ENGSCI 344: PROJECT BRIEF 2023

In this project you will analyse structural and aerodynamic behaviour of a small commercial aircraft wing, similar to that shown in Figure 1.

Figure 1. Cessna 172 Aircraft
https://airfactsjournal.com/2016/07/whats-wrong-cessna-172-pilots/

A data set of points defining the airfoil (cross section) of the wing will be supplied. From these, the geometry of the airfoil section can be constructed. The wing to be analysed consists of five such ribs (airfoils) spread evenly along the wing-span with one hollow tubular-section beam spar running the length of the wing (Figure 2).

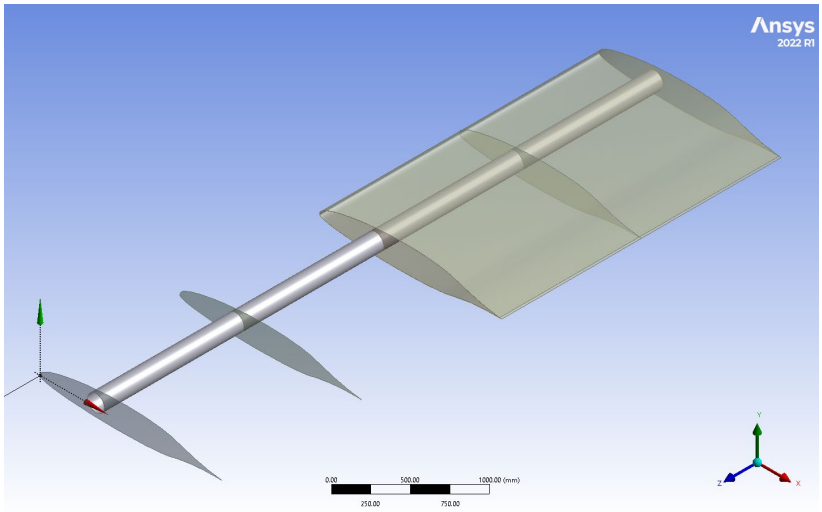


Figure 2. Wing Geometry

The wing dimensions are as follows:

Airfoil chord length:	as per data set supplied
Wing span a:	5.0m
Number of ribs:	5
Width of each rib:	1mm
Thickness of skin:	0.5mm (the skin encloses the ribs and spar)

The wing (ribs, spar, skin) are to be made of Aluminium, Grade 7075.

There are two different aspects of the wing design that you are being asked to computationally analyse and assess:

1. Determine the geometry of the spar that will minimise mass for the aircraft and at the same time ensure an appropriate safety factor for stress in the wing.
2. Determine the aerodynamic performance of the airfoil section at different angles of attack. Also determine whether this airfoil section can improve the performance of the aircraft when compared with a reference section.

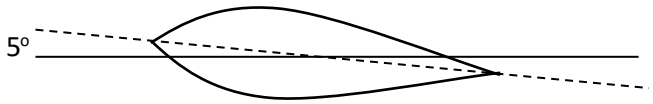
Objective 1: Structural Performance

The aim of this part of the project is to determine the geometry of the spar that results in a minimum mass for the aircraft wing, while having adequate strength to withstand the stresses and forces which arise.

Goal: Using computational simulation, determine an appropriate spar geometry to minimise weight while maintaining an appropriate safety factor.

Note the following:

1. Use a hollow tubular-section spar; the cross-section can be of any size that will be contained within the cross-section and have any aspect ratio. It can vary along the length of the wing.
2. The centre of the spar should be positioned where the airfoil thickness is largest.
3. The structural performance is to be examined at an angle of attack of 5 degrees.



4. You can use an approximate line load along the wing of 1300 N/m lift and 30 N/m drag for design purposes. You also have the option to determine a more accurate loading profile from your Computational Fluid Dynamics analysis (discussed below).
5. An appropriate safety factor for aeronautical engineering should be used.

Objective 2: Aerodynamic Performance

The aim of this part of the project is to determine the aerodynamic performance of the airfoil section (coefficient of drag C_d, coefficient of lift C_l, coefficient of pressure C_p) at different angles of attack. You are then to compare the performance of this airfoil with a reference design.

Goal: Using computational simulation, determine the aerodynamic performance of the airfoil.

1. The aircraft (wing) speed is 65 m/s.
2. The aircraft is to be analysed while flying at 1400m.
3. The angle of attack should be varied between -5 and +15 degrees.
4. This part of the project can be done in two dimensions, i.e., by analysing one airfoil (cross-section).
5. Plot C_d, C_l, C_p, and C_l/C_d, as functions of angle of attack α.
6. From these plots or otherwise determine the angle of attack for which the airfoil gives optimal performance.
7. Compare this airfoil with the data of a reference airfoil section (will be provided later) and comment on the advantages and disadvantages of each.
8. Analyse the airfoil at +20 degrees angle of attack. Discuss whether the flow behaviour at this angle of attack adversely affects the accuracy of the obtained results. If so, recommend changes that could be made to improve the accuracy.

Assessments

Hand-In 1: Computational Design, BCs, geometry and mesh (max 6 pages, 10%): 5pm, Fri 25th August @5pm

Hand-in 2: "Report for Client" (max 10 pages, 15%) 5pm, Fri 13th October @5pm

Final Presentations: (6%) Due 5pm Wednesday 18th Oct

Other Information

The project is worth 31% of your final mark.