Institut Supérieur de l'Aéronautique et de l'Espace
SUPAERO

Syllabus 2027
Spring Semester
in Aeronautical Engineering

SS1 - Representation, analysis and control of dynamic systems

OBJECTIVES

This course is an introduction to automatic control and it aims at providing the non-specialized students the basics of the servo systems theory and above all their implementation on realistic **Aeronautical** and **Aerospace** case studies.

The aims of the module are the following:

- Deriving transfer function and state space representation of a linear dynamic system starting from a set of differential equations;
- Describing the performance of a linear system both in time-domain and frequency-domain;
- Solving a practical control problem in terms of tracking and/or rejection performance with an appropriate controller;
- To understand the technological limits due to real time implementation of a discrete controller.

Pre-requisites:

- Engineering maths

Organization

25x lectures (25h)
10x tutorials (10h)
10x lab work on case study (10h)

Total: 45 hours (excluding examination, revision time, and personal work)

Estimated personal work (including revision time): 65 hours

Evaluation

1 Case study reporting (40%)
1 intermediate written exam (1h) (20%)
1 final written exam (2h) (40%)

US CREDIT HOURS / ECTS : 3 / 6

CONTENTS

Introduction

- The concept of dynamical systems.
- Laplace Transform
- State space and block-diagram representations – Transfer functions
- Introduction to Matlab/Simulink

Linear system analysis

- Modal analysis
- Time-domain analysis
- Frequency-domain analysis: Bode, Black, Nyquist

Control design

- Basic principles: disturbance rejection, performance, stability margins, precision
- Root locus method
- PID control, Modal control

Discrete-time systems

- Representation and analysis
- Controller discrete-time implementation

Case study

- **Aeronautical track**: basics in flight mechanics, Flight control and autopilot design for a civil aircraft,
- **Aerospace track**: basics on spacecraft dynamics and instrumentation: Attitude control of an Earth-observation satellite

Bibliography :

Richard C. Dorf and Robert H. Bishop. *Modern Control Systems*, Prentice Hall

Karl J. Åström and Richard M. Murray, *Feedback Systems: An Introduction for Scientists and Engineers* (online)

Course director: Prof.Daniel Alazard

SS2 - Introduction to Aircraft Structures

OBJECTIVES

This course is an introduction to the preliminary design of aircraft structures. It is mainly focused on the basic concerns required before pre-sizing aircraft structures. The general architecture of aircraft structures is described to justify the interest in the use of the Beam Theory. The Beam Theory is then reminded then focused on the thin walled sections and hyperstaticity. It is then applied to analysis of load transfer within joints. A particular emphasis on the stress analysis on thin walled structure is offered through the presentation of an industrial case. Finally, a fundamental opening on Fatigue and Damage Tolerance (F&DT) applied to aircraft structures is offered from an industrial point of view.

The aims of the module are the following:

- To be able to explain the main problems to be considered when pre-sizing aircraft structures
- To be able to explain how aircraft structures are designed
- To be able to explain how thin walled structures are loaded
- To be able to compute the induced loads in thin-walled structures
- To be able to explain the stakes linked to F&DT
- To be able to perform elementary F&DT analyses

Pre-requisites:

- Fundamentals of continuum mechanics
- Fundamentals of Solid Mechanics
- Basic of Beam Theory

Organization

24x lectures including tutorials and project kick off (24x1h = 24h)
2x workshops (2x2h = 4h)
2x student projects (2x(0.5+0.5)h=2h for intermediate review and final defense)

Total: 30 hours (excluding written examination, revision time, work on project and personal work)

Evaluation

30%: 1 written exam (2h)
25%+25%: 1 oral defense for each of both projects (2x0.5h)
10%+10%: 2 workshops (2x2h)

Estimated personal work: 90 hours

US CREDIT HOURS / ECTS: 3 / 6

CONTENTS

- General architecture of aircraft structures
- Review of basic of Beam Theory
- Focus of Beam Theory on thin section walled section and hyperstatic condition
- Analysis of load transfer within joints through the use of the Beam Theory
- Emphasis on the thin walled structures
- Elements of Linear Fracture Mechanics and of Metallurgy in view of F&DT
- F&DT stakes and basic method for aircraft structures design

Bibliography:

THG MEGSON (2010) An introduction to aircraft structural analysis. Butterworth Heinemann Eds

MCY NIU (1993) Airframe structural design. LOCKHEED AERONAUTICAL SYSTEMS Co., conmilit press ltd, Hong-Kong. ASTM STP 842, J.B. Chang & J.L. Rudd, Eds., American Society for Testing and Materials

Course director: Prof. Eric Paroissien

SS3 - French language and cultural discovery

OBJECTIVES

This course includes a welcoming module, French language classes and cultural workshops and visits in order to help students adapt the host country and make them familiar with their new environment.

French classes based on levels:

- Classes will be set up to help students achieve an A1, A2, B1 or B2 level by the end of the semester, according to their level when arriving.

Cultural aspects:

- Learning about French culture and society
- Discovering a new environment

Organization:

- Courses: 78h (beginners) / 72h (other levels)
- Workshops and visits: 15h
- Pupitrage: 10h
- Personal work: 10h
- **Total: 113 hours (beginners)**
  107 hours (other levels)

Evaluation:

Continuous assessments (50%)
A final written exam (50%): 2h

US CREDIT HOURS / ECTS: 3 / 6

CONTENTS

French language:

A1 level:

- Basic grammar, familiar expressions and vocabulary to use in a concrete context to satisfy immediate needs:
  - Introducing oneself, introducing someone
  - Asking and answering questions
  - Topics related to personal relations and belongings (family, friends, accommodation…)
- Communication in everyday situations (asking in a polite way, doing some shopping, ordering in a restaurant…)

A2 level:

- Grammatical tools, expressions and vocabulary to understand and express simple messages
- Topics related to personal relations and belongings, immediate environment and shared domain of interest
- Interacting in simple and short conversations

B1 level:

- Grammatical tools, expressions and vocabulary to understand the main points of clear standard input on familiar matters regularly encountered in work, school, leisure, etc.
- Producing simple connected text on topics which are familiar or of personal interest.
- Describing experiences and events, dreams, hopes & ambitions and briefly give reasons and explanations for opinions and plans.

B2 level:

- Grammatical tools, expressions and vocabulary to understand the main ideas of complex text on both concrete and abstract topics, including technical discussions in his/her field of specialization.
- Interacting with a degree of fluency and spontaneity that makes regular interaction with native speakers quite possible without strain for either party.
- Producing clear, detailed text on a wide range of subjects and explaining a viewpoint on a topical issue giving the advantages and disadvantages of various options.

Cultural matters:

- Workshops on French culture
- Cultural Visits (The city of Toulouse, Aéroscopia, Cité de l'espace, museums …)

Course director: Dorothée Lamour

SS4 – Applied Aerodynamics

OBJECTIVES

In this course standard results of incompressible potential flow are revisited, along with key aspects of compressible flows, with the view of applications to aerodynamics.

The aims of the module are the following:

- To review conservation laws;
- To review key results of potential flow theory, including application to thin airfoils;
- To design an airfoil for a given set of constraints;
- To review finite wing theory and wing-fuselage integration;
- To study basic properties of two-dimensional transonic and supersonic flow with applications related to aircraft and propulsion;
- To study principles of hypersonics.

Pre-requisites:

- Fundamentals of continuum mechanics
- Basic thermodynamics (BEng Mech Eng, BSc Physics)
- Gas Dynamics for Aerodynamics and Propulsion
- Fundamentals of viscous flows

Organization
15x combined lectures-tutorials (45h)
1x lab (3h)

Total: 48 hours (excluding examinations, revision time, and personal work-project)

Estimated personal work and airfoil & wing projects: 40 + 40 hours

Evaluation
1 lab session report (5%)
1 project reporting (20%)
1 project presentation (20%)
1 intermediate written exam (1h) (15%)
1 final written exam (3h) (40%)

US CREDIT HOURS / ECTS : 3 / 6

CONTENTS

- Potential flows and the Kutta-Jukowski theorem
- Theory of thin airfoils and application to airfoil design
- The lifting-line theory, and non-optimized wing
- Introduction to airfoil and wing design
- Oblique shock waves
- Expansion
- Transonic flows
- Linerarized flows
- Ideal gas model
- Basics of hypersonics

Bibliography :

Anderson J D, Fundamentals of aerodynamics, 2001; ISAE: 629.132 3 AND

Houghton E L, Carpenter P W, Aerodynamics for engineering students, 1960, 1993, 2003: ISAE: 629.132 3 HOU /

P. G. Hill and C. R. Peterson. Mechanics and thermodynamics of propulsion,1992

Course director: Emmanuel Bénard

SS5 – Preliminary Aircraft Design

OBJECTIVES

In this course key aspects of aircraft design will be presented, such as requirements, regulations, design process, aircraft loads, mass models, aerodynamic and propulsion models, aircraft stability. Interactions between disciplinary issues will also be explored.

The aims of the module are the following:

- To discover key engineering disciplines at play in preliminary aircraft design with emphasis on low fidelity models;
- To explore the potential trade-offs at preliminary design stage;
- To complete the preliminary design of a conventional aircraft and, to a limited extent, a less conventional aircraft (high aspect ratio, blended wing body…);
- To use an existing preliminary aircraft design process, with potentially limited software developments;
- To present the final work to peers (oral) and within a synthetic report;

Pre-requisites: none

Organization
10 x lectures (30h)
2 x industrial lectures (6h)

Total: 36 hours (excluding intermediate presentations, project work, review time, and personal work)

Estimated personal work: approx. 90 hours

Evaluation
1 project reporting (60%)
1 intermediate review on certification (10%)
1 industrial lectures reporting (10%)
1 final oral presentation (1h) (20%)

US CREDIT HOURS / ECTS : 3 / 6

CONTENTS

- Review of atmosphere properties
- Aircraft design requirements
- Aviation regulations and certification
- Aircraft loads, mass models
- Review of basic aircraft aerodynamics and stability, and propulsion models
- Preliminary design process

Bibliography :

General Aviation Aircraft Design [0-12-397308-2; 0-12-397329-5] Gudmundsson, Snorri An.:2014

Advanced Aircraft Design: Conceptual Design, Technology and Optimization of Subsonic Civil Airplanes [1-118-56811-7; 1118-56809-5] Torenbeek, Egbert. An.:2013

Aircraft Design [0-521-88516-7; 0-511-68556-4] Kundu, Ajoy Kumar. An.:2010

Course director: Emmanuel Bénard