TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

PULCHOWK CAMPUS

AN ASSIGNMENT REPORT

ON

Aircraft Manufacturing and Fabrication

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Submitted to:

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Acknowledgement

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We also extend our appreciation to all those who contributed to the complete design and ongoing fabrication of the aircraft "Gloster Gladiator" detailed in this report. Everybody's collective efforts, enthusiasm, and teamwork significantly contributed to the success of the endeavour.

Furthermore, we would like to thank The Department of Mechanical and Aerospace Engineering for providing the necessary resources, facilities, and support essential for conducting this project.

1. Objective :

To design and fabricate an aircraft's structural model and test its dynamic stability.

2. Introduction:

The Gloster Gladiator was a British biplane fighter (two sets of wings), which made it look different from modern planes with just one set. It was used by the Royal Air Force (RAF) and the Fleet Air Arm(FAA) and was later exported to a number of other air forces during the late 1930s. Despite the aviation industry's shift towards monoplane designs, The gladiator's Biplane structure proved effective offering, agility and stability in flight..

It had a tough body covered in fabric and a strong landing gear with wheels that couldn't fold up. The plane was armed with four machine guns and was powered by a Bristol Mercury engine, which made it fly fast, reaching about 253 mph. The pilot sat in an open cockpit, so there was no glass covering like in today's planes, and this meant they were exposed to the wind and weather.

Despite being an older design, the Gladiator was known for being good in combat. It could move and turn quickly, and it was tough enough to survive in different battles during World War II.

3. Methodology:

3.1 Design:

The Design of Aircraft was done using CATIA V5 Software. For the aircraft design, we took inspiration from a world war two fighter aircraft called "Gloster Gladiator". Based on its design, we designed our aircraft .

3.1.1 Wing Design:

Our aircraft features a biplane design, with two sets of wings stacked one above the other. This design was common in early aircraft and provided good manoeuvrability and stability.

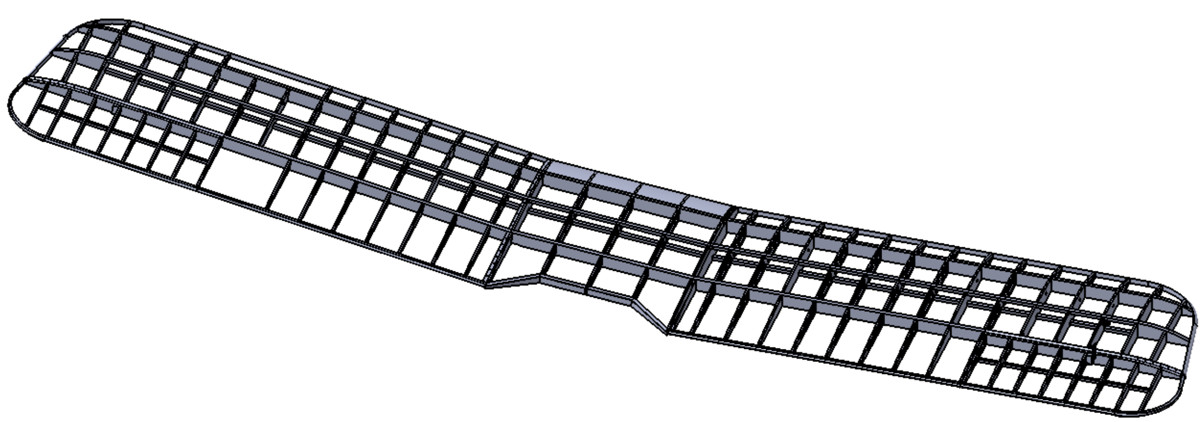


Fig- Top- Wing Design

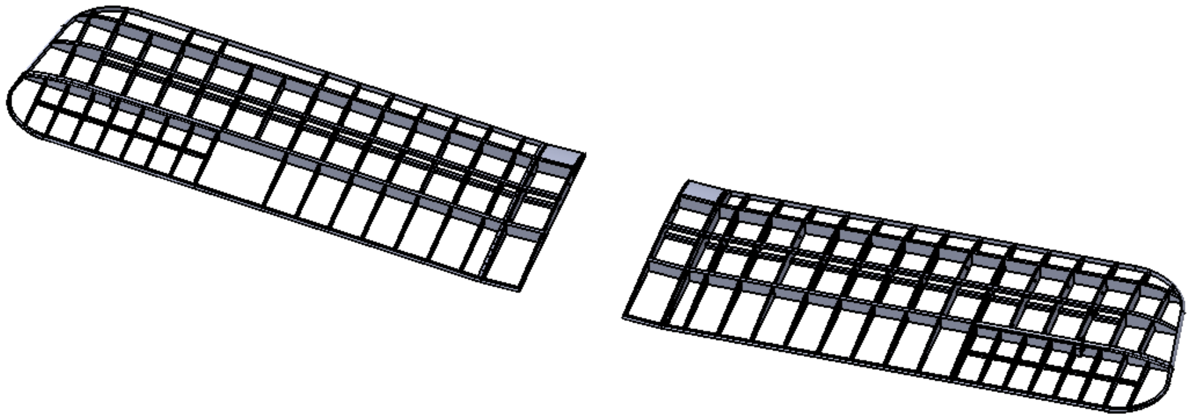


Fig- Bottom wing

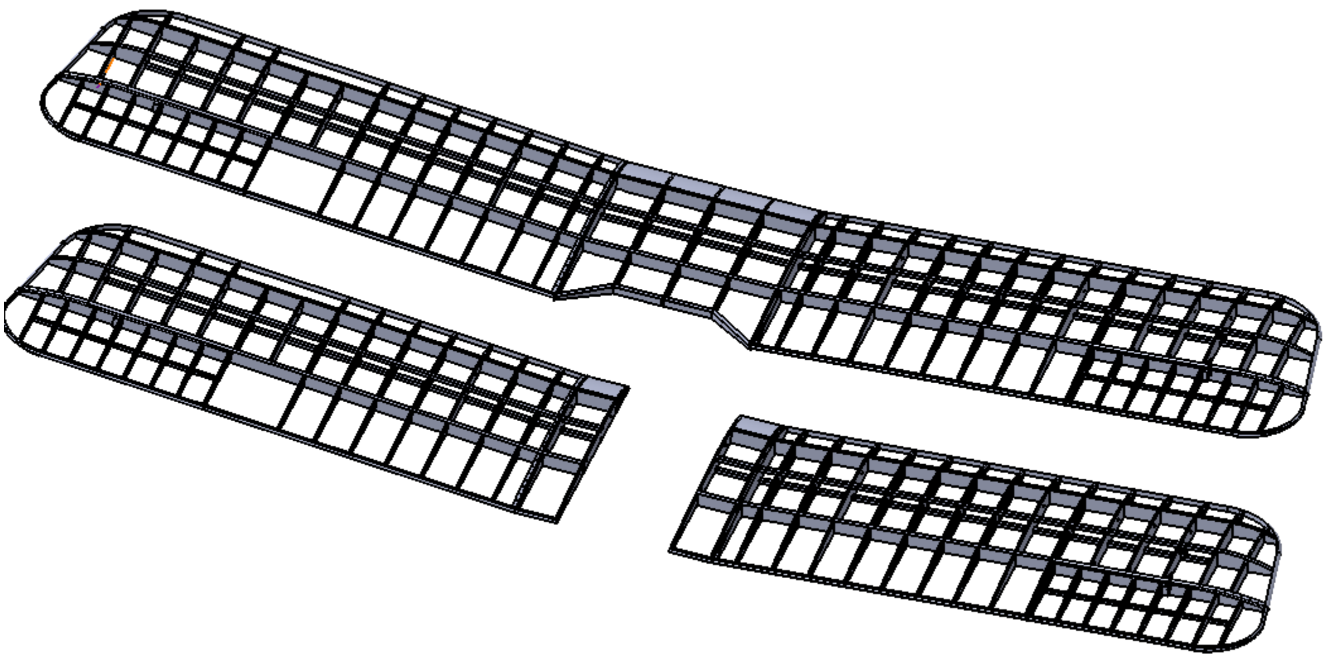


Fig- Both wings

3.1.2 Fuselage Design:

Fuselage Design features a construction where fuselage is divided into 3 sections:
the engine mounting,front fuselage and rare fuselage.

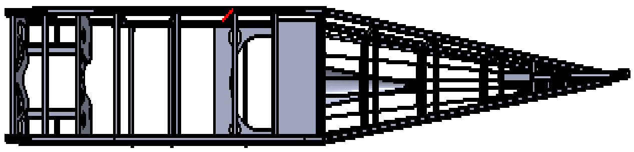


Fig: Top View

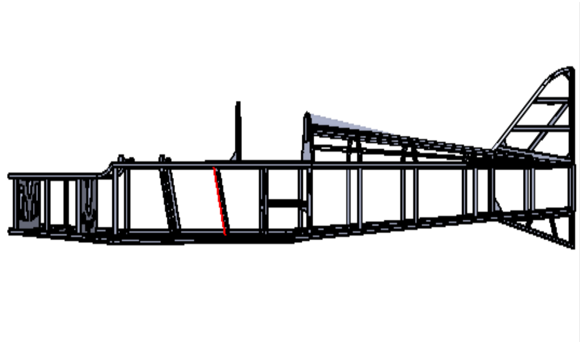


Fig:Side View

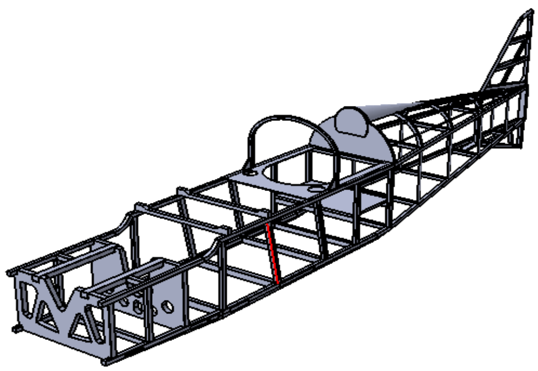


Fig: Isometric View

3.1.3 Empennage Design:

The Gloster Gladiator features a biplane design, with a horizontal stabiliser and elevator for pitch control, along with the vertical stabiliser and rudder for yaw control. This configuration provides necessary stability and control authority for the combat missions.

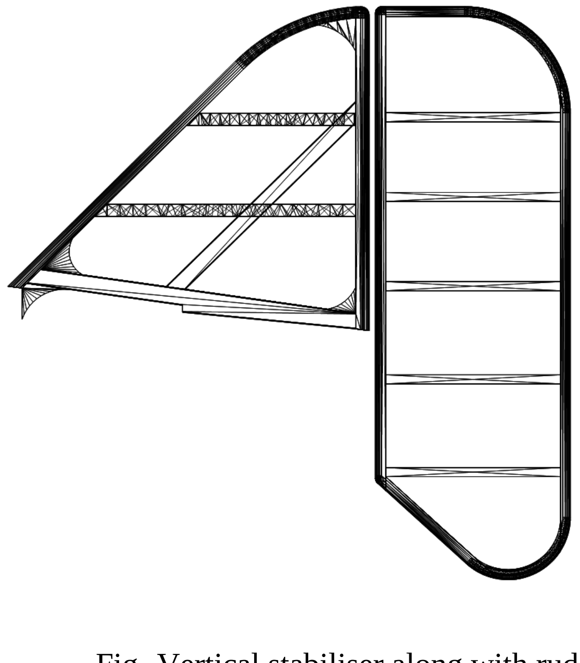


Fig- Vertical stabiliser along with rudder

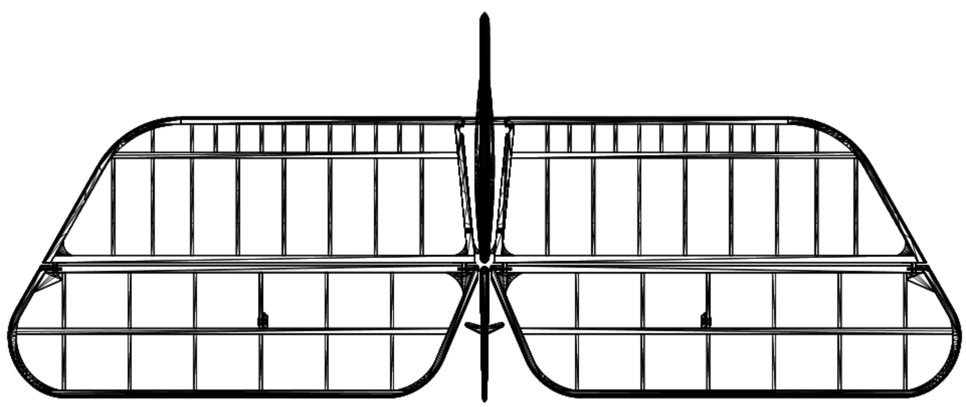


Fig- Horizontal stabiliser along with elevator

3.1.4 Landing Gear and Propeller Design:

Fig: Propeller Design

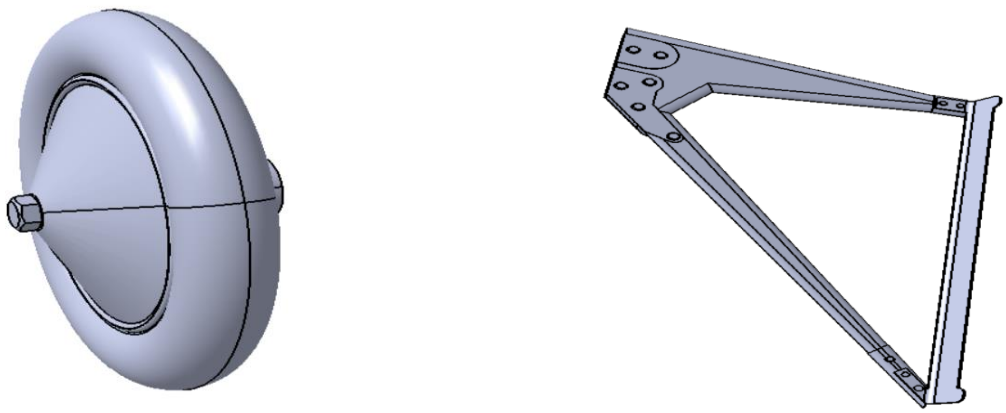
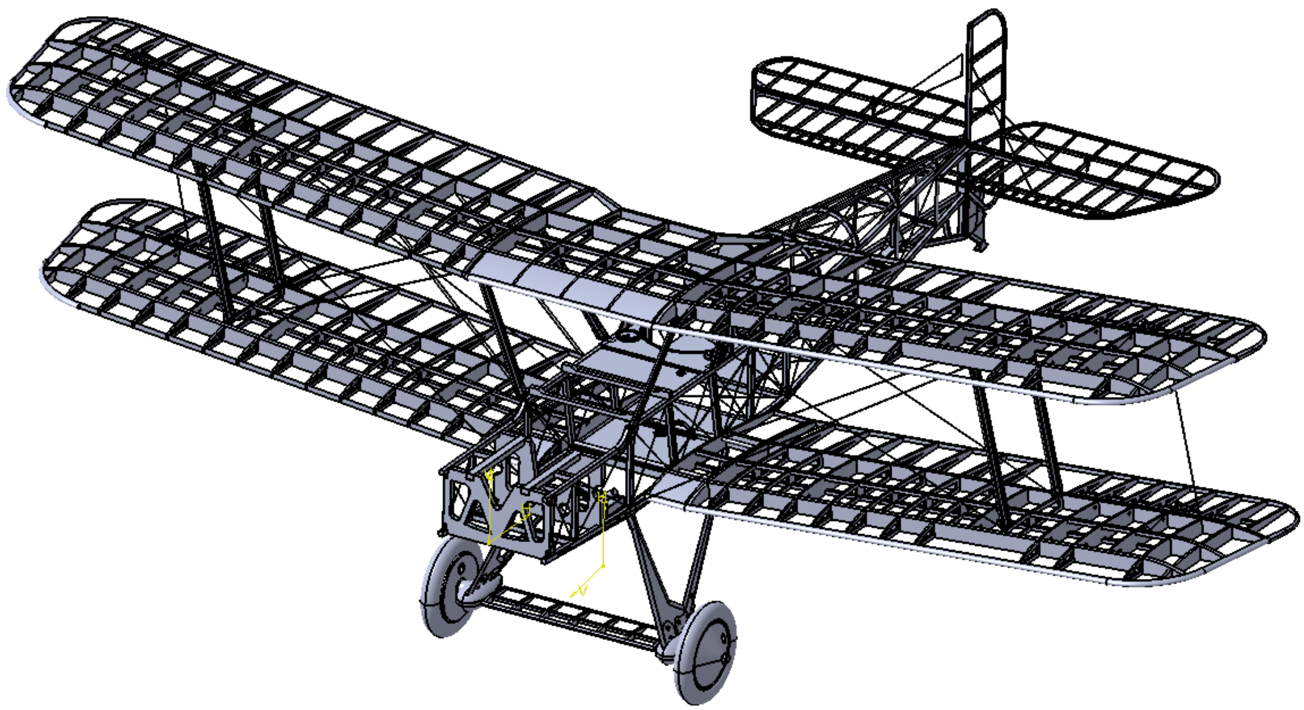


Fig: Landing Gear Design

3.1.5 Assembly Design:

The assembled view of the aircraft is as shown in the following figure.



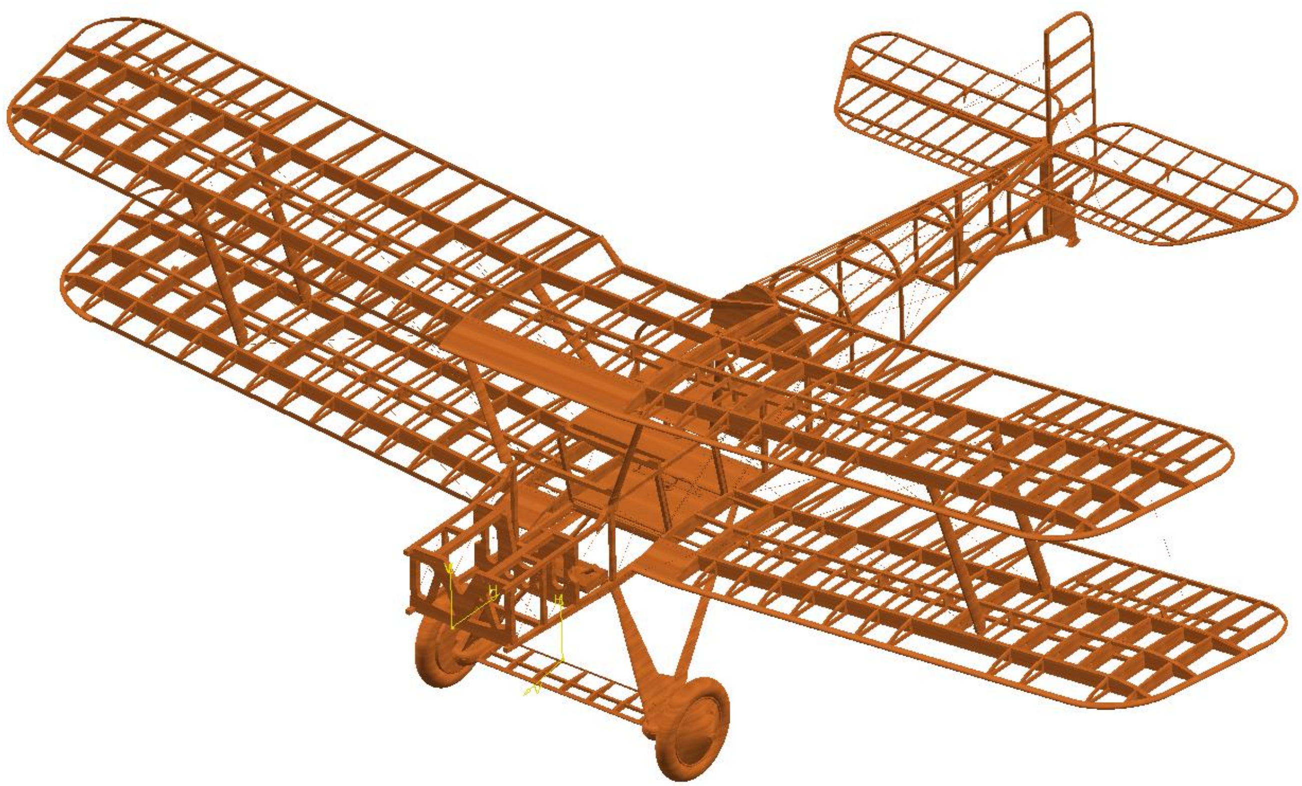


Fig- Isometric view

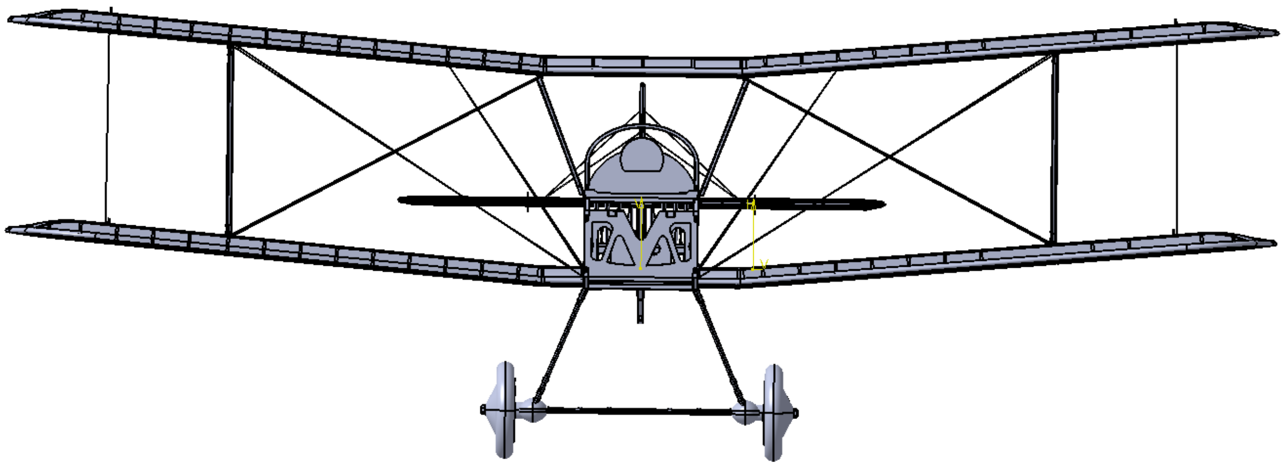


Fig- Front view

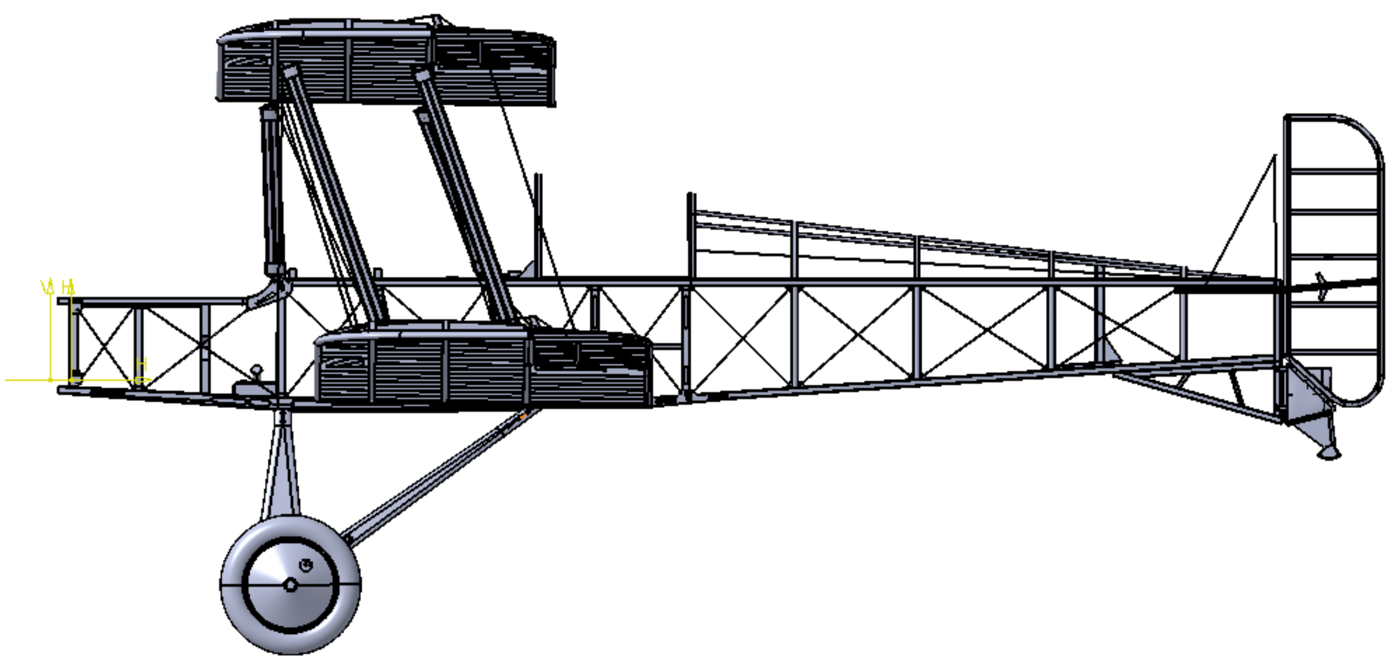


Fig- Side View

3.2 Fabrication:

3.2.1 RD works :

RD works is a program that allows us to perform laser cutting and engraving operations. The “.dxf” file of the design was created using CATIA drafting and then imported into RD works software.

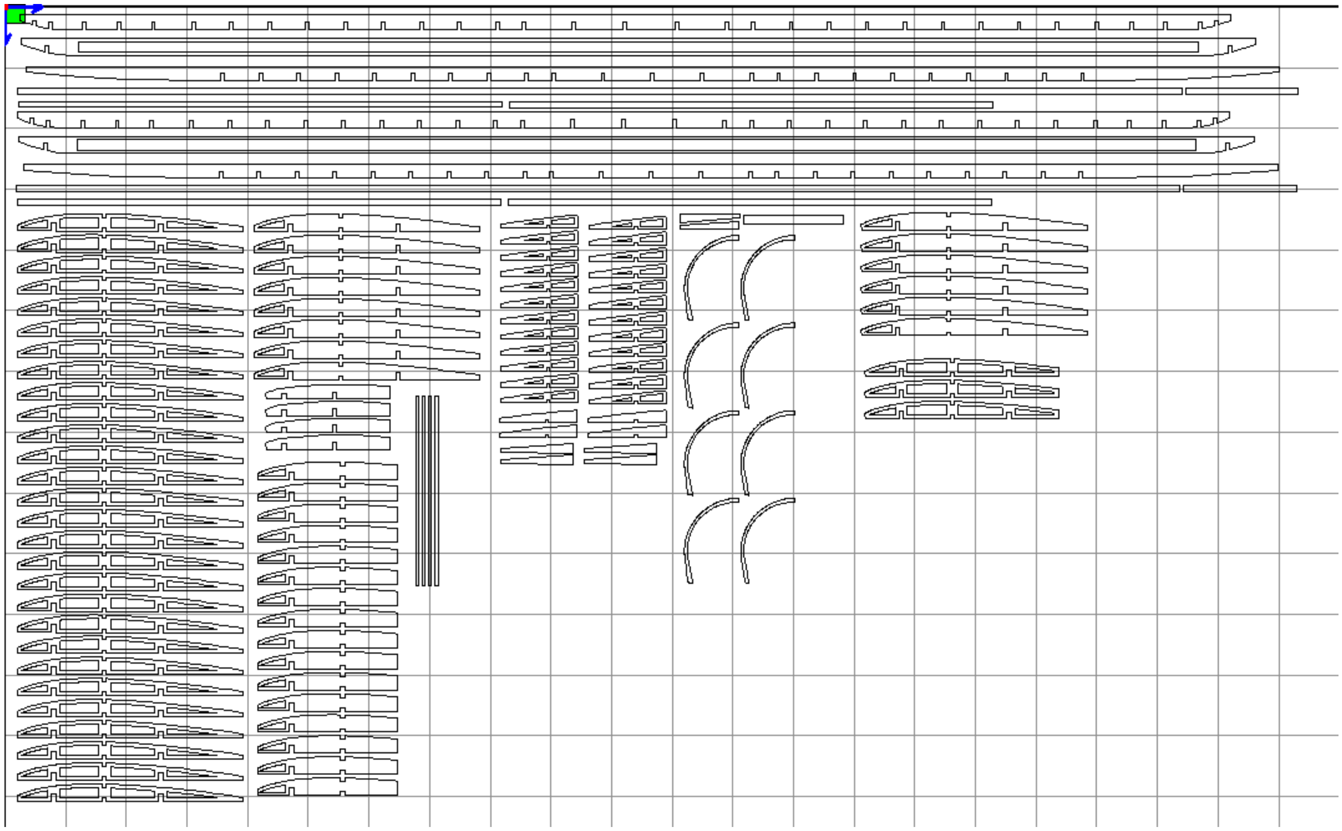


Fig- Drawing Files of Wings

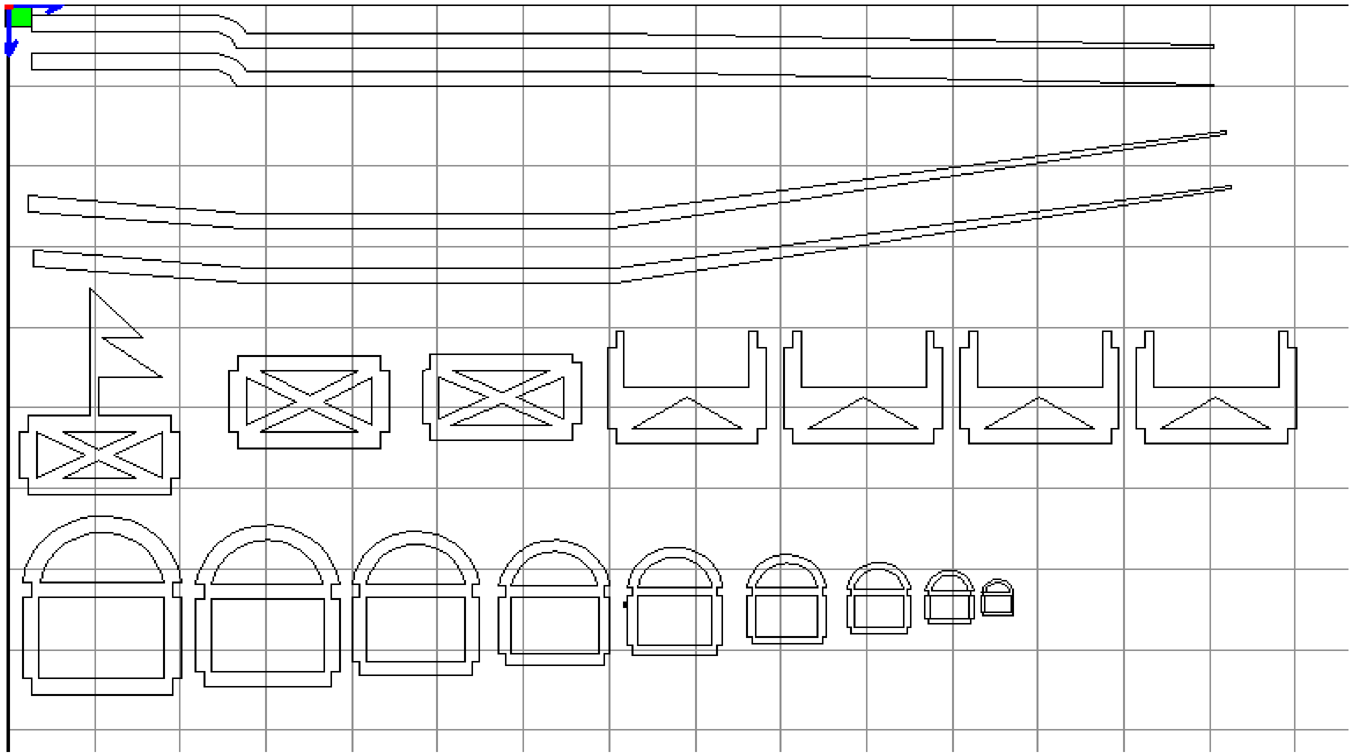


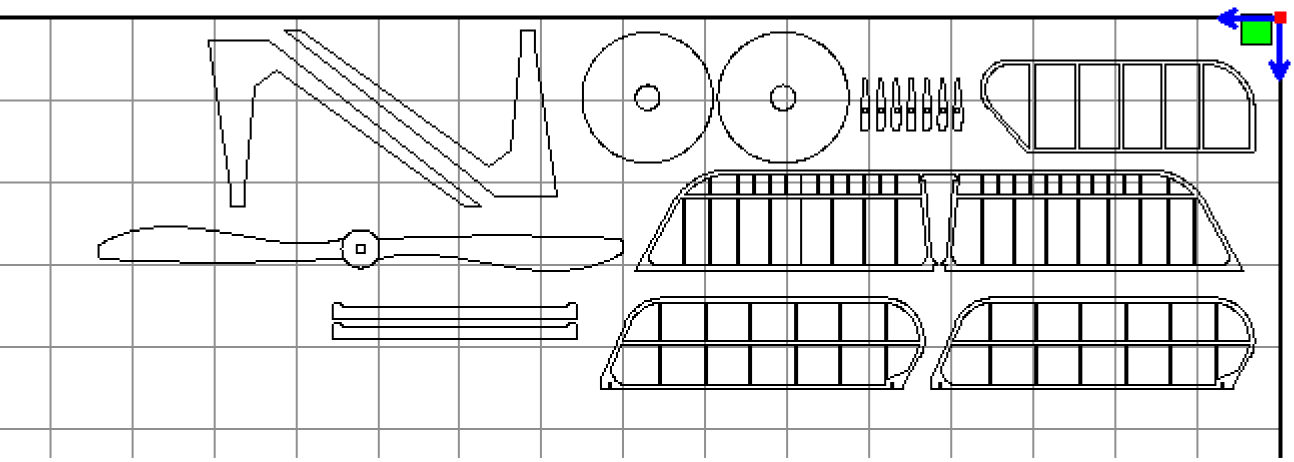
Fig- Drawing of Fuselage

Fig- Drawing of Empennage, Landing gears and Propeller

After setting the speed of 12 mm/s and power of 70%, the file was exported in the form of “.rd” and was transferred to the CNC machine for laser cutting.

3.2.2 CNC (Laser Cutting) :

The “.rd “ file was then transferred to the Thunder CO2 CNC and then after performing required steps, the file was cut according to the predetermined speed and power. For material, a 3mm MDF was used for the wing section, and 5 mm ply was used for the fuselage section.



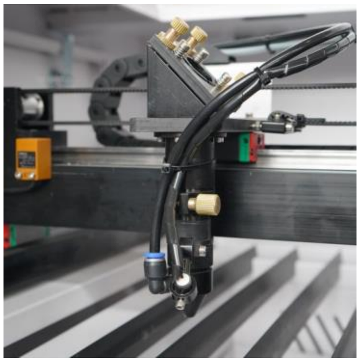


Fig- CO2 laser cutter

3.2.3 Assembly :

Once the design was cut, it was now time to assemble the pieces together. For this we used Vega Quick Instant Adhesive.

Fig- Two wings

Fig- Two wings assembly

3.2.4 Used material:

- **3 mm MDF(Medium Density Fibreboard)** was used for wings and empennage manufacturing.

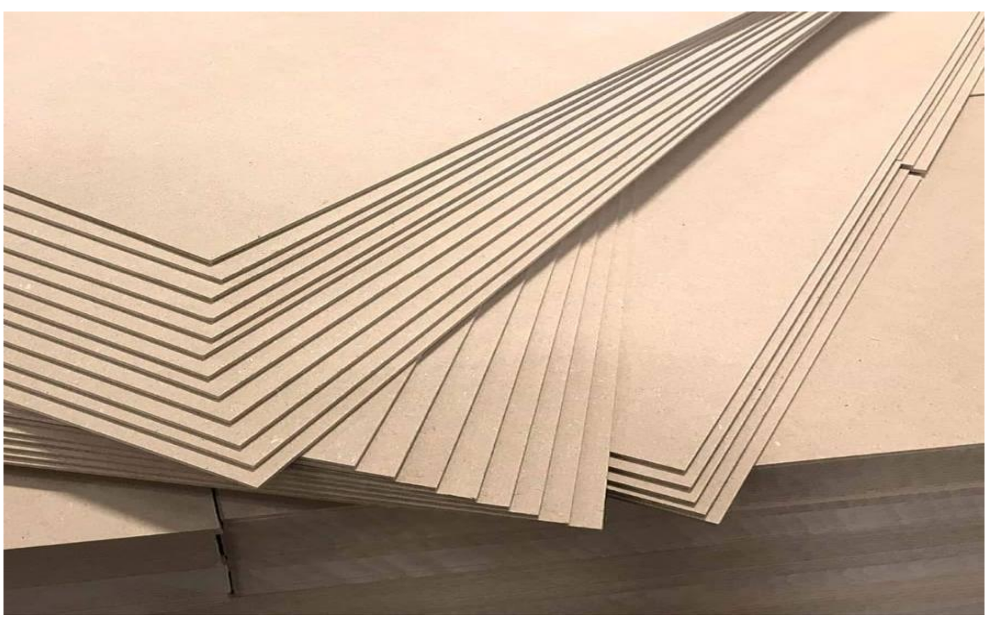
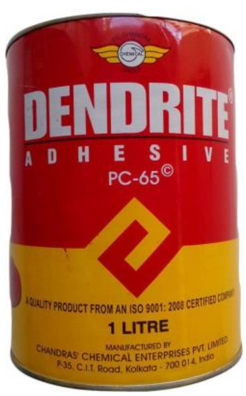


Fig- A 3mm MDF Board

- **Vegaquick instant adhesive**

- **Dendrite**



3.3 Dynamic Stability Analysis:

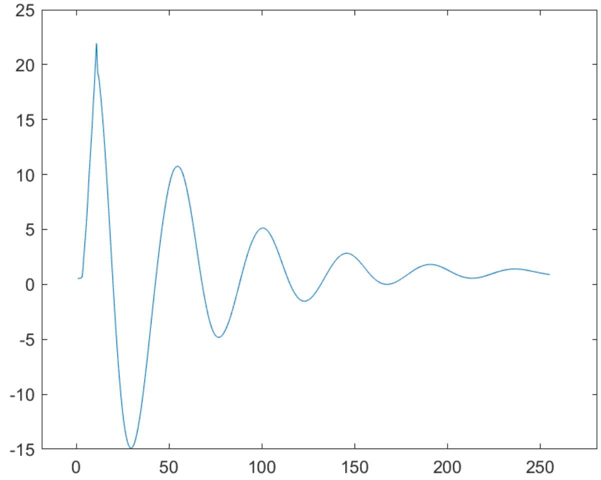
Dynamic stability refers to how the aircraft behaves after it has been disturbed .The tests for showing the dynamic stability were done using Xplane12. The test results of different modes are as follows:

3.3.1 Phugoid Mode : (Pitch angle vs time)

This test was performed in the following ways:

- Stabilising the aircraft in trimmed, SLUF flight, with both pitch and yaw trimmed neutral.
- Performing a RUDDER DOUBLET which is defined as rudder full deflection one way then full deflection the other, and release. This is designed to excite the dutch roll mode. The entire doublet is performed quickly.

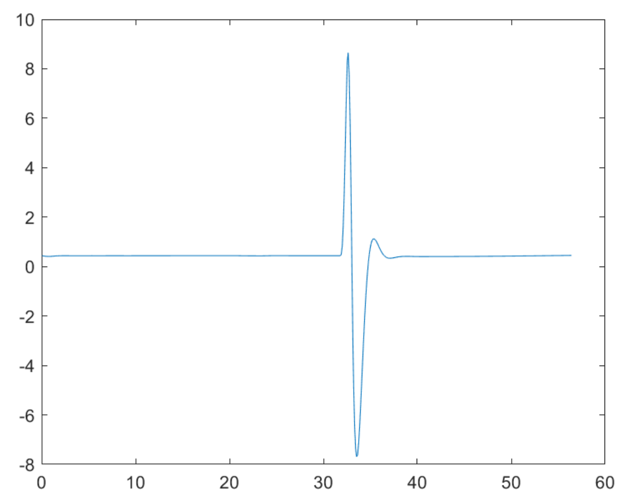
- Releasing the controls and allowing the aircraft to oscillate.



2.3.2 Short Period Mode (alpha vs time):

This test was performed in the following ways:

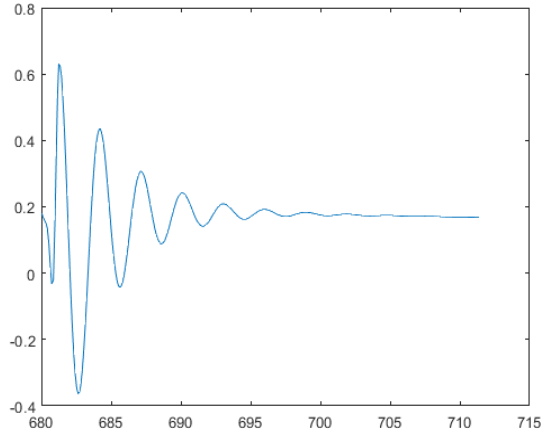
- Stabilising the aircraft in trimmed, SLUF flight, with both pitch and yaw trimmed neutral
- Performing a PITCH DOUBLET which is defined as a sharp pitch up then pitch down and release. This is designed to excite the short period mode. The entire doublet is performed quickly.
- Releasing the controls and allowing the aircraft to oscillate.



3.3.3 Dutch Roll :(Yaw angle vs time)

This test was performed in the following ways:

- Stabilising the aircraft in trimmed, SLUF flight, with both pitch and yaw trimmed neutral.
- Performing a RUDDER DOUBLET which is defined as rudder full deflection one way then full deflection the other, and release. This is designed to excite the dutch roll mode. The entire doublet is performed quickly.
- Releasing the controls and allowing the aircraft to oscillate.

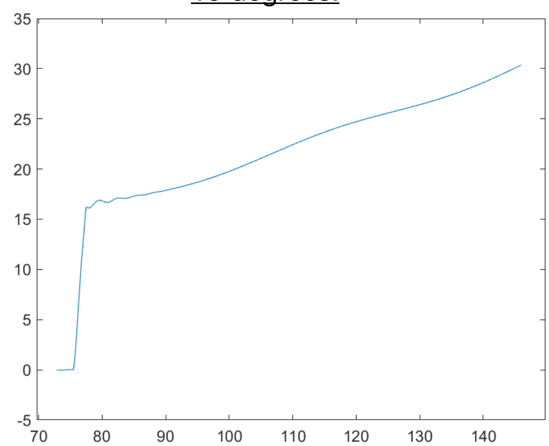


3.3.4 Spiral Mode : (Roll angle vs time)

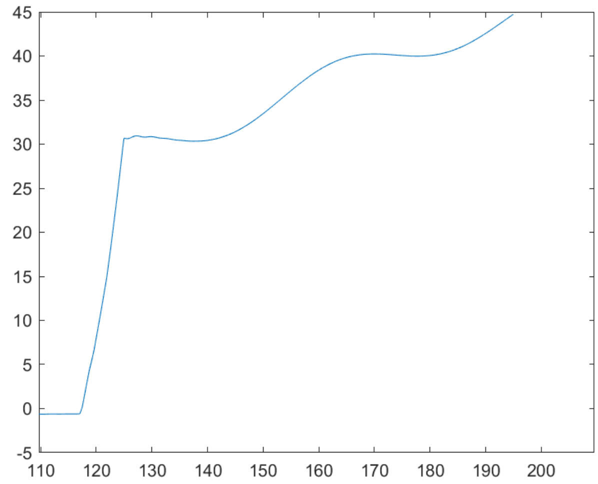
The spiral mode is performed in the following ways:

- Stabilising the aircraft in trimmed, SLUF flight, with both pitch and yaw trimmed neutral.
- Establishing the aircraft at initial bank angle 15°, releasing the controls and measuring the time it takes to double the bank angle (or 1 minute, whichever occurs first)
- Repeating the same for Bank angles 30° and 45°

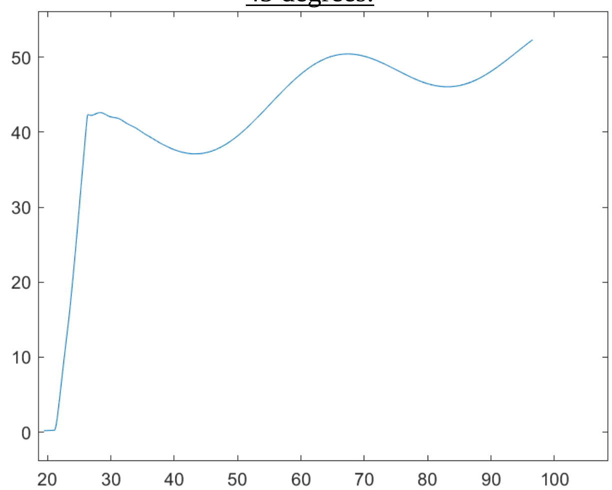
15 degrees:



30 degrees:



45 degrees:



Running these tests, we found that the aircraft's longitudinal stability took over its lateral stability.

4. Result :

4.1 Task completed

a. Selection of reference aircraft i.e. Gloster Gladiator.
b. 3D model design of our aircraft in CATIA V5R21.
c. Cutting parts of our aircraft's structural frame in the CNC laser cutter on a 3mm MDF sheet.
d. Final wing and first iteration of fuselage fabrication.

4.2 Task to be completed

a. Assembly of the components that were cut by laser
b. Finishing of material for inspection
c. If any issues arise, continue iterating multiple times until the desired design is achieved.

5. Conclusion:

In conclusion, the process of selecting, designing, testing the dynamic stability, and fabricating an aircraft's structural model has been an insightful experience..Through our research, careful design considerations, rigorous testing procedures, and fabrication techniques, we have completed the fabrication process of aircraft partially. The insights gained from this project will undoubtedly contribute to our understanding of aircraft design and manufacturing..