UNIVERSIDADE BEIRA INTERIOR

DEPARTAMENTO DE CIÊNCIAS AEROESPACIAIS

Aerospace Structures I – 15089

2025/2026

Description of the Curricular Unit

1. OBJETIVES

The student must acquire appropriate skills to understand the function of different structural components of aerospace vehicles, as well as to undertake stress analysis considering a loading scenario identical to the one obtained in a real operational environment.

At the end of this curricular unit, students should be able to:

- identify the main structural elements of an aircraft and understand their function;
- calculate the loads applied to the various structural elements of the aircraft;
- understand the theoretical background relating to the general equilibrium equations, identifying their different terms and different parameters (stresses and strains);
- calculate stresses and displacements of aerospace components subjected to different types of loads;
- understand structural buckling mechanisms in slender elements;
- know how to size single-cell and multiple-cell thin-walled structures;
- know how to design structural elements of aircraft.

2. SYLLABUS

0. Introduction to the Curricular Unit

1. Introduction to aerospace structures: general concepts; historical overview, types and function of structural components; types of loads on the aircraft; airworthiness requirements; definition of flight envelope.

2. Loads determination: definitions; V-n diagram; forces on the aircraft; wing loads; tail loads; fuselage loads; landing gear loads; other loads.

3. Analysis of thin-walled structures: stresses under bending loading (stresses and displacements); shear and torsion in open and closed section beams; structural idealization.

4. Stress analysis of aircraft structures: tapered spars; variable section beams; fuselages; wings; openings in fuselages and wings; wing ribs and fuselage frames.

5. Structural instability: relevance in aerospace components; Euler buckling of columns and beams; inelastic buckling; effect of initial imperfections; design considerations.

Self-study 1 - Fundamental concepts: definition of stress and equations of equilibrium; stresses in rotated coordinate systems; displacements and strains; compatibility equations; introduction to theory of elasticity; constitutive equations, strain measuring.
Self-study 1 – Joints: simple lap joints; joint efficiency; group riveted joints; excentric riveted joints; bonded joints; lug design and analysis.

3. SYLLABUS / OBJETIVES

The demanding requirements of the design of aircraft structures explain some important differences of these types of structures when compared to others of other transportation modes. Despite some similarities with other areas of the Engineering Sciences, the particular characteristics of aircraft structures justify a specific curricular unit aiming at transmitting scientific and technological knowledge regarding these structures. In this context, the present curricular unit appears as a natural sequence of other previous fundamental curricular units common to an engineering course (namely Solid Mechanics).

Therefore, the syllabus of this curricular unit was designed so that the student can develop adequate skills in order to understand the function of the different aircraft structural components, as well as to be able to undertake a stress analysis under a loading scenario identical to real operational conditions.

4. TEACHING METHODOLOGIES

This curricular unit is structured in a mix of theoretical and practical topics. The material is transmitted orally with multimedia slideshow support, with additional information written on the blackboard and with a large number of example problems solved on the blackboard. A design problem of a wing structure is also developed which integrates most of the topics dealt with in classes.

5. TEACHING METHODOLOGIES / OBJETIVES

The teaching methodologies adopted for this curricular unit follow the trends of similar curricular units in other universities, combining oral exposition and multimedia presentations with the discussion of topics and project work. The adopted pedagogical strategy is also based on the development of a capacity for critical analysis through the transmission of fundamental theoretical knowledge, the resolution of practical problems corresponding to real situations and the elaboration of a bibliographic research work.

Although the professor monitors the progress of the students during the contact hours, both in theoretical and practical subjects, a more extensive individual work by students outside of the classes is necessary, regarding the study of the contents of the curricular unit, the study of other related subjects contained in the bibliographic references and the realization of the project work. This individual work promotes the autonomy and critical capacity of the student.

This curricular unit has no laboratory practice component. However, students can use the available laboratory resources outside the contact hours to complement their learning, including inspecting existing aircraft in the laboratory.

To support the teaching of this curricular unit, different but essential teaching/learning resources are used, namely:
- Video projector
- Books, articles, and other bibliography
- Notes
- Computer
- Spreadsheets
- Aircraft models previously developed at UBI and others

6. CALENDAR

Each class of four hours is a mix of theoretical and theoretical-practical topics where the subjects are presented and discussed, sample exercises are solved, and the assignment work is developed. In the table below the calendar with the topics dealt in each class is presented.

Week	Date	Chapter	Pages
1	08/09/2025	0 / 1	1-20
1	11/09/2025	1	21-41
2	15/09/2025	2	1-33
2	18/09/2025	2	34-67
3	22/09/2025	2	68-104
3	25/09/2025	2	105-145
4	29/09/2025	3	1-27
4	02/10/2025	written test	-
5	06/10/2025	3	28-46
5	09/10/2025	3	47-68
6	13/10/2025	3	69-89
6	16/10/2025	3	90-111
7	20/10/2025	holliday	-
7	23/10/2025	3	112-125
8	27/10/2025	3	126-139
8	30/10/2025	3	140-157
9	03/11/2025	3 / assignment presentation	158-179
9	06/11/2025	4	1-26
10	10/11/2025	written test	-
10	13/11/2025	4	27-35
11	17/11/2025	4	36-51
11	20/11/2025	4	52-69
12	24/11/2025	4	70-81
12	27/11/2025	4	82-86
13	01/12/2025	holliday	-
13	04/12/2025	4	87-92
14	08/12/2025	holliday	-
14	11/12/2025	4	93-108
15	15/12/2025	written test	-
15	18/12/2025	5	1-42

Questions period: Mondays at 4:00-5:30 pm.

7. ASSESSMENT

The assessment of this curricular unit is based on three written tests (T1, T2 and T3) and a design report (T4). The learning process grade is given by $T = 0.2T1 + 0.2T2 + 0.2T3 + 0.4T4$. Every student is admitted to the exam. The assessment of the exam is based on a written test (E1, E2 or E3) and the design report previously submitted (this report is done only once). The grade of the exam is $E = 0.6 \times OR(E1,E2,E3) + 0.4T4$. The final grade is $F = MAX(T,E)$. Approval occurs for $F \geq 10$.

Each assessment moment is summarized below.

1.		Semester ($T = 0.2T1 + 0.2T2 + 0.2T3 + 0.4T4$)		100
	T1	Written test	02-10-2025 (11h00)	20
	T2	Written test	10-11-2025 (09h00)	20
	T3	Written test	15-12-2025 (09h00)	20
	T4	Assignment	19-12-2025 (24h00)	40
2.		Exam ($E = 0.6 \times OR(E1,E2) + 0.4T4$)		100
	E1	Written exam (Normal)	??-01-2026 (??h30)	60
	E2	Written exam (Recurso)	??-01-2026 (??h30)	60
3.		Special exam ($E = 0.6E3 + 0.4T4$)		100
	E3	Written exam	??-07-2026 (??h30)	60

8. BIBLIOGRAPHY

01. P.V. Gamboa, Notes of the curricular unit - Estruturas Aeroespaciais I, ~540 slides, UBI, 2023.
02. T. Megson, “Aircraft Structures for Engineering Students”, 6th edition; Butterworth-Heinemann; 2017.
03. Bruce K. Donaldson; “Analysis of Aircraft Structures: An Introduction”; McGraw-Hill; 1993.
04. David Peery; “Aircraft Structures”, 2nd edition, McGraw-Hill; 1982.
05. C.T. Sun, “Mechanics of Aircraft Structures”; Wiley-Interscience; 1998.
06. F. Beer, E. Johnston, J. DeWolf, and D. Mazurek, “Mechanics of Materials”, 5th edition, McGraw-Hill Science; 2008.
07. F. Beer, E. Johnston, E. Eisenberg, and G. Staab, “Vector Mechanics for Engineers – Statics”; McGraw-Hill Science; 2003.
08. Carlos A. G. Moura Branco, “Mecânica dos Materiais”, 3ª edição, Fundação Calouste Gulbenkian; 1998.
09. Michael C.Y. Niu, “Airframe Structural Design”, Conmilit Press LTD., 1998.