



## MECÂNICA ESTRUTURAL – 10371/10391/10411

2014/2015

### Assignment 2

#### OBJECTIVES

To learn how to use a commercial computer program to determine the modal shapes and natural frequencies of vibration of an aircraft structure and gain experience in solving such problems.

#### 1. PROBLEM

It is required to analyse a rectangular wing of a small unmanned aircraft in terms of its natural modes of vibration.

The geometry and material properties of the rectangular wing are given in Table 1 and Table 2, respectively. The wing is assumed to be clamped at the root and is composed of skins, spars, and ribs. The wing considered has 2 C-shaped spars, located at 30% and 60% of the chord, and 5 ribs distributed uniformly along the wing span. Both skin and spars are made of aluminium. In particular, these components have the following dimensions: skin thickness  $t_0 = 0.4$  mm, spar cap height  $h_1 = 0.4$  mm, spar cap width  $l_1 = 10$  mm, spar web thickness  $t_1 = 0.4$  mm. The ribs are made of PVC foam Airex® C70.75 with 6.2 mm of thickness. These dimensions are collected in Table 3. The aerofoil of the wing is a modified version of the SG6042. The coordinates of the aerofoil are found in Table 4. A general CAD model of the rectangular wing is seen in Figure 1.

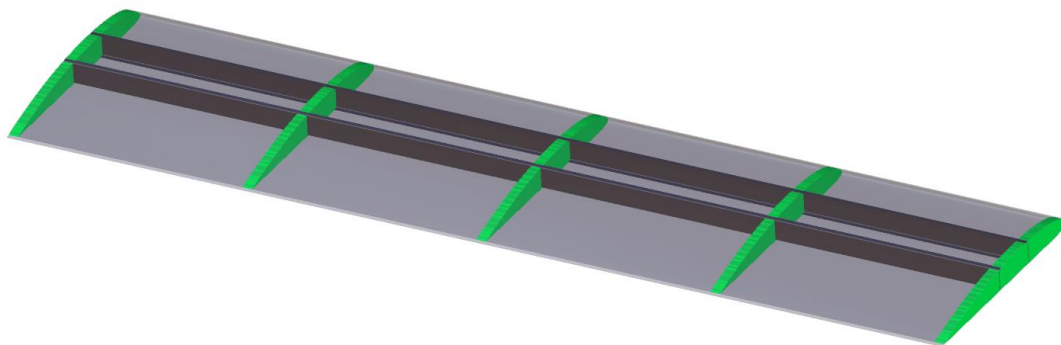


Figure 1: Wing components.

In order to obtain the mode shapes and the corresponding natural frequencies of vibration a finite element (FE) model must be set up in a commercial software package. The first six modes should be obtained. A report should be written explaining the construction of the FE model and containing the mode shapes in graphical form. The results should be discussed taking into account the following: wing mass, wing stiffness, possible impact on aeroelastic behaviour.

## 2. DATA

Below, material and geometry data of the wing and its structural components are given.

Table 1: Wing geometry.

semi-span, m	1.2
tip twist, deg	0
dihedral, deg	0
chord, m	0.25

Table 2: Material properties.

Property	Skin and Spars (Aluminum 6061-T6)	Ribs (Airex C70.75)
density, kg/m <sup>3</sup>	2700	80
Young's modulus, MPa	68900	66
shear modulus, MPa	26000	30
Poisson's ratio	0.33	0.1

Table 3: Dimensions of structural elements.

Structural variable	Value
spars position [chord fraction] (root and tip)	0.3/0.6
spars web thickness, mm (root and tip)	0.4
spars cap height, mm (root and tip)	0.4
spars cap width, mm (root and tip)	10.0
ribs position [semi-span fraction] (LE and TE)	0.0/0.25/0.5/0.75/1.0
ribs thickness, mm	6.2
skin thickness, mm	0.4

Table 4: Aerofoil coordinates.

x/c	y/c	x/c	y/c	x/c	y/c
1.000000	0.000000	0.209656	0.076807	0.214556	-0.016416
0.993692	0.001682	0.192858	0.074783	0.232664	-0.016037
0.981957	0.005159	0.176251	0.072533	0.250805	-0.015658
0.967890	0.009351	0.159815	0.070029	0.268972	-0.015278
0.952747	0.013633	0.143570	0.067264	0.287152	-0.014899
0.936987	0.017740	0.127644	0.064237	0.305338	-0.014518
0.920534	0.021735	0.112121	0.060924	0.323530	-0.014138
0.903586	0.025680	0.097051	0.057304	0.341739	-0.013758
0.886434	0.029541	0.082565	0.053383	0.359960	-0.013377
0.869146	0.033317	0.068960	0.049218	0.378174	-0.012996
0.851755	0.037014	0.056507	0.044852	0.396368	-0.012616
0.834336	0.040626	0.045379	0.040365	0.414542	-0.012236
0.816940	0.044135	0.035800	0.035928	0.432693	-0.011857
0.799533	0.047540	0.027881	0.031703	0.450818	-0.011478
0.782110	0.050847	0.021497	0.027755	0.468916	-0.011100
0.764745	0.054033	0.016376	0.024082	0.486998	-0.010722
0.747482	0.057069	0.012283	0.020702	0.505079	-0.010344
0.730304	0.059939	0.009021	0.017607	0.523171	-0.009966
0.713128	0.062638	0.006424	0.014742	0.541279	-0.009587
0.695871	0.065187	0.004362	0.012063	0.559407	-0.009208
0.678546	0.067597	0.002778	0.009548	0.577559	-0.008829
0.661209	0.069860	0.001624	0.007186	0.595736	-0.008449
0.643875	0.071972	0.000825	0.004960	0.613944	-0.008069
0.626528	0.073934	0.000292	0.002833	0.632174	-0.007688
0.609143	0.075749	-0.000031	0.000766	0.650396	-0.007307
0.591707	0.077422	-0.000096	-0.001225	0.668578	-0.006927
0.574237	0.078960	0.000237	-0.003093	0.686703	-0.006548
0.556761	0.080359	0.001116	-0.004810	0.704774	-0.006170
0.539295	0.081616	0.002549	-0.006384	0.722804	-0.005793
0.521835	0.082730	0.004463	-0.007797	0.740809	-0.005417
0.504361	0.083698	0.006812	-0.009017	0.758778	-0.005042
0.486853	0.084525	0.009669	-0.010092	0.776683	-0.004667
0.469333	0.085215	0.013103	-0.011164	0.794524	-0.004294
0.451851	0.085762	0.017223	-0.012298	0.812330	-0.003922
0.434401	0.086158	0.022212	-0.013427	0.830106	-0.003551
0.416930	0.086402	0.028418	-0.014480	0.847830	-0.003180
0.399430	0.086500	0.036410	-0.015461	0.865461	-0.002812
0.381950	0.086455	0.046687	-0.016372	0.882983	-0.002446
0.364524	0.086258	0.059303	-0.017120	0.900433	-0.002081
0.347140	0.085900	0.074102	-0.017672	0.917765	-0.001719
0.329776	0.085379	0.090360	-0.018037	0.934827	-0.001362
0.312427	0.084690	0.107372	-0.018222	0.951493	-0.001014
0.295103	0.083835	0.124875	-0.018270	0.967382	-0.000682
0.277835	0.082810	0.142600	-0.017920	0.981597	-0.000385
0.260653	0.081606	0.160444	-0.017547	0.993518	-0.000135
0.243572	0.080214	0.178421	-0.017171	1.000000	0.000000
0.226578	0.078617	0.196475	-0.016794		