Master of Science in Aerospace Engineering

All modules carry 5 ECTS Credits each.

COMPULSORY MODULES

1) Introduction to Aeronautics

This module will provide a basic overview of the different systems and processes applied in aviation. A general understanding of civil and military aviation will be given to enable basic differentiation of different aircraft configurational layouts. In particular, the interaction among different system elements, their respective requirements and their impact on configuration level will be outlined.

Hours: 45 / **Semester:** 1

2) Mechanics for Aerospace Engineers

Mechanics addresses the description and predetermination of the movements of bodies and their corresponding forces. Bodies at rest as a sub-field of mechanics are described in (elasto-)statics, the fundamentals of which are taught in this module. After successful participation, students are able to recognize static load-bearing structures in nature and technology and can extract mechanical models from reality, classify them in terms of analysis and calculate statically determinate as well as statically indeterminate systems using the methods they have learned. The basic methods learned contribute to the development of the ability to formulate mechanical issues in engineering problems and to solve them independently.

Hours: 45 / **Semester:** 1

CORE MODULES

3) Aerodynamics

The module Aerodynamics deals with the basics of calculation and analysis of aerodynamic forces acting on aircraft.

Hours: 45 / **Semester:** 1

4) Introduction to Flight Mechanics

This module will cover topics in flight system dynamics and flight control. Students will be able to understand relations between aircraft performance and flight control. Through this course, students will be able to apply aircraft performance calculations that are required in the preliminary design of aircraft and will be able to design basic flight controllers for stabilisation and improvement of flight properties.

Hours: 45 / **Semester:** 1

5) Flight Propulsion

The module provides basic knowledge about aerospace propulsion systems. The basic governing thermodynamic & aerodynamic equations used in the engine design process, Aero engine and gas turbine cycle and component performance as well as their interaction will be covered.

Hours: 45 / **Semester:** 1

6) Structures and Materials

This module covers the essentials of lightweight structures & materials, which provide a basis for structural development including proper material selection. A general view on the basics in elasticity, structural stability, vibrations and strength including fatigue problems are given. Design, numerical analysis and test methods are introduced. On the materials side, metal lightweight alloys and fiber composites are covered.

Hours: 45 / **Semester:** 1

LABORATORY MODULES

7) MATLAB Aero Lab

MATLAB & Simulink for Flight Dynamics & Controls

Embark on an exploration of MATLAB and Simulink in the dynamic field of aerospace engineering with the MATLAB Aero Labs course. This comprehensive module is designed to arm you with the fundamental skills and advanced techniques essential for modeling, simulation, and control in aerospace applications. Through a hands-on approach, you'll delve into MATLAB and Simulink toolboxes, discovering their vast capabilities in simulation, system analysis, optimization, and control design. The course begins with general exercises that introduce you to the breadth of tools and functions available. This foundation will enable you to tackle more complex problems and algorithms confidently. As the course progresses, you'll engage in specialized exercises that focus on aerospace-specific challenges, particularly in flight system dynamics and flight control systems. These exercises are tailored to provide a deeper understanding of how MATLAB and Simulink can be leveraged to enhance innovation and efficiency in aerospace engineering tasks. In engineering, proficiency in MATLAB and Simulink is essential. From startups to major companies, these tools are the backbone of designing control systems, modeling systems, and analyzing dynamics across various engineering fields. Mastering them is essential not only for future aerospace engineers but for any engineer who aims to contribute in the domain of modelling, system analysis and control.

Hours: 45 / **Semester: 2**

8) Structural Modelling Lab

The course demonstrates the use of common Finite Element software tools using typical examples from the field of aerospace structures. The most important basics of FEM, and modelling aspects will be covered. Typical questions in the structural calculation from the areas of statics and dynamics serve as examples. With the knowledge gained, aeronautical structures can be modelled, analysed and evaluated with regard to their characteristics.

Hours: 45 / **Semester:** 2

9) Aerodynamic Modelling Lab

The course provides an introduction to fluid dynamics modelling for aerospace applications. After successful participation, students are able to understand different models and methods available in current flow simulation tools. The set-up and execution of flow simulations as well as the analysis and evaluation of the results are discussed. Upon successful completion, participants will be able to analyse and evaluate aerodynamic properties, such as forces and pressure distributions, as required in the aircraft design process.

Hours: 22.5 / **Semester:** 2

ELECTIVE MODULES*

10) Additive Manufacturing

The module is an introduction to additive manufacturing and focuses on additive manufacturing technologies for both polymers and metals. The entire process chain of additive manufacturing is discussed, including feedstock materials, part design, production processes, monitoring, post-processes, and standardization. The module is enriched by a **hands-on printing exercise**, exemplary applications, expert talks from industry, and field trips.
Lecturers: Prof. Dr. Peter Mayr / **Hours:** 45 / **Semester:** 2-310) **Advanced Flight Control Systems**

This module conveys complex control concepts for aircraft. How the C*-criterion is derived and modern concepts of adaptive control in aviation are covered.

Hours: 45 / **Semester:** 2-3

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Hours: 45 / **Semester:** 2-3

12) Aerodynamic Design of Turbomachinery

This module covers the various types of turbomachinery applications with particular emphasis on compressors. Starting from the fundamental equations in fluid dynamics, the working principle of turbomachinery are derived. Moreover, main components, characteristics and associated flow phenomena are explained. For compressors, design methods and processes, topics of operability and stability enhancement are covered.

Hours: 45 / **Semester:** 2-3

13) Aeroelasticity

This module describes basic aeroelastic phenomena arising from the mutual interaction of elastic, aerodynamic and inertial forces on a structure, with special emphasis on problems related to fixed wing vehicles. Aeroelasticity plays a major role in the design, qualification and certification of flying vehicles, as it contributes to the definition of the flight envelope and affects various performance indicators.

Hours: 45 / **Semester:** 2-3

14) Aerospace Structures

This module introduces the approaches for the development process of lightweight and aerospace structures, including design, simulation, optimisation and testing aspects. Current structural design concepts for aerospace applications are shown in the context of goals and requirements to be achieved. Possible future developments are addressed and reasons are discussed.

Hours: 45 / **Semester:** 2-3

15) Aircraft Design

This module covers various current design methods & relevant design tools for the applied design of surface aircraft. With the simultaneous introduction to the aircraft design system, students are enabled to design both individual components of the aircraft with regard to the overall aircraft, and define the overall aircraft configuration so that it complies with the current requirements with regard to safety, safety and security economy, comfort, the environment and the performance of flights.

Hours: 45 / **Semester:** 2-3

16) Boundary Layer Theory

This module covers basic phenomenons present in boundary-layers. Physical models and the derivation of the boundary-layer equations from the Navier-Stokes equations are discussed for flat 2-dimensional cases. Temperature, compressible and 3-dimensional boundary-layers are explained. The stability theory explains the laminar-turbulent transition, turbulent boundary-layers and experimental research methods.

Hours: 45 / **Semester:** 2-3

17) Flight Control Systems

This module introduces the basic operating principle of flight controls. Based on the non-linear equations of motion of airplanes and basic control theory principles, control strategies are derived in order to improve the handling qualities or stability of airplanes. In addition, strategies for the implementation of autopilots are presented.

Hours: 45 / **Semester:** 2-3

18) Helicopter Engineering

The content extends over different design requirements and their classification, the sizing process, evaluating the flight performance with respect to power consumption, rotor craft limits and mission design. Additionally, the lecture will cover tools for the cost and weight estimation of the designed rotorcraft.

Hours: 45 / **Semester:** 2-3

19) Safety and Certification of Aircraft

This module covers Aviation Safety Principles, Basics in Regulations, Airworthiness Code (CS-27, CS-29), Loads, Stress & Fatigue, Performance Categories, Safety Analysis & Flight Accident Investigation. During the presentation of the basic chapters of flight safety and certification the students have the possibility to discuss the important aspects together with the professor. The module covers following chapters such as Aviation Safety Principles, Basics in Regulations Airworthiness Code (CS-27, CS-29), Loads, Stress and Fatigue, Performance Categories, Safety Analysis, and Flight Accident Investigation.

Hours: 45 / **Semester:** 2-3

20) Safety & Certification of Avionics & Flight Control Systems

This module addresses the certification process of avionics and flight control systems in commercial aviation. The focus of this lecture lies in safety analysis methods, taking common approaches of their employment in development projects of safety-critical systems in the industry into account. The course begins with giving a general overview of the development and certification of flight control systems, along with the contents of relevant development standards and recommended practices and the resulting process structure. Based on this, profound knowledge of the process and methods of safety assessment of complex technical systems in aircraft is conveyed.

Hours: 45 / **Semester:** 2-3

21) Spacecraft Technology

This module covers astronautical and space engineering topics, and relevant theoretical background and engineering design methods to find suitable solutions for spaceflight and spaceflight technology. The module will be following the processes and technologies from launch (physics of spaceflight, rockets, propulsion, trajectory, spaceflight environment) to orbit with topics in physics (orbital mechanics and dynamics, interplanetary flight, navigation) and engineering subsystem technologies (power, thermal, communication, sensors, actuators). The topics and processes will be presented with practical applications in mind.

Hours: 45 / **Semester:** 2-3