Syllabus 2021
Spring Semester
in Aeronautical / Aerospace 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 (10x)

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 directors: Daniel Alazard

ISAE-SUPAERO contact: 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: Eric Paroissien

ISAE-SUPAERO contact: Emmanuel Bénard

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:

- To learn about French culture and society
- To discover a new environment

Organization :

- Courses: 75h
- Workshops and visits: 15h
- Pupitrage: 10h
- Personal work: 10h

Total: 110 hours

Evaluation :

Regularly tested in the French classes
1 final oral exam (30 min)
1 final written exam (1.5h)

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…)
- Simple 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

Cultural matters:

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

Course director: Emmanuel Bénard

ISAE-SUPAERO contact: Dorothée Vilaine

SS4 – Aerodynamics and Propulsion

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 both aerodynamics and propulsion.

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;
- To study basic properties of two-dimensional transonic and supersonic flow;
- To study principles of gas turbine combustion.

Pre-requisites:

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

Organization
13x combined lectures-tutorials (40h)
3x labs (6h)

Total: 46 hours (excluding examinations, revision time, and personal work-project)

Estimated personal work and airfoil project: 46 + 20 hours

Evaluation
3 lab session reports (2x10%+20%)
1 project reporting (20%)
1 intermediate written exam (1h) (10%)
1 final written exam (3h) (30%)

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
- Propulsion principles
- The Ideal and Non-ideal Turboshaft Cycle
- Thrust and Propulsive Efficiency. The Turbojet Cycle
- The Turbofan Cycle

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 directors: Emmanuel Bénard

ISAE-SUPAERO contact: 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

ISAE-SUPAERO contact: Emmanuel Bénard

SS6 – Introduction to Astrodynamics

OBJECTIVES

This course provides an introduction to astrodynamics by developing mathematical descriptions of the orbital and rotational motions of spacecraft. The student will learn how to apply this knowledge to space mission analysis problems through group work and assessed labs.

The aims of the module are the following:

- To learn the characteristics of the motion of a system of particles with emphasis on the two-body problem;
- To understand the effect of main perturbations of spacecraft motion;
- To understand the rotational dynamics of a rigid spacecraft;
- To apply the knowledge to space mission design;
- To solve space mission analysis problems, both with analytical and numerical approaches.

Pre-requisites:

- Engineering maths

Organization
25x lectures (25h)
10x tutorials (10h)
10x lab sessions (10h)

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

Estimated personal work (including revision time): 75 hours

Evaluation
1 lab-based assignment (20%)
1 final written exam (2h) (80%)

US CREDIT HOURS / ECTS: 3-4 / 6

CONTENTS

Two Body Problem

- Equations of motion
- Kepler's laws
- Integral of motions
- Kepler's equation
- Orbital parameters and ephemeris

Orbit perturbations

- Geopotential
- Atmospheric drag
- Solar radiation pressure
- Third-body perturbations

Mission Design

- Orbital maneuvers
- Hohmann transfer
- Hyperbolic orbits
- Interplanetary mission design
- Reference frame and time
- Launch windows
- Ground-tracks and special orbits

Rigid Body Dynamics

- Attitude parameterization (direction cosine matrix, Euler angles, Euler axis and angle, quaternions
- Attitude kinematics
- Equations of motion of the angular momentum
- The moment of inertia matrix
- Euler's equations

Satellite Attitude Dynamics

- Torque free motion
- Single spin spacecraft
- Reaction/momentum wheels and control moment gyros
- Introduction to attitude control laws

Bibliography:

Howard D. Curtis, Orbital Mechanics for Engineering Students, 3rd Edition, Elsevier Aerospace Engineering Series, 2010

Course directors: Roberto Armellin

ISAE-SUPAERO contact: Roberto Armellin