wing to detach from main body.

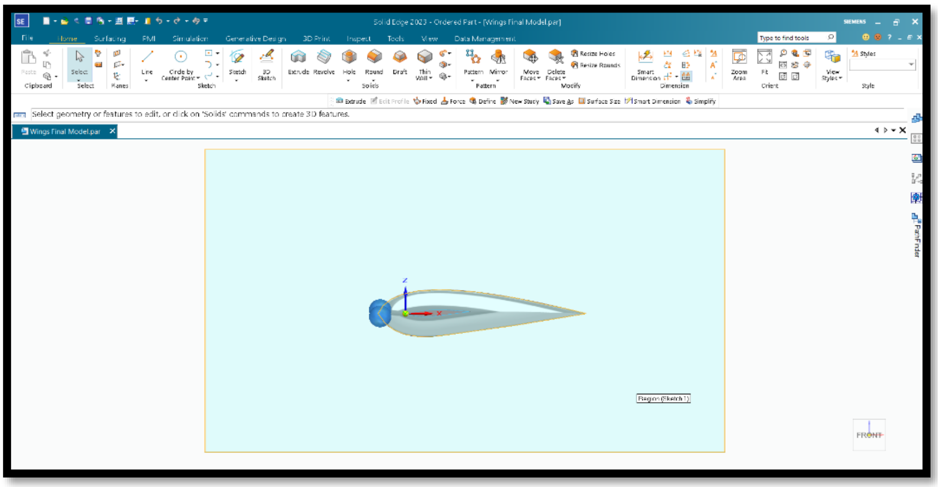
This analysis has been studied and simulated by two different softwares.

1. Solid Edge by Siemens (Modelling).
2. Ansys (Workbench).

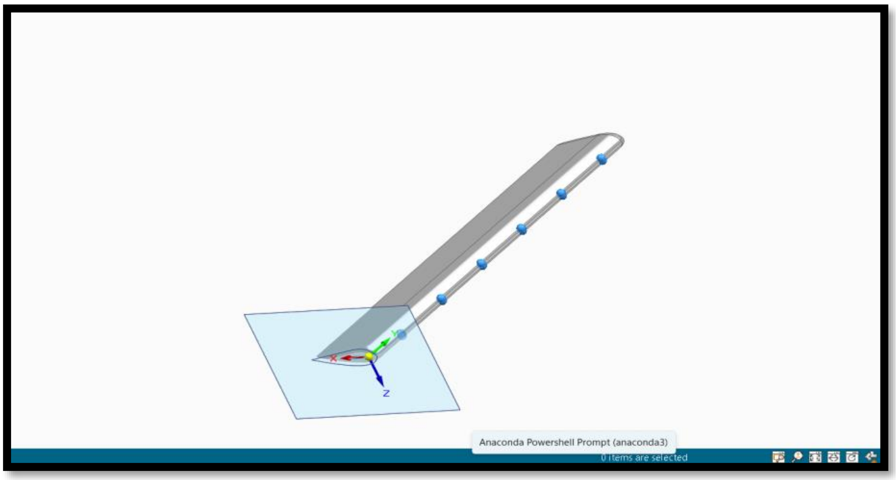
Methodology

1. How to Create 3D-Model via Solid Edge?

Firstly, Open solid Edge and create new project. Select plane and draw Aircraft Wing line diagram in 2D.



Provide thickness to the 2D wire frame by using extrude option in solid edge.



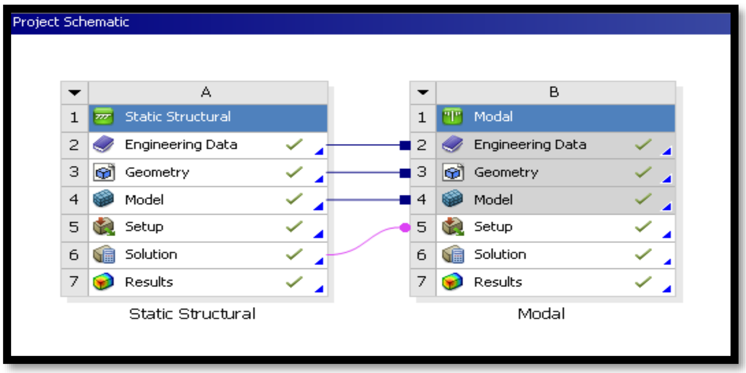
Once the 3D structure created successfully, Save the project in the igs. Format for further import formalities in simulation software ahead.

Why Ansys and How to simulate 3D model in Ansys framework for Simulation?

Ansys is a software which helps to simulate Models via performing static calculations to solve both linear and non-linear problems when it comes to structures, heat transfer and fluid dynamics, as well as acoustic and electromagnetic issues and generates result based upon the external factors which might affect the performance of prototype before coming into real existence.

Step 1:

Open Ansys Workbench and select "Static Structure" & "Modal" for the static structure analysis and behavioral characteristics of static structure.



Set all the parameters Sequentially and solve the end result.

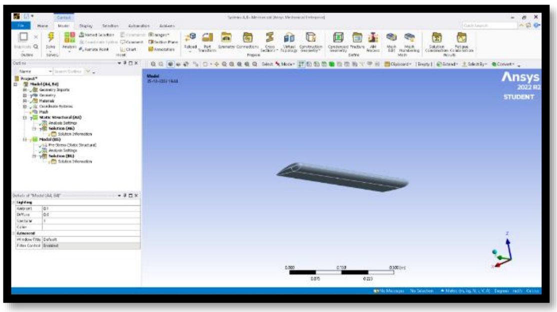
Step 2:
Engineering Data:

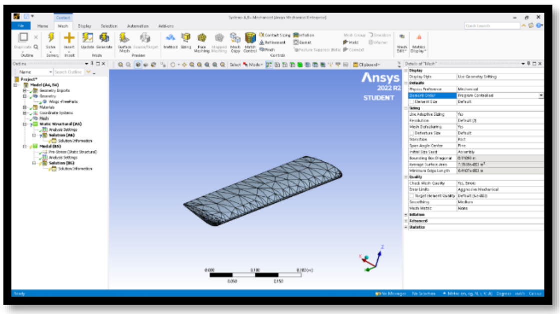
Properties of Outline Row 4: Titanium Alloy

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	4620	kg m^-3
4	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
12	Tensile Yield Strength	9.3E+08	Pa
13	Compressive Yield Strength	9.3E+08	Pa
14	Tensile Ultimate Strength	1.07E+09	Pa
15	Compressive Ultimate Strength	0	Pa

Step 3:
Geometry Import:

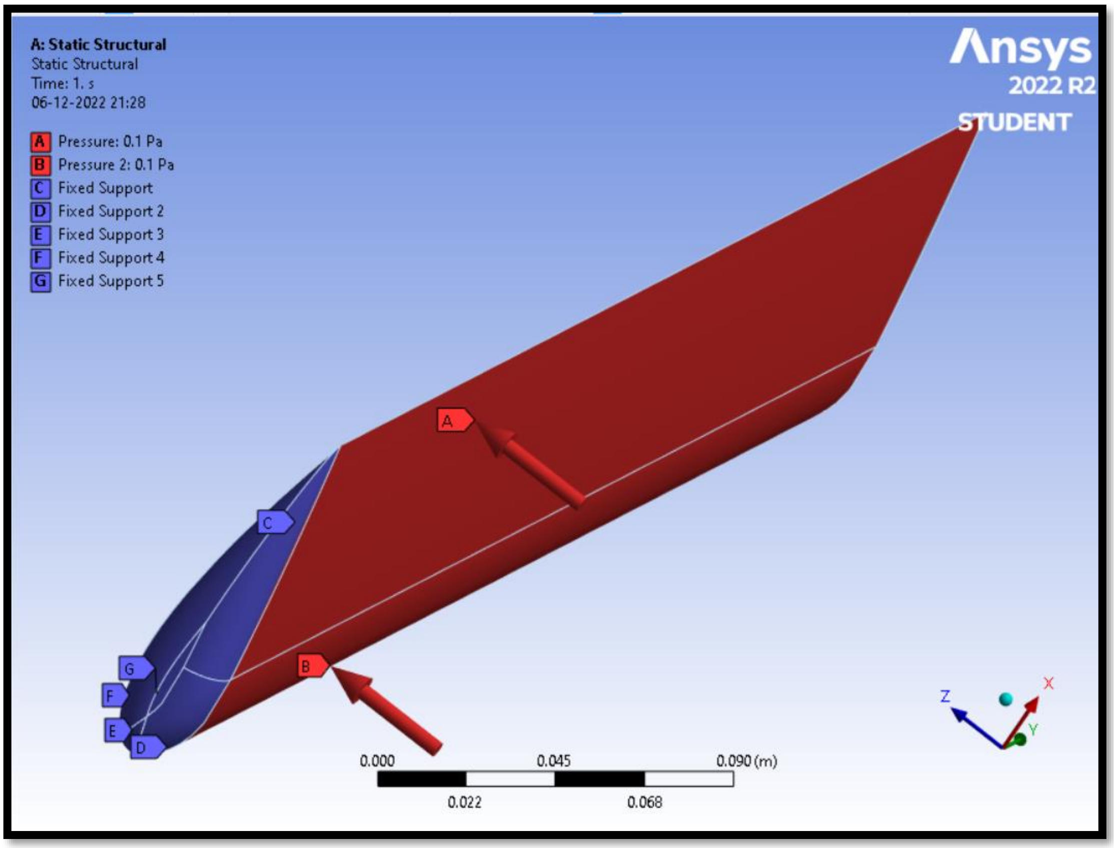
Click on geometry and import .igs format to Ansys.





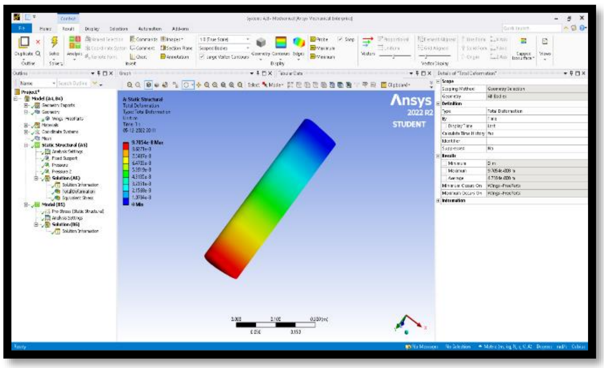
Step 4:
Model Setup:

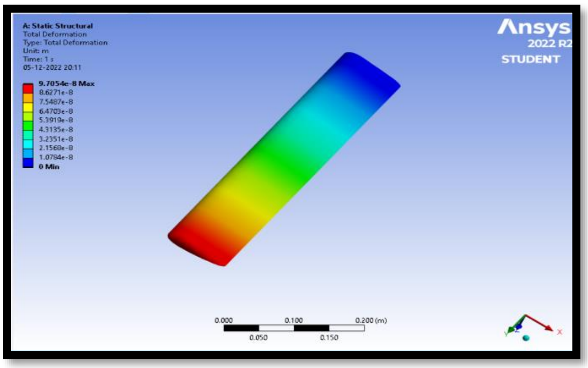
This option allows you to enable access for creating fixed end support and force magnitude & Direction.



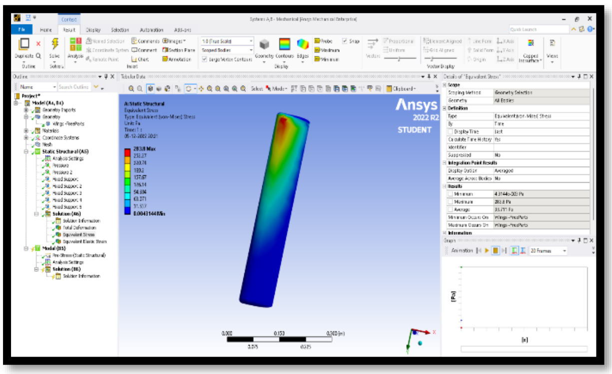
Result:

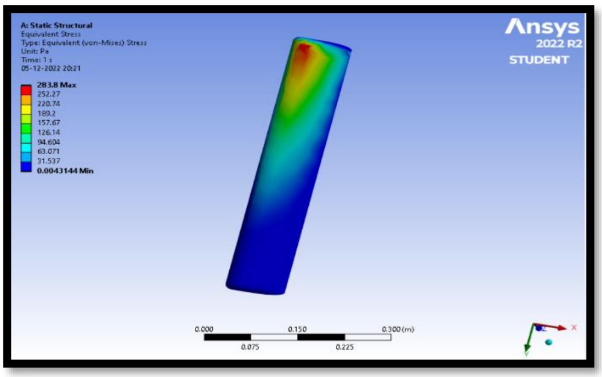
1. The wing has fixed support and load application at two different location and the behavior of total deformation is shown as follows. The deformation is more likely will noticed at the red portion of the wing which is a fixed support (wing attached to the main body). Whereas, Blue colored region has very less magnitude to deformation in terms of stress accumulation.



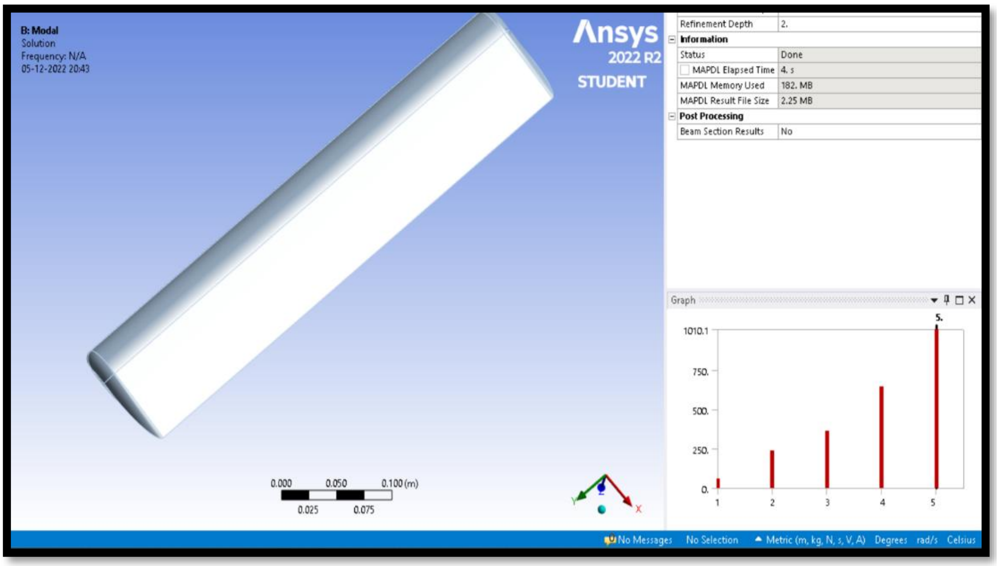


Below images states that the equivalent stress saturation in whole structure of the wing is marked with red color region on the wing. This equivalent stress behavior throughout the wing is shown as below.
If we observed carefully, maximum stress accumulation is near to the fixed support. Which might cause wing to vibrate wing at higher extent and results in to fluttering effect.

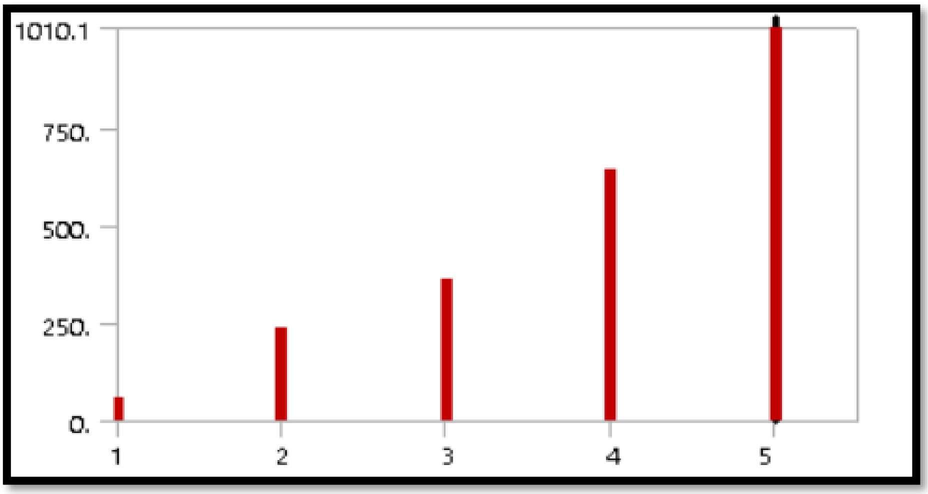




Natural Frequency



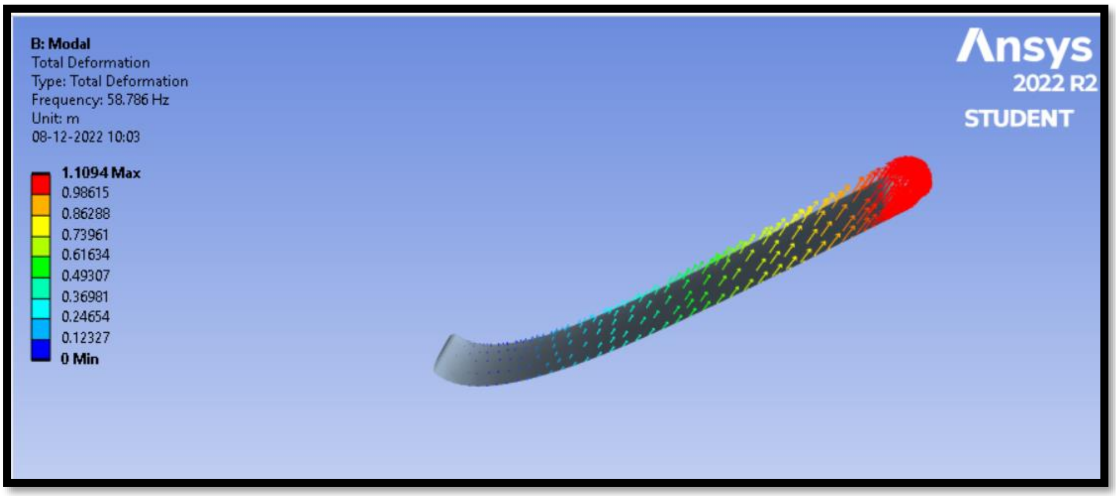
Bar Graphical Presentation of Natural Frequencies



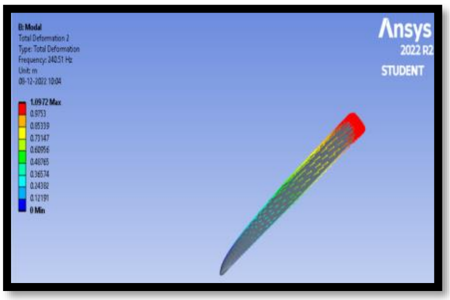
Tabular Data

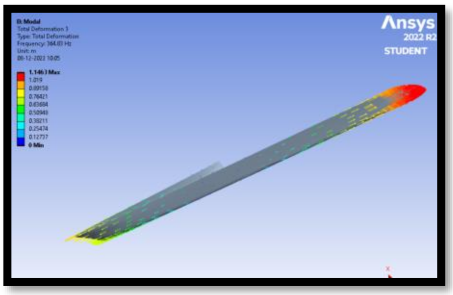
	Mode	Frequency [Hz]
1	1.	58.786
2	2.	240.51
3	3.	364.83
4	4.	643.71
5	5.	1010.1

We have analyzed the five different types of natural frequencies which causes aircraft wing to vibrate in five different patterns of fluttering vibration. Which can lead to cracking of aircraft wing from main body.

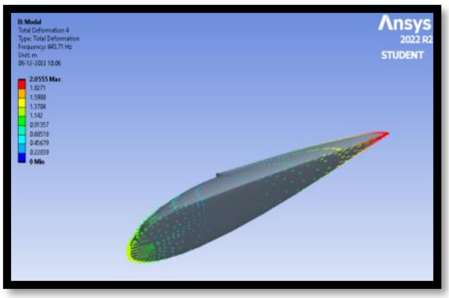


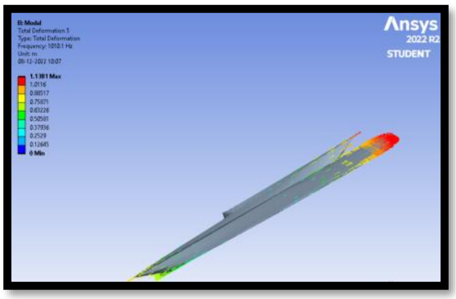
Frequency 58.78 Hz





Frequency 240.51 Hz **Frequency 364.83 Hz**





Frequency 643.71Hz **Frequency 1010.1 Hz**

Conclusion:

Aircraft Technology is solely relay on the concept of aerodynamics. Which helps aircraft or any flying object to into the air without any rigid support.

Similarly, the science of take off phenomenon is based on aircraft aerodynamic aspect, mainly depend upon three main crucial parameters such as Lift, Drag & Thrust Generated. To generate these three parameters to have a successful take off from runways aircrafts need to undergo different mechanical and challenges such as momentum gain & change of state of inertia which causes unavoidable vibrations in the main frame of the aircraft and can be cause *resonance* effect in the wing joints. As soon as the aircraft loses the contact with ground, the whole weight of the aircraft is taken by the wings of the aircraft and this results in the vibration of the wings. Other than weight of the aircraft many other parameters are responsible for the fluttering effect such as air resistance, Turbulence, Jet Engine Vibration. This fluttering effect can be eliminated completely but can be reduced at certain extent.
The increase in the weight of aircraft wing or addiction external weight attached to the wing can be result into the reduced fluttering.