Universidade de Aveiro
Departamento de Engenharia Mecânica

Aircraft Structural Analysis (ASA)

Master Course in Aerospace Engineering

Guidelines and Syllabus 2024/2025 (v. 2.0)

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Aircraft Structural Analysis

Main Goals

The curricular unit on “Aircraft Structural Analysis" of the Master Course on Aerospace Engineering represents an attempt to provide beginner learners with an integrated path (and a “birds’ eye view”) on a number of branches within the scientific domains of Structural Mechanics, Mechanics of Materials, and Modelling and Simulation.

During this introductory one semester course, it is intended that the enrolled students can acquire fundamental technical competences within the following Goals:

- G1: to become aware and understand the different methodologies involved in aircraft structural analysis;
- G2: to identify and characterise different stresses and strain paths typical in aircraft structures, and their influence on the performance and mechanical behaviour of these structures, at a macroscopic level;
- G3: to be able to critically identify the most suitable materials for different structural requests and in service scenarios;
- G4: to employ the most appropriate design methodologies (and respective analytical and numerical validation steps) for the structural calculation of simple aircraft components;
- G5: to autonomously and objectively present the results of a given structural analysis and design, with its strengths, limitations, and opportunities for further improvement.

Main Scientific Topics (overview)

The main relevant topics to be covered in the curricular unit are as follows. Complimentary topics can be covered in practical works carried out by the students.

- plate bending; generalised classic formulation
- thin rectangular plates: the Kirchhoff theory
- generic rectangular plates: the Mindlin theory and approximation methods (Navier, Lévy)
- theory of shells: generalised classic formulation
- shells of revolution and the membrane solution
- symmetric bending of shells of revolution
- general theory of cylindrical shells
- structural instability: buckling of columns and thin plates (*complimentary topic, related to practical assignments*)
- reinforced/stiffened plates and shells (*complimentary topic, related to practical assignments*)
- laminated composite structures (*complimentary topic, related to practical assignments*)
- linear and nonlinear geometric analyses and numerical simulation tools (*related to all practical assignments*)

References (suggestions)

- Ugural, "Stresses in Plates and Shells", 3rd ed., McGraw-Hill, 2010 (main theoretical reference)
- Megson, “Aircraft Structures for Engineering Students”, 7th ed., 2021 (main applied reference)

- Timoshenko and Woinowsky-Kreiger, "Theory of Plates and Shells", 2nd Edition, McGraw-Hill, 1959 (secondary theoretical reference);
- Madier, “Practical Finite Element Analysis for Mechanical Engineers”, 1st Edition, FEA Academy, 2020 (auxiliary reference on the Finite Element Method)

Evaluation and final gradings

The final grading is obtained by means of a number of feedback and assessment moments during the semester. These are distributed in the following form:

- 2 (two) **oral presentations** on the evolution on each group **practical work**, following a research topic assigned at the beginning of the semester;

- 1 (one) **written report** summarising the practical work carried out by the group during the semester;

- 1 (one) **test** covering theoretical aspects of the main topics covered during the semester.

The **“follow up” (pitch) presentations** are scheduled to happen during class time, at the following dates:

- 05 November, 2024, 15h30 - 17h00

- 17 December, 2024, 14h00 - 16h00 (end of classes)

Each **group** can be composed by 2, 3, or 4 students. Each **“follow up” presentation** by the students will cover the progress of each individual practical assignment, for a maximum of 10 minutes per presentation / group.

Each practical work will correspond to a **written summary report** covering the fundamental aspects of each work: objectives, methodologies adopted, developments created, main results and conclusions. **This summary report can be either in Portuguese or English languages, with a maximum length of 20 pages.** The report is supposed to be delivered until the date of the “Normal” exam (09 January, 2025). An updated version of the report can be (optionally) delivered until the date of the “Recurso” exam (28 January, 2025).

The final grading will be calculated by means of the following weights:

- theoretical tests (“Normal” and/or “Recurso” exams): 35%, individual grade (up to 7/20 points)

- written reports: 35%, group grade (up to 7/20 points)

- “follow up” presentations: 10% for the first presentation + 20% for the final presentation (total up to 6/20 points)

Schedule for 2024/2025

Week #01 (01 October)
Kick-off meeting with students: discussion and definition of the teaching/learning strategies for the semester, the practical assignments, groups' definition, presentations and final test

Week #02 (08 October)
Review of fundamental concepts: strength of materials, constitutive modelling, dimensioning, project and design guidelines

Week #03 (15 October)
Elements of plate bending theory: Ugural, Chapter 3, Sections 3.1 — 3.6 (theory + case studies)

Week #04 (22 October)
Elements of plate bending theory: Ugural, Chapter 3, Sections 3.7 — 3.13 (theory + case studies)

Week #05 (29 October)
Session dedicated to the practical projects, individually with each group

Week #06 (05 November)

"Follow up" presentations (assessment session), by each group

Week #07 (12 November)
Session dedicated to the Finite Element Method (FEM): theory and fundamentals, applications, advantages and limitations

Extra material: Navier and Levy approximated solutions for rectangular plates can be used as testing problems for FEM

Week #08 (19 November)
Membrane stresses in shells: Ugural, Chapter 12 (theory + case studies)

Week #09 (26 November)
Bending stresses in shells: Ugural, Chapter 13 (theory + case studies)

Week #10 (03 December)
Bending stresses in shells: Pressure Vessels (Part 1): Ugural, Chapter 14 (theory + case studies), comparison with FEM solutions

Week #11 (10 December)
Bending stresses in shells: Pressure Vessels (Part 2): Ugural, Chapter 14 (theory + case studies), comparison with FEM solutions

Week #12 (17 December)

Final presentations, by each group

Deadlines and milestones after the ending of classes

"Normal" exam season: Deadline for delivery of the written report + Written test (09 January, 2025)

"Recurso" exam season: Deadline for delivery of the updated/improved version of written report (optional) + Written test (28 January, 2025)

Calendar for 2024/2025