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Glider Design

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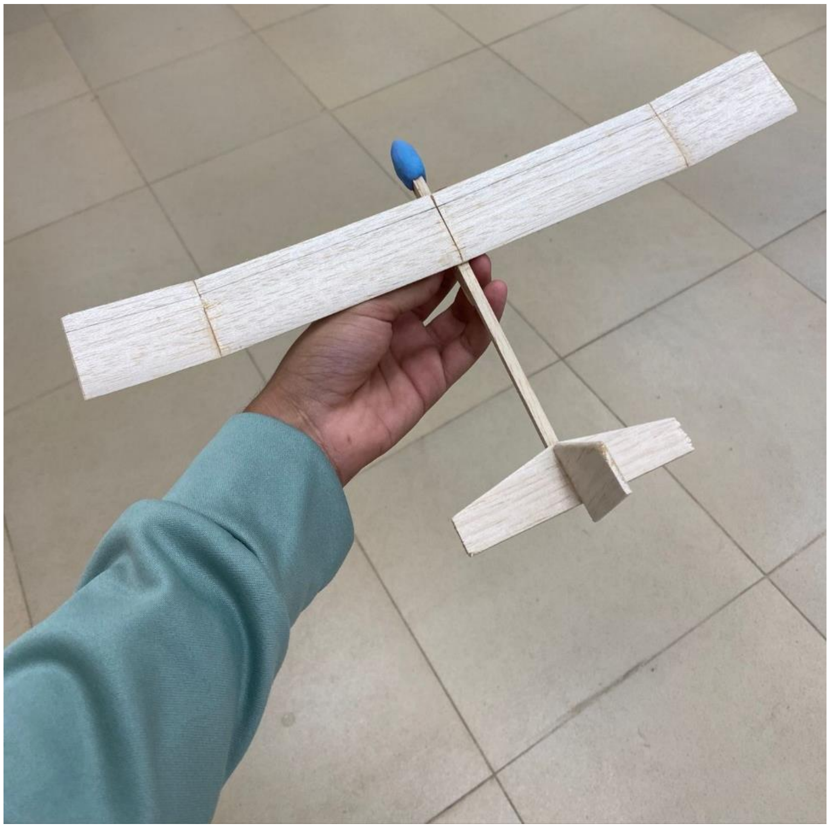
SPC201: Introduction to Air and Space Flights

Glider Design Project Report



1. Project Abstract

The project's aim is to use the concepts we learnt on the course and apply them in designing an unpowered glider that solely relies on it's glide flight characteristics to stay in the air for as much time as possible.

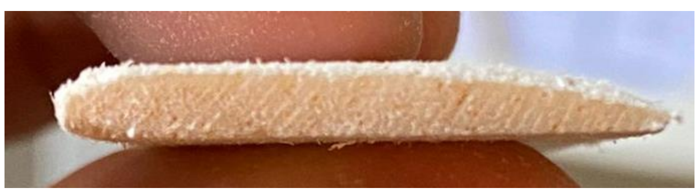
We made our build using a sheet of 3mm balsawood, a 6mm balsawood square-prism rod, and the wing was made using a 4mm balsawood sheet that was shaped like an airfoil. We also added some weight to the nose using a small piece of clay to try to bring the center of gravity slightly infront of the center of lift. We chose the wing to have an aspect ratio(AR) of about 8. As this is ideal for a free flight glider.

The stabilizer of the sailplane was placed at the very back to help with the alignment of the Center of Gravity C_g.

Our sailplane's design was simple yet effective. Achieving 20 meters of flight in the test, and 34 meters of flight in the open area.

2. Introduction to the Project

We were recommended to just use a flat plate design for the wings, as setting an airfoil will be difficult to do for the time period allotted. However, seeing as how airfoils play a big part in the course, we used sandpaper to shape our wing's 4mm balsawood sheet to look like an airfoil. Here is one cross-section:



This was an initial model for the wing that we planned with dimensions 40cm x 2.5cm x 3mm.

One issue we faced is that the aircraft was very unstable, our interpretation was that the airfoil shape cross-section was too thin, which means that while the sailplane could travel quickly, it sacrifices stability.

this inspired the decision to increase the thickness of the wing from 3mm to 4mm. (we sacrificed some velocity for more stability).

that this model had an AR of 16, which was an advantage because the induced drag was reduced very well. This comes from the relation:

$$D_i = L\frac{C_L}{\pi AR} \text{ where } D_i \text{ is induced drag and } \frac{C_L}{\pi AR} \text{ is } \alpha_i.$$

However, since we needed to increase weight such that

$$L = W$$

We had to increase the thickness of the sheet used to 4mm and the width of the wing to be 4.5cm instead of 2.5cm (maintaining the airfoil shape as best as possible).

By doing this, $L \approx W$ and our sailplane was able to maintain flight for a good amount of time.

In short, the most desirable characteristic is that the lift produced is equal to the weight of the sailplane.

Some other desirable characteristics of our airfoil and wing are:

- High $\frac{L}{D}$, which is defined as lift-to-drag ratio, calculated as $\frac{C_L}{C_d}$.
- A desirable lift coefficient $C_l = \frac{L}{q_\infty S}$, where $q_\infty = \frac{1}{2}\rho V_\infty^2$.
- A desirable drag coefficient $C_d = \frac{D}{q_\infty S}$.
- An appropriate initial angle of attack α.
- Suitable camber
- Suitable thickness-to-chord ratio $\sfrac{t}{c}$.
- For our case, a low reynold's number $Re = \frac{\rho_\infty V_\infty x}{\mu_\infty}$.
- Appropriate moment coefficient $C_M = \frac{M}{q_\infty S}$.

We have achieved most of these desirable conditions.

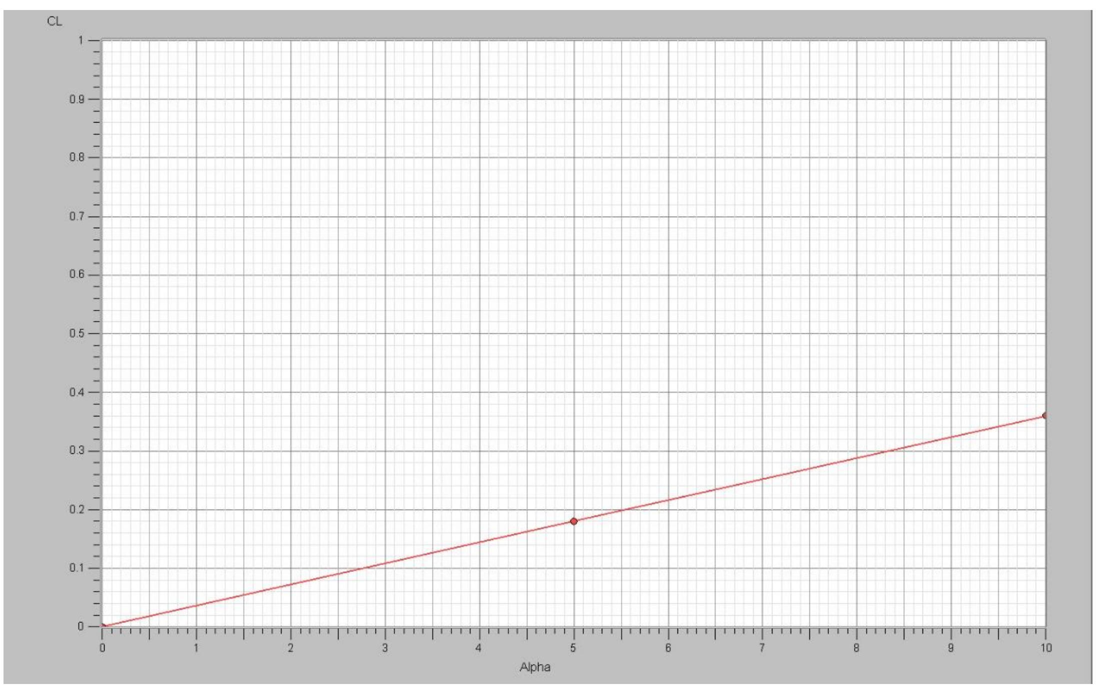
3. Methodology

We mostly used CFD software's for our calculations to minimize errors and to be able to plot them in a diagram if needed.

We started with the calculation of the center of moment for the airfoil, below is the result of $C_{\{My\}vs\ \backslash alpha}$. Please note that we picked the angle of attack $\backslash alpha$ to be $5°$.

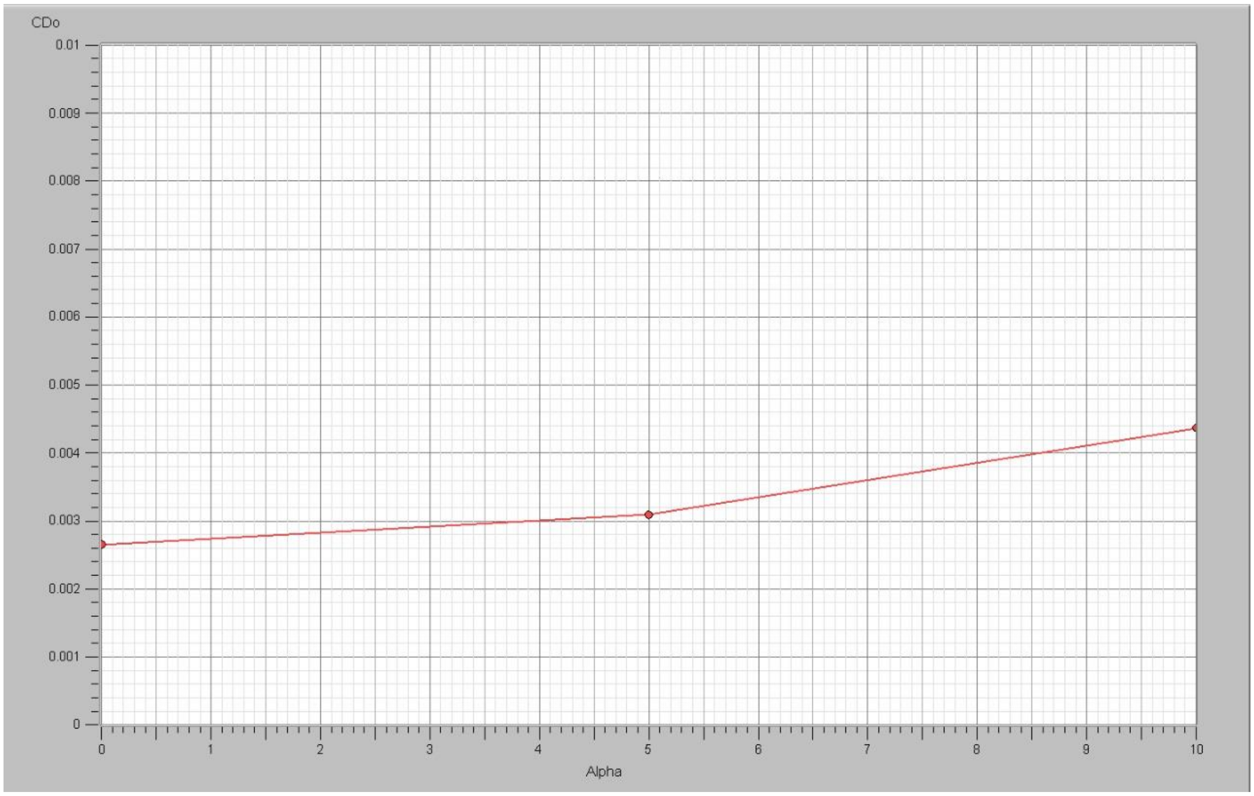
Since it’s not that huge at $5°$, it gave us a good sign to go ahead with the design.

Proceeding with the calculations for the center of lift $C_{l\ vs\ \backslash alpha}$, we get the below results:



Using calculations of assumed density of the balsawood and the dimensions of the sailplane, the mass of the sailplane was around 22.56g.

Now we can use the CFD software to find the coefficient of drag $C_{\{D_0\}}$, and plot $C_{\{D_0\}}$ vs $\backslash alpha$:



Since $C_{\{D_0\}}$ at 5°is very small, this also gives another good sign for our model.

Overall information from the CFD software is as follows:

	f (m²)	C_D	% Total
Geom:	0.5481	0.00548	100.0
Excres:	0.0000	0.00000	0.0
Total:	0.5481	0.00548	100.0

From then on, we can follow with finding the dimensions of the rest of the sailplane, such as the stabilizer and the fuselage to be as follows:

After gathering all of these details, we can go ahead and find a suitable blueprint:

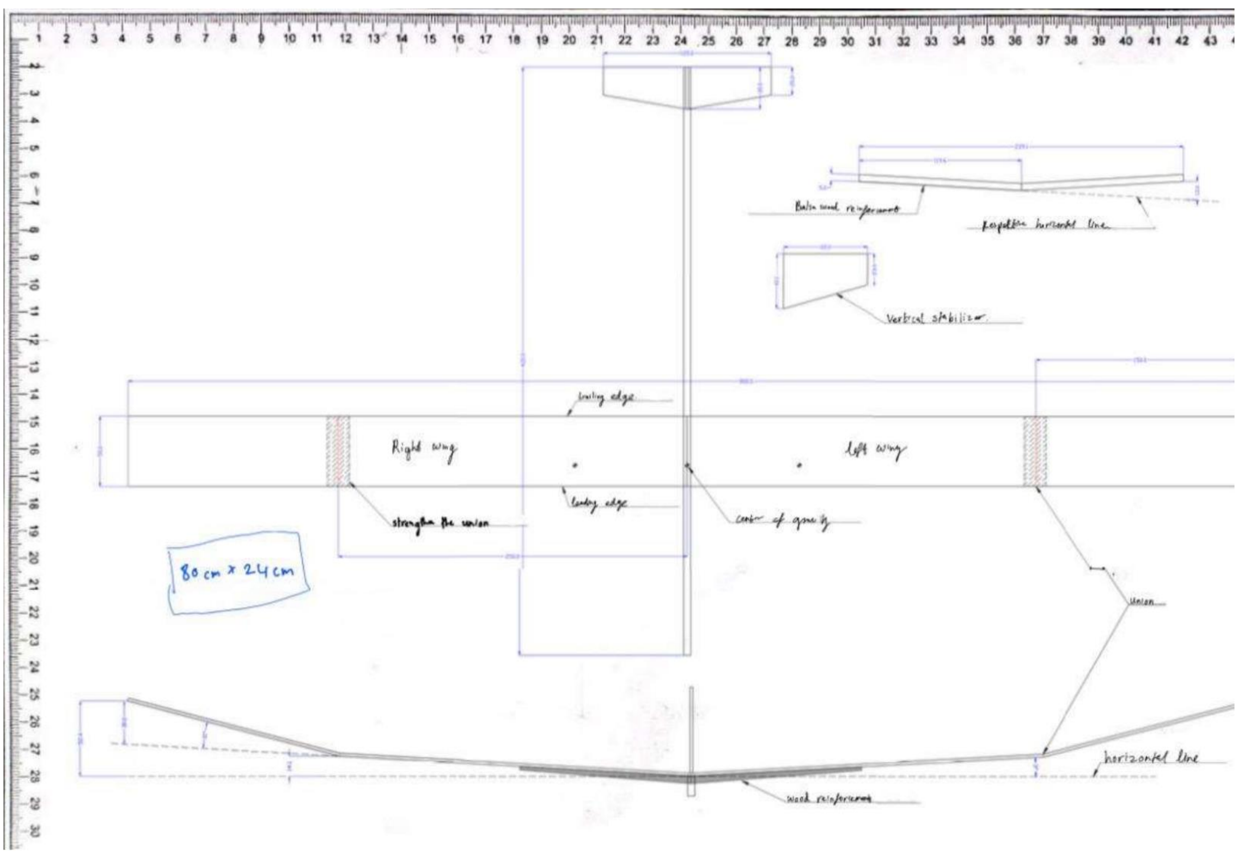


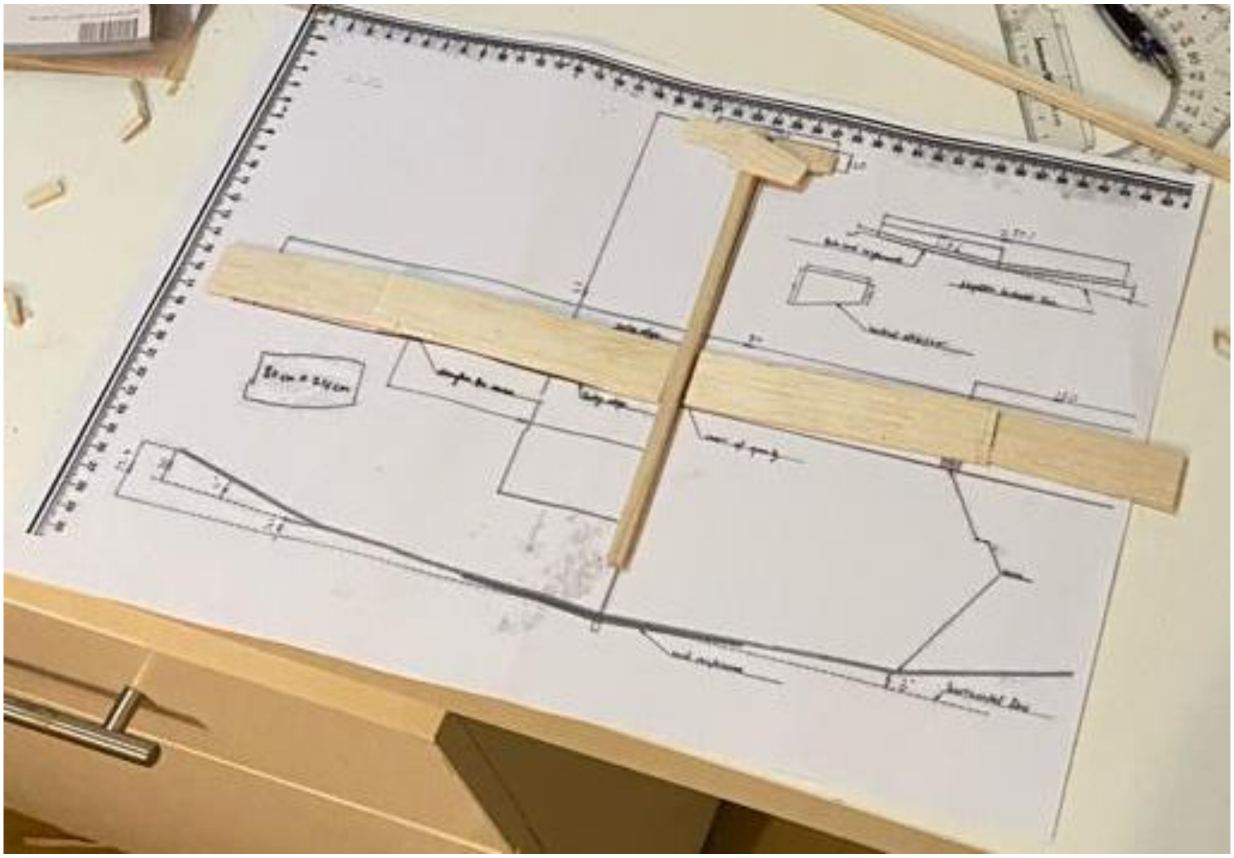
Figure 1This is a scanned picture

We also made the wing a dihedral to enhance it's initial issue with roll stability.

4. Results and discussion

After getting these calculations we can now go ahead and build our model.

We gather all our parts into the model and check that they match:



After that, we sand the wings to look like an airfoil:

Please note that we didn't sand the tail as much as the airfoil because we don't want the tail to overlift.

We now assemble the pieces together:

Figure 3 The tail

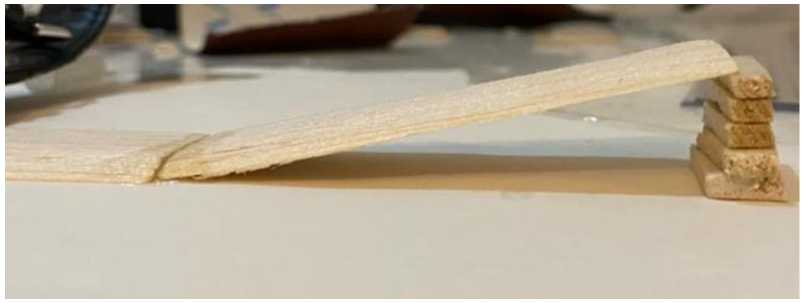


Figure 2 the dihedral in the wing

Figure 4 Fully assembled wing

Figure 5 The fuselage

Figure 6 Assembled glider without tail

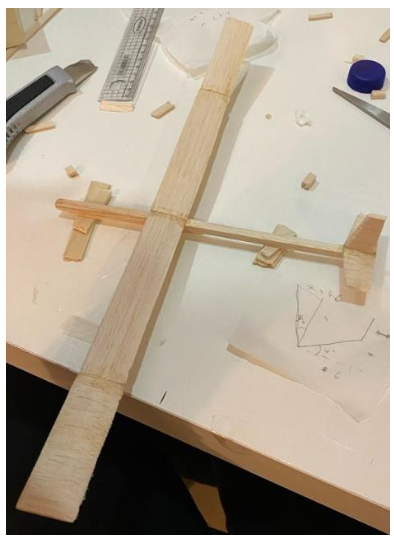


Figure 7 Assembled glider with tail

5. Conclusions

The glider design project aimed to apply the concepts learned in an Introduction to Air and Space Flights course to design an unpowered glider that relies on its glide flight characteristics to stay in the air for as long as possible. The glider was constructed using materials such as balsawood and clay.

The design of the glider incorporated an airfoil-shaped wing made from a 4mm balsawood sheet. Initially, the wing had a thinner cross-section, which made the glider unstable. To improve stability, the wing thickness was increased to 4mm, sacrificing some velocity for stability. The wing also had an aspect ratio of 16, reducing induced drag.

The desirable characteristics of the glider's airfoil and wing included a high lift-to-drag ratio, a suitable lift coefficient, a suitable drag coefficient, an appropriate angle of attack, suitable camber, suitable thickness-to-chord ratio, and a low Reynolds number.

Computational Fluid Dynamics (CFD) software was used for calculations and analysis. The center of moment, center of lift, coefficient of drag, and other parameters were determined using the software. The mass of the glider was around 22.56g.

Based on the calculations and analysis, a blueprint was created for the glider design. The wings were sanded to resemble an airfoil shape, and the glider was assembled, including the stabilizer and fuselage.

The results of the glider design project showed that the glider achieved a flight of 20 meters in testing and 34 meters in an open area. The design aimed to balance stability and performance to maximize the glider's flight time.

Overall, the project demonstrated the application of aerodynamic principles and the use of CFD software in designing a functional glider with desirable flight characteristics.

6. References

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2. Airfoil tools http://www.airfoiltools.com/
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