Structures

# Task 1



Above are the graphs showing the cross-sectional properties along the span of the wing for the initial set of design variables, as well as a graphical example of the discretization. As shown, the cross section is split into 4 elements for the wing box, and then each stringer is represented by one element each. The decision was made not to discretize into even more elements, as testing showed that increasing this had a minimal effect on results, due to the relatively simple geometry. We can see the general trend of the values of the cross-sectional properties, decreasing as we move outboard along the wing which is what we would expect due to the dimensions of the wing box decreasing as we move outboard, as well as the thickness of the web, skin and stringers.

# Task 2





The internal shear and bending moments were calculated for the whole span of the beam for both the load cases given, -1g and 2.5g. For the internal shear forces, this was done by integrating the loads along the span, for multiple fictitious cuts along the wing, in order to give a distribution of the shear forces along the span. This was then simply integrated in a similar process (using MATLABs trapz function) to work out the distribution of the bending moment along the span. As seen in the results, we can see that there is a maximum of both near the root of the wing, with it decreasing to 0 at the tip, this is true for both load cases.

# Task 3





The first figure shows the axial stress variation of the 1st rib under the negative 1g load case, with the variation of the Y of the cross section. There is maximum magnitude stress at the top and bottom surfaces of the wing, with the bottom surface being in compression (negative stress) and the top surface in tension. We can also observe zero axial stress at the neutral axis, y = 0. The second figure shows the variation of the maximum and minimum axial stress along the span of the wing. We can see that this is symmetrical, ie the maximum is just equal and opposite to its minimum counterpart. This reflects what we would expect as the cross section is symmetrical about y = 0.

# Task 4



The above graph shows the failure indices represented in a graphical form, where a positive value implies a failure in that condition. This is the graph for the initial set of design variables. With the initial set of variables, the only mode of failure, when not accounting for shear, is the buckling of the top and bottom stiffened panels. These fail up to 8 meters along the span. The Stringers buckling failure condition is also close to failure with a small margin , but the rest of the failure modes have a good amount of margin to failure.

# Task 5



The first step in the FE wing model was to break up the wing (modelled as a beam) in the spanwise direction into multiple nodes. For our analysis, this was 50 nodes from root to tip, hence dividing the beam into 49 elements. For the purposes of this analysis, as we are only interested in the deflection of the wing in the y direction, we modelled the wing in 2D as a beam. Therefore, we used the stiffness matrix for a 2D beam, and due to the fact that all the nodes were in line with each other, the rotational matrix was not needed. The next step was to model the distributed load given, into an approximate representation using point loads. This is shown in the figure above. The displacement solution, and gradient of the displacement was then calculated and is shown below.



# Task 6