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Brandenburgische
Technische Universität
Cottbus - Senftenberg

Modulhandbuch für den Studiengang Hybrid Electric Propulsion Technology (universitäres Profil), Master of Science, Prüfungsordnung 2024

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Module 13789 Master Thesis

assign to: Total Account

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13789	Mandatory

Modul Title	**Master Thesis** Master-Arbeit
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Höschler, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	18
Learning Outcome	Throughout their thesis, students substantiate their ability to independently and successfully handle specific tasks under the guidance of a supervisor. They demonstrate the application of scientifically grounded theoretical and practical knowledge to address problems, encompassing tasks such as literature review, problem definition, methodology identification, analysis, scientific discussion, and thesis writing.
Contents	The thesis content may have either a theoretical or practical orientation and should align with the latest scientific knowledge in the educational field. It is expected to address current problems within the field. A Master's thesis comprises a written work in accordance with the program's regulations (PStO).
Recommended Prerequisites	none
Mandatory Prerequisites	Admission to the Master's thesis is granted to students who have completed at least 78 CP at the time of registration for the Master's thesis, 36 of which must be in the area of subject specialisation.
Forms of Teaching and Proportion	Self organised studies - 540 hours
Teaching Materials and Literature	Required material will be provided by the thesis supervisor.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Written thesis, 75% • Colloquium, 25 %

Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The deadline for the written part of the Master's thesis is four months.
Module Components	.
Components to be offered in the Current Semester	No assignment

Module 13790 Industrial Internship

assign to: Total Account

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13790	Mandatory

Modul Title	**Industrial Internship** Praktikum
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Höschler, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	12
Learning Outcome	The internship is mandatory for students in order to get to know the essential work processes of engineers and to apply the skills they have acquired in practice. The internship helps to supplement key qualifications such as the design and control of collaboration and communication in the team in their practical relevance. An important aspect of the internship is understanding the sociological perspective of what is happening in the company. The students should understand the company as a social structure and in particular get to know the relationship between managers and employees.
Contents	The industrial internship can include both operational and engineering-related activities. Various areas of responsibility in propulsion technologies and thermal management systems can be chosen. Further practical activities in the context of project work in which the interns work on a typical engineering project or in the area of research and development can be completed. The industrial internship can be completed in domestic or foreign companies. Typical company sectors include companies in the motor vehicle industry, the rail transport industry, shipbuilding, aerospace, as well as engineering service providers, component suppliers. Details are regulated in the relevant internship regulations in the PStO.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Practical training - 320 hours Research paper/essay - 40 hours

Teaching Materials and Literature	Must be provided by the company
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	According to the PStO: • an internship report including an internship certificate must be submitted after the internship.
Evaluation of Module Examination	Study Performance – ungraded
Limited Number of Participants	none
Remarks	none
Module Components	.
Components to be offered in the Current Semester	No assignment

Module 13793 Study Project

assign to: Total Account

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13793	Mandatory

Modul Title	**Study Project** Studienprojekt
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Höschler, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	Students are able to prove that they are capable of completing a subject-related project. This should be interdisciplinary in nature and contain a challenging and solution-orientated task. They train skills in construction and design. The students are able to analyse problems in the process of development and solve them by adapting of learned methods or communicating with specialists supporters. They can visualise and present the results of the project.
Contents	The project assignment can include both practical and theoretical content that represents the student's advanced level of knowledge. In addition to the purely content-related elaboration, the project should also be planned with project goals, milestones and expenditure, which is orientated towards research and industry projects.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Consultation - 1 hours per week per semester Study project - 165 hours
Teaching Materials and Literature	Depending on the task.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Submission of a project documentation of at least 30 pages (70%) and • Presentation of the results, 15 minutes (30%)

Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	none
Components to be offered in the Current Semester	**350355** Seminar Study Project - HEPT

Module 11494 Control Engineering 1

assign to: Subject Specialization

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	11494	Compulsory elective

Modul Title	**Control Engineering 1** Regelungstechnik 1
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Schiffer, Johannes
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	On completion of this module, students should be able to: • Analyze the behavior of linear dynamical systems in the frequency domain; • Design single-input-single-output controllers in the frequency domain; • Control linear systems with time delays; • Have developed an understanding for the application of control engineering methods to real-world applications based on examples and laboratory exercises.
Contents	Feedforward and feedback control; Fundamentals on signals and systems (repetition); Description of dynamical systems in the time and frequency domains; Frequency response; Control system properties and specifications; Stability; Hurwitz criterion; Nyquist criterion; Bode diagrams; Controller synthesis in the frequency domain; PID control; Cascaded control; Control of systems with time delays.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Laboratory training - 1 hours per week per semester Self organised studies - 105 hours
Teaching Materials and Literature	• K. J. Åström and R. M. Murray, "Feedback Systems", Princeton University Press, 2009

- G. F. Franklin, J. D. Powell, A. Emami-Naeini, "Feedback Control of Dynamic Systems", Vol. 3. Reading, MA: Addison-Wesley, 1994
- J. Lunze, "Regelungstechnik 1", Springer-Verlag, 2013
- Unbehauen, Heinz, "Regelungstechnik I – Klassische Verfahren zur Analyse und Synthese linearer kontinuierlicher Systeme", Vieweg Verlag Braunschweig/Wiesbaden

Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	Prerequisite: • Submission of at least 65% of the online homework • Successful participation in all lab sessions including short tests (ungraded) Final Module Examination: • Written exam, 90 minutes Permitted aids are **two** DIN A4 sheets, **handwritten** on both sides. For calculations, non-programmable calculators are allowed. Any other type of electronic device is **not** allowed. For successfully completed online homework, a maximum of 10% bonus points can be earned for the final examination.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Control Engineering 1 (lecture) • Control Engineering 1 (exercise/practical training) • Control Engineering 1 (exam)
Components to be offered in the Current Semester	**320673** Examination Control Engineering 1

Module 13249 Introduction to Gas Dynamics

assign to: Subject Specialization

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13249	Compulsory elective

Modul Title	**Introduction to Gas Dynamics** Einführung in die Gasdynamik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Schmidt, Heiko
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successful participation the students are able to distinguish the physical properties of compressible and incompressible fluid flows. They have understood the governing equations, relevant phenomena, and control parameters, and they are able to perform a quantitative analysis of simple problems. In the exercise the students apply theoretical concepts to sample problems in order to develop analytical and numerical problem-solving skills.
Contents	• Conserved quantities and conservation laws • Nondimensional numbers • Sound speed and propagation • Flow regimes • Basics of aerostatics • Isentropic, barotropic, and polytropic flows • State change with entropy change • Steady compressible flows • Unsteady compressible flows • Stationary and propagating shocks
Recommended Prerequisites	Basic knowledge of continuum mechanics, fluid dynamics, and thermodynamics is an asset.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	• Liepmann & Roshko. Elements of Gas Dynamics. Dover, 2002. • Babu. Fundamentals of Gas Dynamics. Springer, 2011. • Achterberg. Gas Dynamics: An Introduction with Examples from Astrophysics and Geophysics. Atlantis, 2016. • Oswatitsch. Grundlagen der Gasdynamik. Springer, 1976.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• oral examination, approx. 40 minutes
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The module aims at Bachelor students from all disciplines with interest in but no or little knowledge of gas and fluid flows.
Module Components	VL/ÜB/PRÜ Introduction to gas dynamics
Components to be offered in the Current Semester	**350412** Lecture Introduction to gas dynamics - 2 Hours per Term **350413** Exercise Introduction to gas dynamics - 2 Hours per Term **350472** Examination Introduction to gas dynamics

Module 13801 Fundamentals of Engine Technology

assign to: Subject Specialization

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13801	Compulsory elective

Modul Title	**Fundamentals of Engine Technology** Grundlagen der Triebwerkstechnik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Höschler, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successfully participating in the module, students have basic knowledge of the design and performance calculation of aero engines. You are able to work on given questions using engine-specific construction and modeling methods and to critically question both current and future scientific problems and answer them independently.
Contents	• Design of aero engines • Requirements and specialist areas in engine design • Design process, design rules and strength of materials • Annulus diagram, rotor dynamic design, internal air system, oilsystem and bearing chambers, radial gap behavior in compressors and turbines • Engine installation and suspension, equipment, devices, dressings • Introduction to thermodynamics, thermodynamic basics of cycle calculation, performance management (ratings) and regulation, • Advanced modeling capabilities - ways to increase accuracy • Basics of testing and analysis (sea level, altitude, compliance testing)
Recommended Prerequisites	none
Mandatory Prerequisites	No successful completion of module *31302 Grundlagen der Konstruktion und Leistungsrechnung*.
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Bräunling: Aircraft engines, ISBN 3-540-67585-X

Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Oral examination, 60 minutes OR Written examination, 120 minutes In the first lecture it will be announced, if he examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	VL + PRÜ Fundamentals of Engine Technology
Components to be offered in the Current Semester	**350388** Examination Fundamentals of Engine Technology

Module 13835 Fundamentals of Electrical Drive Technology

assign to: Subject Specialization

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13835	Compulsory elective

Modul Title	**Fundamentals of Electrical Drive Technology** Grundlagen der elektrischen Antriebstechnik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Möhlenkamp, Georg
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Students learn the basics of Electrical Machines in Drive Systems. They understand the functional principle in modelling and can explain the static and dynamic electrical and thermal behavior. Concrete Drive Parameters are calculated in the seminar. Due to the learned kinetic and energetic laws students are able to calculate the behavior of the system and the dimensioning of the machine. In the exercise students apply these learnings in the laboratory and train teamwork.
Contents	• Introduction and basics: Drive system, energetic and information/ controls part, Requirements, Definitions, Motions • Basics of electrical machines: Types, Design, physical basics, characteristic, move- and break operation of DC and AC machines • Modelling: Transformation in drive systems, linear and rotational movement, mechanical Power, kinetic Energy, static and dynamic behavior • Dimensioning of the drive machine: losses, temperature classes, thermal behavior, operational modes, criteria/method of machine selection
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	• will be given in lecture
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• written examination, 90 min
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Fundamentals of Electrical Drive Technology (lecture) • Fundamentals of Electrical Drive Technology (seminar)
Components to be offered in the Current Semester	**320544** Lecture/Seminar Fundamentals of Electrical Drive Technology - 4 Hours per Term **320585** Examination Fundamentals of Electrical Drive Technology

Module 13916 Fundamentals of Electrical Power Engineering

assign to: Subject Specialization

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13916	Compulsory elective

Modul Title	**Fundamentals of Electrical Power Engineering** Grundlagen der elektrischen Energietechnik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Möhlenkamp, Georg
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Students of mechanical engineering (bachelor) learn to understand the functional principle, specific components, electrical circuits, and the characteristic behavior of electric power circuits. They are able to find proper concepts and define components and systems for electric power problems.
Contents	• Basics of electrical power engineering • Components of electric power circuits and their static and transient behavior: resistors, capacitors, inductors and transformers, 1-phase AC, 3-phase AC, DC power calculations, ring and star power distribution topologies • single, three phase and DC applications • characteristic values of components and topologies • losses and cooling
Recommended Prerequisites	• Electric basics for mechanical engineers
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• will be given in lecture

Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• written examination, 90 min
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Fundamentals of Electrical Power Engineering (lecture) • Fundamentals of Electrical Power Engineering (seminar)
Components to be offered in the Current Semester	No assignment

Module 13917 Aviation Industry Safety Processes and Standards

assign to: Subject Specialization

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13917	Compulsory elective

Modul Title	**Aviation Industry Safety Processes and Standards** Sicherheitsprozesse und -standards in der Luftfahrtindustrie
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Höschler, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The primary aim of this lecture is to provide students with a comprehensive understanding of the safety processes and standards that govern the aviation industry. By the end of the session, students should be able to: • Recognize the significance of international and national regulatory bodies in maintaining aviation safety. • Comprehend the principles and implementation of Safety Management Systems. • Analyze the role of human factors in aviation incidents and propose strategies for improvement. • Understand the latest technological contributions to enhancing safety in aviation operations. • Understand the collaborative efforts required at both national and international levels to uphold and improve safety standards in the aviation industry.
Contents	• Introduction to Aviation Safety • International Regulatory Bodies • Safety Management Systems (SMS): • Accident Investigation and Reporting • Human Factors in Aviation Safety • Technological Advancements in Safety
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester

	Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• "Safety Management Systems in Aviation" by Alan J. Stolzer, Carl D. Halford, and John J. Goglia • "Aviation Safety Programs: A Management Handbook" by Clarence C. Rodrigues • "Introduction to Aviation Safety and Security" by Stephen K. Cusick and Scott Shappell
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Two homeworks, each including a presentation of approximately 20 min. (70%) • Final oral exam, 30 min. (30%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	VL + Ü +PRÜ Aviation Industry Safety Processes and Standards
Components to be offered in the Current Semester	**350345** Lecture/Exercise Aviation Industry Safety Processes and Standards - 4 Hours per Term

Module 13956 Thermal Turbo Machines (Cycle Processes)

assign to: Subject Specialization

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13956	Compulsory elective

Modul Title	**Thermal Turbo Machines (Cycle Processes)** Thermische Turbomaschinen (Kreisprozesse)
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Berg, Heinz Peter
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After attending the module, the students will be able to understand and classify the behavior of thermal turbo-machines. At the same time, they learn to design systems of turbo-machines and gas turbines. The module aims at the receiving of engineering knowhow in the field of applied thermodynamic and turbo-machines. Through learning the realization of technologies with the help of analysis of the thermodynamic cycle, the students will be enabled to analyze and estimate fluidic machines, in order to develop or refine according machines. Therefore, methods and technologies for increasing of effectiveness will be taught with which systems and components can be improved.
Contents	Application of a turbo engine in the technical cycles, fundamentals of gas dynamics, fundamentals of turbo-machines, theory of a stage, compressor, ventilator, high-pressure and low-pressure turbines, steam turbines, gas turbine specifics, gas turbine components, operating behaviour, inlets, diffusers and nozzles.
Recommended Prerequisites	• Knowledge in Technical thermodynamics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Exercise - 1 hours per week per semester Practical training - 1 hours per week per semester Self organised studies - 90 hours
Teaching Materials and Literature	• Lecture script: Thermal Turbomachines

	• Literature, see appendix in script
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	Prerequisite: • Participation in dismantling internship Final Module Examination: • Written exam, 90 minutes
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	First offer expected in winter semester 24/25
Module Components	• VL Thermal Turbo Machines (Cycle Processes) • Ü Thermal Turbo Machines (Cycle Processes) • P Thermal Turbo Machines (Cycle Processes) • PRÜ Thermal Turbo Machines (Cycle Processes)
Components to be offered in the Current Semester	**350882** Examination Thermal Turbo Machines (Cycle Processes)

Module 14049 Electrified Aero Engines

assign to: Subject Specialization

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	14049	Compulsory elective

Modul Title	**Electrified Aero Engines** Elektrifizierte Luftfahrtantriebe
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr. rer. nat. Enghardt, Lars
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Students will get a deeper inside into the technology background and aviation requirements of disruptive means for novel propulsion systems to minimize the climate impact of civil aviation. The lecture will tackle air transport vehicles up to the size of a regional aircraft.
Contents	Air transport of the future will have to be more climate friendly. The lecture will give an introduction into the novel field of more or purely electrified aero engines for civil aircraft. The course will provide an holistic overview of different topics in this regard: • Motivation - why do we need novel propulsion systems, what technology solutions are focussed • Component technologies • Architecture of Electrified Aero Engines • Aircraft Integration of Electrified Aero Engines • Aeronautical Requirements • Environmental Impact • Control of Electrified Aero Engines • Test Facilities to Validate and Certificate Novel Aero Engines
Recommended Prerequisites	• Modul 31302 Grundlagen der Konstruktion und Leistungsrechnung
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Script based on lecture slides

Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• written examination, 90 min., OR electronic-examination, 60 min., OR oral examination, 30 min. *At the beginning of the courses it will be announced the type of examination.*
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	VL, Ü Electrified Aero Engines
Components to be offered in the Current Semester	No assignment

Module 14873 Thermodynamics for Engineers

assign to: Subject Specialization

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	14873	Compulsory elective

Modul Title	**Thermodynamics for Engineers** Thermodynamik für Ingenieure
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. Gorelova, Darya
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successfully completing the module, students are able to evaluate the properties of real substances, such as steam and ideal gases. They can apply the first and second laws of thermodynamics to analyze processes in both open and closed systems. They distinguish different forms of energy such as work (power) and heat, internal energy and enthalpy. They can describe thermodynamic cycles and processes, in particular, using graphical diagrams such as PV, TV or TS.
Contents	Fundamentals and definitions, energy and the first law, properties of pure substances, second law of the thermodynamics, entropy and second law analysis, thermodynamic cycles, heat transfer.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Michael J. Moran and Howard N. Shapiro: *Fundamentals of Engineering Thermodynamics*
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of exercise assignments (50% must be reached)

	Final module examination: • Written examination, 120 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Lecture: Thermodynamics for Engineers • Accompanying exercises • Related examination
Components to be offered in the Current Semester	**150252** Examination Thermodynamics for Engineers - Reexamination

Module 12233 Experiments in Aerodynamics and Fluid Mechanics

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	12233	Compulsory elective

Modul Title	**Experiments in Aerodynamics and Fluid Mechanics** Experimente in Aerodynamik und Strömungslehre
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Egbers, Christoph
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Participants of the module Experiments in aerodynamics and fluid mechanics will be able to understand the topic from an analytic and a practical point of view. The main scope is the understanding of fundamental Fluid mechanics. At the end of the module the students are able to understand basic aerodynamic and fluid mechanics phenomena as well as measurement techniques which are state of the art.
Contents	The specific topics will be explained theoretically in the lecture while in the exercise experiments will be performed. The experiments will focus on different fundamental flow phenomena and investigate them using different measurement techniques. The main contents of the module will be: • Wind tunnel • Water tunnel • Flow around bodys • Principle of Airfoil • Laminar flow • Turbulence • Pipe flow • Rotating Machinery • Flow Instabilities • Taylor-Couette flow • Convection • Aeroacoustics • Aeolsharp • Karman Vortex street • Car Aerodynamics • Wheel housing

	• Flow Visualization techniques • Pressure measurements • LASER-based measurement techniques • Particle Image Velocimetry • Laser Doppler Anemometry
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 1 hours per week per semester Exercise - 3 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Selected literature will be presented at the beginning of the module. • Guidelines for the experiments will be given in first lecture
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Written project reports of 10 experiments (2/3) • Oral defense of one experiment, 10 minutes (1/3)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	This module is based on experimental and fluid mechanical knowledge. The interested students should bring skills on these fields.
Module Components	participation in lecture, exercise
Components to be offered in the Current Semester	No assignment

Module 12886 Flow Measurements

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	12886	Compulsory elective

Modul Title	**Flow Measurements** Flow Measurements
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Egbers, Christoph
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Understanding the bases of the experimental and optical measurement techniques. The students learn and know the basics of optical flow measurements for Fluid Mechanics and Aerodynamics. After successful completion of the module, they are able to apply the basic methods and measurement techniques to solve experimental Fluid Mechanics and Aerodynamics problems. They are able to work in a team and they are able to present their work in a seminar.
Contents	Methods of Flow Visualization, Overview on Optical Measurement Techniques, Laser-Doppler-Anemometry; Particle-Image-Velocimetry; Particle-Tracking-Velocimetry; Liquid Crystal Technique, Dye-Injection Method; Hot-Wire- and Hot-Film Anemometry, Doppler-Global Velocimetry, Oil-Fim-Technique, Measurement Techniques for Channeland Pipe Flows, Wind Tunnel Measurement Techniques (i.e. Pressure Sensitive Paints).
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Selected literature will be presented at the beginning of the module. • Guidelines for the experiments will be given in first lecture
Module Examination	Prerequisite + Final Module Examination (MAP)

Assessment Mode for Module Examination	Prerequisite: • Successful written project reports of 10 experiments Final Module Examination: • Oral examination, 30 minutes
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The lecturer also answers questions in German.
Module Components	• Flow Measurements (Lecture) • Flow Measurements (Excercise) • Flow Measurements (Examination)
Components to be offered in the Current Semester	No assignment

Module 12887 Engineering Acoustics - Sound Fields

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	12887	Compulsory elective

Modul Title	**Engineering Acoustics - Sound Fields** Ingenieursakustik - Schallfelder
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Schmidt, Heiko
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Participants will gain an insight into the theoretical treatment of the propagation of sound and acquire an in-depth knowledge of noise control of vehicles, aircraft and machinery using sound insulation, attenuation, and damping.
Contents	Basics of acoustics and the human perception of sound, the acoustic wave equation and its solutions, reflection and refraction of sound waves, absorption of sound in porous media, sound fields in cavities and flow ducts, silencers, structure-borne sound, sound transmission and insulation in structures, sound enclosures, trim.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	none
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination, 90 minutes OR • Oral examination, 30 minutes In the first lecture it will be announced, if the examination will be offered in written or oral form.

Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Engineering Acoustics - Sound Fields (Lecture) • Engineering Acoustics - Sound Fields (Exercise) • Engineering Acoustics - Sound Fields (Examination)
Components to be offered in the Current Semester	No assignment

Module 13519 CFD 1

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13519	Compulsory elective

Modul Title	**CFD 1** CFD 1
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Schmidt, Heiko
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	After successful participation the students are able to understand the basic concepts of numerical flow simulation. In the practicals they learn to apply methods to solve sample problems in computational fluid dynamics.
Contents	The topics covered include: • Basic concepts for flows of fluids • Basics of Discretization • Methodsforsolving large systems of equations • Methods for steady and unsteady flows Conservation property • flow regimes • finite differences • finite volume • lattice types • consistency • stability • convergence • compact differences • up wind schemes • central schemes • implementation of boundary conditions • Gaussian processes and variations • iterative equationsolver • CG-type methods • ADI method • multigrid method • Newton's method • time method for unsteady problems

	• Application to convection and diffusion equation • pressure correction methods
Recommended Prerequisites	• Mathematical knowledge (calculus) • Basics of Fluid Mechanics • Module *11844 Grundlagen der Computersimulation von Strömungen*
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• D. Hänel: Mathematische Strömungsmodellierung, Skript • Ferziger, J./ Peric, M.: Computational Methods for Fluid Dynamics, Springer 1996
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	The exam can be in written form or held as an oral exam. • For the written examination: 90 minutes duration • For the oral exam mode: 30 - 40 min duration Until the end of the first three weeks of lectures it will be announced, if the examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• VL/Ü CFD 1 • P CFD 1
Components to be offered in the Current Semester	**350440** Lecture/Exercise CFD 1 - 4 Hours per Term **350477** Examination CFD 1

Module 13762 CFD 2

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13762	Compulsory elective

Modul Title	**CFD 2** CFD 2
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Schmidt, Heiko
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successful completion of this course, participants have gained a general understanding of the formulations, discretization strategies, numerical approaches, and burdens for computer simulations of compressible and incompressible fluid flows. They have furthermore learned how to quantify the role of compressibility and to judge its influence for a given application. Hands-on exercises strengthen the theoretical background thought and put the students in the position to be able to select the most suitable numerical tools.
Contents	General topics: • Conserved quantities and conservation laws • Mathematical properties of the governing equations • Discretization strategies (conservative vs. non-conservative, FDM vs. FVM) • Systems of scalar conservation equations • Mach-number asymptotics Topics related to compressible flows: • Riemann problem • Exact and approximate Riemann solvers • Flux functions, reconstructions, and limiters • Shock waves and other discontinuities Topics related to incompressible flows: • Role of pressure and Poisson problem

	• Poisson solvers (direct, spectral, iterative) • Pressure-projection schemes • Nonlinear instability and (de-)aliasing
Recommended Prerequisites	Interest in numerical simulations of fluid flows with an inclination for computational methods relevant across applications. Successful completion of the courses CFD 0 and CFD 1 offered by the department is highly recommended but not mandatory.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Kong, Siauw & Bayen. Python Programming and Numerical Methods: A Guide for Engineers and Scientists. Academic Press, 2020. URL: https://pythonnumericalmethods.berkeley.edu/notebooks/Index.html • Ferziger, Péric & Street. Computational Methods for Fluid Dynamics. Fourth Edition. Springer, 2020. ISBN: 978-3-319-99691-2 • LeVeque. Finite Volume Methods for Hyperbolic Problems. Cambridge University Press, 2002. • LeVeque. Numerical Methods for Conservation Laws. Lectures in Mathematics, ETH Zurich. Birkhauser-Verlag, Basel, 1990. ISBN 3-7643-2464-3 • Orlandi. Fluid Flow Phenomena: A Numerical Toolkit. Kluwer, 2000. • Geurts. Elements of Direct and Large-Eddy Simulation. Edwards, 2003.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• oral examination, ~30-40 min
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• The module primarily aims at Master students in the engineering and natural sciences who plan to specialize in a field that has a strong link to computational fluid dynamics.
Module Components	none
Components to be offered in the Current Semester	**350451** Lecture/Exercise CFD 2 - 4 Hours per Term **350481** Examination CFD 2

Module 13763 Flow Modeling with Machine Learning

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13763	Compulsory elective

Modul Title	**Flow Modeling with Machine Learning** Strömungsmodellierung anhand maschinelles Lernen
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Schmidt, Heiko
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The students are offered an introduction to machine learning in the context of computational fluid dynamics, and turbulent flow analysis and modeling. Elementary definitions and concepts in machine learning will be motivated by CFD applications. A large part of the course is dedicated to the analysis of numerical simulation data using supervised learning approaches. Some aspects of flow feature extraction using unsupervised learning, reduced order modeling, as well as general State-Of-The-Art research issues in machine learning for CFD will also be discussed. At the end of the course, the students are able to understand the key concepts and algorithms in machine learning and how they could be applied in CFD.
Contents	The course contents offer an overview on key machine learning concepts and fundamentals, and how they can be applied in CFD, mainly in the context of analysis of numerical simulations, and modeling of turbulent flows. • Review of linear algebra, conservation equations, dimensional analysis, and turbulence modeling • Linear regression algorithms and optimization • Fourier and Gabor transforms: links to turbulence modeling • Model selection • Proper Orthogonal Decomposition (POD) and Principal Component Analysis (PCA) • Generalities on neural networks • Clustering and classification • Flow modeling using reduced order models

Recommended Prerequisites	The student should be highly motivated to study numerical simulations of fluid flows using computational methods. This is a Python-based course demanding some relevant programming background. To that extent, successful completion of the module “Introduction to Computational Thinking and Programming for CFD” is highly desired (but not mandatory). Completion of the module “Turbulence Modeling” is also recommended for a better theoretical overview, but not mandatory.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Duraisamy, Iaccarino and Xiao. “Turbulence Modeling in the Age of Data”, Annu. Rev. Fluid Mech. 51 (2019), 357-377 • Brunton, Noack and Koumoutsakos. “Machine Learning for Fluid Mechanics”, Annu. Rev. Fluid Mech. 52 (2020), 477-508 • Brunton & Kutz. Data-driven Science and Engineering. Cambridge University Press, 2019. • Chapra & Canale. Numerical Methods for Engineers. McGraw-Hill Higher Education, 2006. • Hastie, Tibshirani, and Friedman. The Elements of Statistical Learning: Data Mining, Inference and Prediction. Springer, 2009. • MacKay. Information Theory, Inference, and Learning Algorithms. Cambridge University Press, 2003.
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	Prerequisite: • Successful completion of the 4-6 exercises discussed in the course Final Module Examination: • Oral exam (Presentation of short project with consecutive discussion of the results), 30-45 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The module primarily aims at Master students in the engineering and natural sciences who plan to specialize in computational fluid dynamics.
Module Components	.
Components to be offered in the Current Semester	**350453** Lecture Flow Modeling with Machine Learning - 2 Hours per Term **350454** Exercise Flow Modeling with Machine Learning - 2 Hours per Term **350482** Examination Flow Modeling with Machine Learning

Module 13804 Engine Integration

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13804	Compulsory elective

Modul Title	**Engine Integration** Triebwerksintegration
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Höschler, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The students will learn about the specification, the design realisation and the validation process of those components which are required to integrate a propulsion system into an aircraft. Furthermore, the required engineering processes to attain this task are provided. The students will therefore be prepared for the work at the interface between propulsion system and aircraft.
Contents	Requirements, functioning and design of a nacelle (intake, cowl doors, nozzle), thrust reverser, engine build-up unit and mounts, assembly, maintenance, noise reduction, fire protection, development- and validation process, interface management, legal requirements and means of compliance, cost and cost reduction, future aircraft concepts and their propulsion integration.
Recommended Prerequisites	none
Mandatory Prerequisites	No successful completion of module *11351 Triebwerks-Integration.*
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	none
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Oral examination, 60 minutes OR Written examination, 120 minutes

	In the first lecture it will be announced, if he examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	VL+Ü+PRÜ Engine Integration
Components to be offered in the Current Semester	**350302** Lecture/Exercise Engine Integration - 4 Hours per Term **350386** Examination Engine Integration

Module 13805 Lifetime Assessment and Fracture Mechanics

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13805	Compulsory elective

Modul Title	**Lifetime Assessment and Fracture Mechanics** Lebensdauerberechnung und Bruchmechanik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Höschler, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	The students will learn about the fundamentals of life prediction methods as they are applied in the automotive and aero engine industry. The students will be enabled to do some first calculations to establish the life of a component until crack initiation. Furthermore, the introduction into fracture mechanics, that are methods to predict the crack propagation, will allow the life calculation of a component until it finally fractures.
Contents	Damage mechanisms, nominal stress concept, local stress concept, linear and non-linear damage models, damage parameters, multiaxial fatigue, linear and non-linear damage accumulation, counting methods, validation, J-integral, Paris law, legal requirements and means of compliance, examples of aero engine and piston engine components, research topics.
Recommended Prerequisites	none
Mandatory Prerequisites	No successful completion of module *11489 Grundlagen der Lebensdauerberechnung und Bruchmechanik metallischer Werkstoffe.*
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	none
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Oral examination, 60 minutes OR Written examination, 120 minutes

	In the first lecture it will be announced, if he examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	VL + Ü + PRÜ Lifetime Assessment and Fracture Mechanics
Components to be offered in the Current Semester	No assignment

Module 13918 Fundamentals in Battery Systems

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13918	Compulsory elective

Modul Title	**Fundamentals in Battery Systems** Grundlagen von Batteriesystemen
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Höschler, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Students learn to understand the functional principle of batteries, their specific components, materials, control structures and the characteristic behaviour. They are able to design battery systems based on available battery cells and their field of application.
Contents	• Definition of batteries • Battery types and their chemical basis • Materials and costs • Decomposition of batteries • Components and their tasks • HV safety • Cell-module-system • Battery thermal management • Battery Management System and functions • Modeling and simulation • Smart Battery Testing • Charging at cold temperatures • Battery safety • Functional safety • Production steps • Simulation tools
Recommended Prerequisites	• Fundamentals in electrical engineering
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	Will be given in lecture.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination (90 min)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	none
Module Components	VL + PRÜ Batteries
Components to be offered in the Current Semester	No assignment

Module 13919 Testing and Certifications of Flight Propulsion Systems

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13919	Compulsory elective

Modul Title	**Testing and Certifications of Flight Propulsion Systems** Prüfung und Zertifizierung von Flugantriebssystemen
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Höschler, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The student should understand the inetraction of Airworthiness organisations, agencies and legeslativ processes. Get a deeper knowledge of establisched certification specifications and Means of compliance. They Learn to transfer established rules into novel propulsion systems and to develop novel means of compliance while using learnt V&V methods and tools Also, the students will practise and establish deterioration functions of electrical components and develop methods to measure deterioration effects.
Contents	• Fundamental understanding of processes concerning Aviation Authorities & Legislation. (10%) • Detailed understanding of established EASA rules (CS-E, CS-P, CS25, CS23, CS-APU) (10%) • Detailed understanding of EASA SC E-18 and E-19. Transfer principles from CS-E into not established means of compliance for hybrid electric and hydrogen flight (30%) • Develop a potential means of compliance for a discrete use case while addopting the learnt working principles and tools . (50%)
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	• Presentation with hand out. • Webpages of EASA, FAA and EUROCAE.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• One group homework which include a presentation and discussion approximately 30 min, (20%) and • one individual homework which need to be presented in 15 min. (35%). • Final written exam, 60 min. (45%).
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	50
Remarks	none
Module Components	VL + Ü + PRÜ Testing and Certifications of Flight Propulsion Systems
Components to be offered in the Current Semester	**350344** Lecture/Exercise Testing and Certifications of Flight Propulsion Systems - 4 Hours per Term

Module 13920 Unsteady Aero-Thermodynamics of Turbomachinery

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13920	Compulsory elective

Modul Title	**Unsteady Aero-Thermodynamics of Turbomachinery** Instationäre Aero-Thermodynamik von Turbomaschinen
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Höschler, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Upon successful completion of the module, students will attain fundamental knowledge in unsteady phenomena within turbomachines and the aerothermodynamic instabilities affecting both compressors and turbines. Furthermore, students will gain insight into recent cycle innovations and their impacts on turbomachines, as well as the interplay between unsteadiness in turbomachines and combustors. In addition to theoretical understanding, students will acquire practical skills in modeling unsteadiness in turbomachines, utilizing various methods, including high-fidelity and low-order approaches.
Contents	Despite the inherent unsteadiness in turbomachines, the design of turbomachinery has historically neglected the dynamic nature of the flow. The prevalent assumption of steady flow in each blade row overlooks significant phenomena. This oversight becomes particularly critical when dealing with innovative cycles, such as Pressure Gain Combustion cycles, where the unsteadiness reaches extremely high levels, making a steady flow assumption untenable. The primary objective of this module is to look into the unsteady aerothermodynamics of turbomachines and the associated phenomena affecting the performance of the machines. Following an initial overview of unsteadiness in turbomachines, the module offers a comprehensive examination of introducing unsteady phenomena, exploring their causes, and understanding their effects on both compressors and turbines. Additionally, participants will be introduced to modeling techniques, which will be applied through a class project as part of the learning experience. The following topics are addressed in this module: • Introduction to unsteadiness in turbomachines

	• Aerothermodynamic unsteadiness in axial and radial compressors • Aerothermodynamic unsteadiness in turbines • Cycle innovations and the effects on turbomachines • The intereffects of unsteadiness in turbomachines and combustors • Modeling of unsteadiness in turbomachines • Design considerations of turbomachines for unsteady operations
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Turbomachinery Flow Physics and Dynamic Performance, Schobeiri, Meinhard T., Springer. • Axial Turbine Aerodynamics for Aero-engines, Z. Zou , S. Wang , H. Liu , W. Zhang, Springer. • Compressor Aerodynamics, N. A. Cumpsty, Krieger Pub. • Scientific journal papers and theses
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• written exam, 90. min
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	50
Remarks	none
Module Components	VL + SEM +PRÜ Unsteady Aero-Thermodynamics of Turbomachinery
Components to be offered in the Current Semester	**350342** Lecture/Seminar Unsteady Aero-Thermodynamics of Turbomachinery - 4 Hours per Term **350382** Examination Unsteady Aero-Thermodynamics of Turbomachinery

Module 13921 Lightweight Design and Construction

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13921	Compulsory elective

Modul Title	**Lightweight Design and Construction** Leichtbaudesign und Konstruktion
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. habil. Beirow, Bernd
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Students gain a deeper knowledge in particurlarities of specific light weight structures, primarily in the fields of enhanced basics of stress, deformation, and strength analyses with fibre reinforced structures included as well as stability analysis and vibration of continua. Students are enabled to select, develop, and design problem specific light weight solutions.
Contents	Repetition of elasticity theory; beam, membrane and plate theory; patricularities of thin-walled profile bars (shear, torsion), fibre reinforced plastic structures (GRP, CRP, etc.), sandwich structures, stablility of elastic structures, structural vibration, practical exercises employing FE-software.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 1 hours per week per semester Practical training - 1 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Teilskripte und ergänzende Umdrucke • B. Klein: Leichtbau-Konstruktion, Vieweg Verlag, 1999, ISBN 3-528-24115-2. • J. Wiedemann: Leichtbau1, Springer Verlag, 1996, ISBN 3-540-60746-3.

- J. Wiedemann: Leichtbau 2, Springer Verlag, 1996, ISBN 3-540-60304-2.
- W. Michaeli: Dimensionieren mit Faserverbundkunststoffen, Hanser Verlag, 1994, ISBN 3-446-17659-4
- A. Kühhorn und G. Silber: Technische Mechanik für Ingenieure, Hüthig Verlag Heidelberg, 2000, ISBN 3-7785-2620-0.
- D. Gross, W. Hauger, W. Schnell, P. Wriggers: Technische Mechanik 4, Springer Verlag, Berlin-Heidelberg-New York, ISBN 3-540-65205-1.

Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• homework tasks as 8 e-tests (10 %) • written exam (85 minutes) (90 %)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	Contents of the module are directed to master students. The module is also suitable for bachelor students if there is sufficient prior knowledge.
Module Components	• Vorlesung • Übung • Praktikum
Components to be offered in the Current Semester	No assignment

Module 13926 Hydrogen and Fuel Cells

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13926	Compulsory elective

Modul Title	**Hydrogen and Fuel Cells** Wasserstoff und Brennstoffzellen
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr. rer. nat. Röntzsch, Lars
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Students are introduced to the complete chain of hydrogen energy technology, covering hydrogen production, storage, distribution, and utilization. Each chapter of the course explores the physico-chemical principles underlying specific hydrogen technologies, provides a detailed description of the technology (including material selection and production aspects), and illustrates its applications through practical examples. The course also incorporates exercises and a graded laboratory experiment, enhancing hands-on learning and practical application of theoretical knowledge.
Contents	1. Introduction to hydrogen and its properties 2. Hydrogen energy cycle 3. Hydrogen production 4. Hydrogen purification 5. Hydrogen storage 6. Distribution and infrastructure 7. Fuel cells 8. Hydrogen combustion 9. Hydrogen safety
Recommended Prerequisites	Good knowledge and coherent understanding of power engineering, physics, chemistry, and mathematics (Master's level)
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 3 hours per week per semester Exercise - 1 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	The course documents are provided in the learning management system Moodle. Further literature: • Compendium of Hydrogen Energy, Volumes 1-4 (Woodhead, 2015). • Hydrogen - Its Technology and Implications, Volumes 1-5 (CRC Press, 2018). • Fuel Cells and Hydrogen Production (Springer Science, 2019). • Hydrogen Energy - Challenges and Solutions for a Cleaner Future (Springer, 2019). • Hydrogen Production Technologies (Wiley, 2017). • Handbook of Hydrogen Energy (CRC Press, 2014). Hydrogen Safety (CRC Press, 2013).
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Final written exam (80 min; 75 % of final grade) • Graded laboratory experiment (entrance test (~10 min.), self-managed realisation (~80 min.) and report including evaluation of the experiments (at least 10 pages); 25 % of final grade)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	30
Remarks	none
Module Components	Lectures, exercises, laboratory experiment, exam
Components to be offered in the Current Semester	No assignment

Module 14050 Environmental Impact of Aero Engines

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	14050	Compulsory elective

Modul Title	**Environmental Impact of Aero Engines** Umweltauswirkungen von Luftfahrtantrieben
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr. rer. nat. Enghardt, Lars
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	In a first step, students learn about the emissions of conventional aircraft engines – including NOx, CO2 and noise – based on examples and some basic mathematical equations. In a second step, it will be detailed how the electrification of the aircraft power train will affect the emissions. This will include the generation of contrails but also the generation of noise by the new components of the electric propulsion system, such as electric motors. In the accompanying exercises, students will solve some basic mathematical problems related to the emissions of conventional and electrical aircraft propulsion systems. In addition, the students will have the chance to work on a self-chosen topic and present it to their peers at the end of the module.
Contents	• aircraft emissions • cloud formation and contrails • aircraft effect on global warming • aircraft noise measurements • sources of noise in conventional aircraft engines • effect of electrification on the noise generation • noise from the electric components • noise reduction measures • introduction to relevant acoustic measurements and simulations • review of current research projects on novel engines concepts and their implications on emissions
Recommended Prerequisites	none
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Script based on lecture slides.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• 4 short multiple-choice tests, each lasting 15 minutes (10% each) • Written partial assessment lasting 80 minutes (60%).
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	VL + Ü Environmental Impact of Aero Engines
Components to be offered in the Current Semester	**352201** Lecture/Exercise Environmental Impact of Aero Engines

Module 14055 Thermal Management Systems in Hybrid-Electric Propulsion Aviation

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	14055	Compulsory elective

Modul Title	**Thermal Management Systems in Hybrid-Electric Propulsion Aviation** Wärmemanagementsysteme in der Luftfahrt mit hybridelektrischem Antrieb
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Höschler, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After a successful completion of this module, the students aquire the knowledge on the whole thermal management system (TMS) and the subsystems and components involved. They will be able to analyse the system and design a TMS for a specific appication. In general, the students will gain the knowledge and skills on how to handle the heat generated by the components in a hybrid-electric propulsion systems, and make the whole system more efficient.
Contents	The following topics will be addressed in this module: • Introduction to TMS and heat transfer mechanisms • General concepts, applications and examples • Thermal management in electric motors and generators • Thermal management in batteries • Thermal management in power electronics • Thermal management in fuel cells • Thermal management in power distribution systems • Heat exchangers • Pumps, fans and heat exchanger intakes • Cooling fluid and storages • TMS design, integration and control
Recommended Prerequisites	none
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Literature will be recommended in the course.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Oral examination, 60 minutes OR Written examination, 120 minutes In the first lecture it will be announced, if he examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	VL + SEM +PRÜ Thermal Management Systems in Hybrid-Electric Propulsion Aviation
Components to be offered in the Current Semester	**350343** Lecture/Exercise Thermal Management Systems in Hybrid-Electric Propulsion Aviation - 4 Hours per Term **350383** Examination Thermal Management Systems in Hybrid-Electric Propulsion Aviation

Module 14514 Lecture Series Hybrid-Electric Propulsion

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	14514	Compulsory elective

Modul Title	**Lecture Series Hybrid-Electric Propulsion** Ringvorlesung Hybrid-Elektrische Antriebe
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr. rer. nat. Enghardt, Lars
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The module will give an overview into selected topics referring to hybrid-electric propulsion systems from experts in the field - including current research from DLR, CHESCO and BTU, plus invited guests. Each lecture will cover a specific topic chosen by the corresponding lecturer and will give deep insights into current problems and solutions concerning hybrid-electric propulsion systems and their components. Students will thus require expert knowledge on selected, very specific topics from current research areas with suggestions on how to obtain additional (background) information as well as contacts to representatives from academia and industry.
Contents	The lectures are given by experienced researchers from different research institutions. A full list of lectures will be presented at the beginning of the summer semester.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Study project - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	The lecture slides will be made available after each lecture if the lecturer agrees and the intellectual property rights situation permits.
Module Examination	Continuous Assessment (MCA)

Assessment Mode for Module Examination	• Students will write a 15 page report on one topic of their choice (70 %) to be chosen from a provided preselection list and • a corresponding presentation of approximately 30 minutes at the end of the semester (30 %).
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The module is not currently being offered.
Module Components	VL, PROJ Lecture Series Hybrid-Electric Propulsion
Components to be offered in the Current Semester	No assignment

Module 14642 Machine Learning for Engineers

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	14642	Compulsory elective

Modul Title	**Machine Learning for Engineers** Maschinelles Lernen für Ingenieure
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Härtel, Sebastian
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	At the end of the module the students are able to build and apply a collection of machine learning models, ranging from simple linear predictors to deep neural networks to common engineering problems. Selection of case studies is focused on manufacturing processes. Students are able to implement data-driven algorithms of increasing complexity directly in Python. Advanced neural network architectures for image processing or time series will be based on Pytorch.
Contents	Brief introduction to statistical learning theory and empirical risk minimization. Supervised and unsupervised learning framework with an optional part on reinforcement learning. Supervised Learning models include linear predictors, support vector machines and neural networks. Unsupervised Learning models include dimensionality reduction via matrix decompositions (singular value decomposition, principal component analysis) or autoencoders, clustering algorithms and empeddings (t-distributed stochastic neighbour embedding).
Recommended Prerequisites	Mathematics for Engineers (Multivariate Calculus, Linear Algebra) Programming in Python
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Study project - 30 hours Self organised studies - 90 hours
Teaching Materials and Literature	none

Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	Prerequisite: • Successful completion of homework assignments. Final Module Examination: • Oral exam (45 min) including presentation with discussion (15 slides)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	Machine Learning for Engineers (Lecture) Machine Learning for Engineers (Exercise)
Components to be offered in the Current Semester	**340588** Examination Machine Learning for Engineers

Module 14726 Mathematical Optimization Techniques and Applications

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	14726	Compulsory elective

Modul Title	**Mathematical Optimization Techniques and Applications** Mathematische Optimierungstechniken und Anwendungen
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Fügenschuh, Armin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Upon successful completion of the module, students will have acquired an understanding of core mathematical tools used in modern optimization. They will be able to identify optimization structures in real-world problems, formalize these problems in mathematical terms, and apply suitable algorithms to obtain and interpret solutions.
Contents	Foundations of optimization theory, global vs. local optimality, geometry of optimization, optimization for graph problems, fundamentals of linear programming, duality principles, advanced simplex methods, discrete optimization, interior point and ellipsoid methods, nonlinear optimization, applied modeling. Emphasis is placed both on theoretical insights and algorithmic implementation.
Recommended Prerequisites	Knowledge of subject matters of the modules • 11103: Analysis I • 11104: Analysis II • 11101: Lineare Algebra und analytische Geometrie I or of the modules • 11112: Mathematik IT-1 (Diskrete Mathematik) • 11113: Mathematik IT-2 (Lineare Algebra) • 11213: Mathematik IT-3 (Analysis)
Mandatory Prerequisites	• No successful participation in module 13862 Optimierung und Operations Research.

Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 90 hours
Teaching Materials and Literature	• V. Chvatal, Linear Programming, Bedford St Martins Pr 3PL, 2016 • R.J. Vanderbei: Linear Programming - Foundations and Extensions, 5th Edition, Springer, 2020
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• 4 intermediate tests of 30 minutes each, written during the lecture period. The best 3 count 1/3 each for the final grade.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Angewandte Mathematik M.Sc.: Compulsory elective module in complex „Optimierung" • Study programme Mathematics M.Sc.: Compulsory elective module in complex „Optimization" • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Advanced Mathematical Methods in Data Science" • Study programme Artificial Intelligence Science M.Sc.: Compulsory elective module in complex „Advanced Methods" • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Software-basierte Systeme" • Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject"
Module Components	• Lecture: Optimization and Operations Research • Accompanying exercise
Components to be offered in the Current Semester	No assignment

Module 14815 Systems Engineering

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	14815	Compulsory elective

Modul Title	**Systems Engineering** Systemtechnik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Höschler, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successfully completing the module, students have extensive knowledge of systems engineering. Knowledge in detail: • Basics and technical terms in the teaching content • Change and challenges in the design of the systems • Holistic view of a system from various perspectives • Systems engineering in companies The students will have skills in: • Confident use of technical terms • Classification and use of the approaches in the topic area • Reflection on your own experiences in product development • Systematic approach to describing systems Through interactive group exercises, students acquire the following skills: • Systems thinking • Abstraction • Visualization of specific views • Building consensus within the group • Reflection and transfer
Contents	Cars, household appliances or machines and systems - they are all basic mechanical products that have new, intelligent functions and thus develop into intelligent technical systems. The design of these systems has become an interdisciplinary issue. Systems engineering addresses the systemic and systematic approach to implementing complex systems. It provides the means to view the systems holistically and

	in an interdisciplinary manner, as well as to orchestrate the specialist disciplines involved. In this module, students are taught the basics of systems engineering. The following topics are addressed: • Introduction to the topic of systems engineering • Challenges in the design of intelligent technical systems • Systems thinking • Requirements engineering • System architecture • Model-Based Systems Engineering • Processes and procedures • Challenges in introducing systems engineering company-wide
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Gausemeier - Innovationen für die Märkte von morgen: Strategische Planung von Produkten, Dienstleistungen und Geschäftsmodellen • Haberfellner - Systems Engineering: Grundlagen und Anwendung, 2018 • INCOSE Systems Engineering Handbuch • More literature will be announced at the event.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• 80% Group homework, with 4 parts (2 intermediate Reviews, final presentation, report; each 20%) • 20% written exam, 40min
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	30
Remarks	none
Module Components	• Lecture Systems Engineering Current Description • Exercise Systems Engineering Current Description
Components to be offered in the Current Semester	No assignment

Module 14840 Aero Engine Design and Analysis 1

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	14840	Compulsory elective

Modul Title	**Aero Engine Design and Analysis 1** Flugtriebwerkskonstruktion und -analyse 1
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Höschler, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	At the end of the module the student are able to understand the layout and construction of core engine designs, including compressor and combustion chamber. They are able to evaluate new designs in the field of core engines and to independently propose and develop justified adaptations of standard designs. The independent development of application-related and research-oriented knowledge represents a complementary point of the acquired competence. In general, the students will learn: • How an aero engine works • Different types of aero engines • Introduction to major system, subsystems and components • Design and analysis challenges • Impact of new technologies (digital, electrification,..) • Technology and innovation management • Real world applications • How a large enterprise works and new working practices • Career progression and expectations
Contents	Introduction & Engine Performance • Overview • History • Types of aero engines • Cycle Design • EEP

	• Noise Engine Systems • Air Systems (Stefan 180 min) • Oil Systems & Fire & Vent Compressor • Aerodynamics • Mechanical Design including Lifing • Special topics Combustor • Aerodynamics • Mechanical Design • Special topics
Recommended Prerequisites	• Ideally basic knowledge on turbomachinery and thermodynamics
Mandatory Prerequisites	No successful completion of module *13802 Core Engine Design 1*
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	• Lecture notes • Aircraft Engine Design, Third Edition, eISBN: 978-1-62410-650-7 • Jet Engines: Fundamentals of Theory, Design and Operation, ISBN: 0760304599
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination, 120 minutes.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	This module is previously offered as Core Engine Design 1
Module Components	<p>Lecture and exam
Components to be offered in the Current Semester	**350341** Lecture Aero Engine Design and Analysis 1 - 2 Hours per Term **350381** Examination Aero Engine Design and Analysis 1

Module 14841 Aero Engine Design and Analysis 2

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	14841	Compulsory elective

Modul Title	**Aero Engine Design and Analysis 2** Flugtriebwerkskonstruktion und -analyse 2
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Höschler, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	By the conclusion of the module, students will have acquired the ability to comprehend the structure and building of core engine designs, encompassing turbines and exhaust chambers. They will be proficient in assessing innovative designs within the core engine domain and capable of autonomously suggesting and implementing well-justified modifications to conventional designs. The autonomous cultivation of application-oriented and research-focused knowledge serves as an additional aspect of the competencies gained in this module. In general, the students will learn: • How an aero engine works • Different types of aero engines • Introduction to major system, subsystems and components • Design and analysis challenges • Impact of new technologies (digital, electrification,..) • Technology and innovation management • Real world applications • How a large enterprise works and new working practices • Career progression and expectations
Contents	Turbines • Aerodynamics • Mechanical Design including Lifing • Special topics

	Whole Engine Modelling (2) • Mechanical Design including Lifing • FBO, Design Challenges • Power Gear Box Digital • Simulation & Modelling • Digital Twins • DevOps Excursion & Innovation Management
Recommended Prerequisites	Ideally successful completion of • 13802 Core Engine Design 1 or • 14840 Aero Engine Design and Analysis 1, and • basics knowledge on thermodynamics and turbomachinery
Mandatory Prerequisites	No successful completion of module *13803 Core Engine Design 2*
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	• Lecture notes • Aircraft Engine Design, Third Edition, eISBN: 978-1-62410-650-7 • Jet Engines: Fundamentals of Theory, Design and Operation, ISBN: 0760304599
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination, 120 minutes
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Lectures start in winter semester 2026/27. • This module is previously offered as Core Engine Design 2.
Module Components	<p>Lecture and exam
Components to be offered in the Current Semester	No assignment

Module 14905 Control of Electrified Aero Engines

assign to: Main Focus Engine Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	14905	Compulsory elective

Modul Title	**Control of Electrified Aero Engines** Regelung Elektrifizierter Luftfahrtantriebe
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Schiffer, Johannes Prof. Dr. rer. nat. Enghardt, Lars
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The students will get a deeper understanding of the challenges presented by the need to control electrified aeronautical propulsion systems. They will learn to formulate mathematical models of the components involved in the control system, analyze the behavior of those models, and develop controllers for such components using linear and non-linear methods.
Contents	Air transport of the future will have to be more climate friendly. The lecture provides an overview of the technological development required to guarantee the reliable, safe, and environmentaly friendly performance of novel hybrid or purely electrified engines for civil aircraft. In parallel, the course will introduce control theoretical topics motivated by the application. • Motivation - FADEC and the Control of Aeronautical Propulsion • Modeling and Control of Individual Components • High-level control • Integration with the Aircraft Control System • Certification Requirements and Processes
Recommended Prerequisites	• Modul 11494 Control Engineering I OR • Modul 12894 Regelungstechnik I
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester

	Self organised studies - 120 hours
Teaching Materials and Literature	• Script based on lecture slides
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	Prerequisite: • There will be bi-weekly homework assignments. The estimated time required for each assignment is about 4 hours. To be allowed for the final exam, students must submit at least 75% of the assignments. Final exam: • 90 mins written OR 20 min oral presentation. At the start of the semester it will be announced, if the examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• VL Control of Electrified Aero Engines • ÜB Control of Electrified Aero Engines • PRÜ Control of Electrified Aero Engines
Components to be offered in the Current Semester	**352221** Lecture/Exercise Control of Electrified Aero Engines - 4 Hours per Term **352272** Examination Control of Electrified Aero Engines

Module 11191 EMC in Electrical Power Installations

assign to: Main Focus Electric Drive Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	11191	Compulsory elective

Modul Title	**EMC in Electrical Power Installations** EMV in elektrischen Anlagen
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Schenk, Mario
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Students will get a deeper understanding of possible interferences in power systems and will be able to design a EMC compatible layout in large scale power installations and systems
Contents	Electromagnetic environment (high frequency impulse fields, lightning impulse overvoltages, switching impulses, low and medium frequency interferences), EMC design criteria (protection against direct lightning stroke, potential grounding, screening, overvoltage protection,filters), EMC system planning (zone concept, interface definition) EMC measuring and testing technique
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Script
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination, 90 minutes
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none

Remarks	• The seminar will include exercises, practical training and homeworks • another registration for this module in moodle • different forms of teaching are announced in moodle
Module Components	• EMC in Electrical Power Installations (lecture/seminar)
Components to be offered in the Current Semester	**320272** Examination EMC in Electrical Power Installations

Module 11221 Fundamentals in Power Electronics

assign to: Main Focus Electric Drive Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	11221	Compulsory elective

Modul Title	**Fundamentals in Power Electronics** Grundlagen der Leistungselektronik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Möhlenkamp, Georg
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Students learn to understand the functional principle of power electronics, their specific components, control structures and the characteristic behaviour. They are able to find suitable concepts and define components and auxiliaries for power converters.
Contents	• Definition of power electronics • Components and their static and transient behaviour • Circuit topologies as grid commutated converter • Self commutated converter • Dc-dc-converter • Resonant and quasi-resonant converter • Single and three phase applications • Characteristic values of components and topologies • Cooling • Passive components and filters • Firing • Driver and protection devices • Pulse-width-modulation • Simulation tools
Recommended Prerequisites	Fundamentals in electrical engineering
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 1 hours per week per semester Practical training - 1 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	will be given in lecture
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of the laboratory work **Final Module Examination:** • Written examination, 90 minutes
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The seminar contains a mixture of exercises, laboratory tests and homework.
Module Components	• Fundamenatls in Power Electronics (lecture/seminar/laboratory)
Components to be offered in the Current Semester	**320570** Examination Fundamentals in Power Electronics

Module 11496 Research Seminar in Power Electronics

assign to: Main Focus Electric Drive Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	11496	Compulsory elective

Modul Title	**Research Seminar in Power Electronics** Forschungsseminar Leistungselektronik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Möhlenkamp, Georg
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	At the end of the module the student is able to: • analyse advanced topics in power electronics • discuss and evaluate recent developments • present a selected topic • write a research or review report
Contents	Current selected research topics in the field of: • power electronics for high-voltage networks, • power electronics for e-cars, • design of energy efficient, high performance drives • optimization of complex drive systems
Recommended Prerequisites	• Urgently recommended: module 35436 *Power Electronic Applications in High Voltage Grids* • Urgently recommended: module 35437 *Power Electronic Applications in Drive Systems*
Mandatory Prerequisites	Successful participation in module: • 11221 - Fundamentals in Power Electronics
Forms of Teaching and Proportion	Seminar - 4 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Literature is depending from the research topic.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Oral presentation and discussion (50%), ca. 15 min. • Written report (50%), ca. 20 pages

	At least 75% are required to pass the module successfully.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	None
Module Components	• Research Seminar in Power Electronics (seminar)
Components to be offered in the Current Semester	**320560** Seminar Research Seminar in Power Electronics - 4 Hours per Term

Module 11747 Control Engineering 2

assign to: Main Focus Electric Drive Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	11747	Compulsory elective

Modul Title	**Control Engineering 2** Regelungstechnik 2
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Schiffer, Johannes
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	On completion of this module, students should be able to: • Model dynamical multiple-input-multiple-output (MIMO) systems from diverse domains in state-space form; • Analyze the behavior of linear state-space systems; • Understand the concepts of controllability and observability for linear time-invariant (LTI) systems; • Design static and observer-based dynamic state-feedback controllers for LTI MIMO systems.
Contents	State space modeling of dynamical systems; Dynamic behavior of linear systems; Solution of linear time-invariant systems; Lyapunov stability; Controllability and observability; State feedback; Pole placement; PI state feedback control; Control design via linear matrix inequalities; Duality principle; Luenberger-observer and observer-based control; Separation principle; Optimal control (Linear quadratic regulator, H-infinity control)
Recommended Prerequisites	Knowledge in: • Mathematics • Physics • Control Engineering 1 (or equivalent)
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Laboratory training - 1 hours per week per semester Self organised studies - 105 hours

Teaching Materials and Literature	• K. J. Åström and R. M. Murray, "Feedback Systems", Princeton University Press, 2009 • G. F. Franklin, J. D. Powell, A. Emami-Naeini, "Feedback Control of Dynamic Systems", Vol. 3. Reading, MA: Addison-Wesley, 1994 • H. Khalil, "Nonlinear Systems", Prentice-Hall, New Jersey, 1996 • J. Lunze, "Regelungstechnik 2: Mehrgrößensysteme Digitale Regelung", Springer-Verlag, 2013
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	Prerequisite: • Submission of at least 65% of the online homework • Successful participation in all lab sessions including short tests (ungraded) Final Module Examination: • Written exam, 90 minutes Permitted aids are **two** DIN A4 sheets, **handwritten** on both sides. For calculations, non-programmable calculators are allowed. Any other type of electronic device is **not** allowed. For successfully completed online homework, a maximum of 10% bonus points can be earned for the final examination.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Control Engineering 2 (lecture) • Control Engineering 2 (exercise/laboratory) • Control Engineering 2 (exam)
Components to be offered in the Current Semester	**320623** Lecture Control Engineering 2 - 2 Hours per Term **320624** Exercise/Practical training Control Engineering 2 - 3 Hours per Term **320671** Examination Control Engineering 2

Module 12887 Engineering Acoustics - Sound Fields

assign to: Main Focus Electric Drive Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	12887	Compulsory elective

Modul Title	**Engineering Acoustics - Sound Fields** Ingenieursakustik - Schallfelder
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Schmidt, Heiko
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Participants will gain an insight into the theoretical treatment of the propagation of sound and acquire an in-depth knowledge of noise control of vehicles, aircraft and machinery using sound insulation, attenuation, and damping.
Contents	Basics of acoustics and the human perception of sound, the acoustic wave equation and its solutions, reflection and refraction of sound waves, absorption of sound in porous media, sound fields in cavities and flow ducts, silencers, structure-borne sound, sound transmission and insulation in structures, sound enclosures, trim.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	none
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination, 90 minutes OR • Oral examination, 30 minutes In the first lecture it will be announced, if the examination will be offered in written or oral form.

Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Engineering Acoustics - Sound Fields (Lecture) • Engineering Acoustics - Sound Fields (Exercise) • Engineering Acoustics - Sound Fields (Examination)
Components to be offered in the Current Semester	No assignment

Module 13836 Electrical Machines for Flight Applications

assign to: Main Focus Electric Drive Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13836	Compulsory elective

Modul Title	**Electrical Machines for Flight Applications** Elektrische Maschinen für Fluganwendungen
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Möhlenkamp, Georg
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Students learn the dedicated requirements and solutions for electrical machines in flight applications. Under the very high requirements concerning power density, reliability and safety, different designs of electrical machines for motor and generator applications are discussed.
Contents	Students learn the dedicated requirements for electrical machines in flight applications (compared to other traction and industrial applications). Different designs to achieve those requirements like high speed PMSM or low speed axial flux machines are designed and calculated. Different power converter designs and their potential integration into the electrical machine are constructed. The integration into aircraft bodies is explored.
Recommended Prerequisites	• Fundamental lectures in electrical engineering and electrical machines
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• will be given in lecture
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• written examination, 90 min

Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Electrical Machines for Flight Applications (lecture) • Electrical Machines for Flight Applications (seminar or exercise)
Components to be offered in the Current Semester	No assignment

Module 13918 Fundamentals in Battery Systems

assign to: Main Focus Electric Drive Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13918	Compulsory elective

Modul Title	**Fundamentals in Battery Systems** Grundlagen von Batteriesystemen
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Höschler, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Students learn to understand the functional principle of batteries, their specific components, materials, control structures and the characteristic behaviour. They are able to design battery systems based on available battery cells and their field of application.
Contents	• Definition of batteries • Battery types and their chemical basis • Materials and costs • Decomposition of batteries • Components and their tasks • HV safety • Cell-module-system • Battery thermal management • Battery Management System and functions • Modeling and simulation • Smart Battery Testing • Charging at cold temperatures • Battery safety • Functional safety • Production steps • Simulation tools
Recommended Prerequisites	• Fundamentals in electrical engineering
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	Will be given in lecture.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination (90 min)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	none
Module Components	VL + PRÜ Batteries
Components to be offered in the Current Semester	No assignment

Module 13919 Testing and Certifications of Flight Propulsion Systems

assign to: Main Focus Electric Drive Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	13919	Compulsory elective

Modul Title	**Testing and Certifications of Flight Propulsion Systems** Prüfung und Zertifizierung von Flugantriebssystemen
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Höschler, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The student should understand the inetraction of Airworthiness organisations, agencies and legeslativ processes. Get a deeper knowledge of establisched certification specifications and Means of compliance. They Learn to transfer established rules into novel propulsion systems and to develop novel means of compliance while using learnt V&V methods and tools Also, the students will practise and establish deterioration functions of electrical components and develop methods to measure deterioration effects.
Contents	• Fundamental understanding of processes concerning Aviation Authorities & Legislation. (10%) • Detailed understanding of established EASA rules (CS-E, CS-P, CS25, CS23, CS-APU) (10%) • Detailed understanding of EASA SC E-18 and E-19. Transfer principles from CS-E into not established means of compliance for hybrid electric and hydrogen flight (30%) • Develop a potential means of compliance for a discrete use case while addopting the learnt working principles and tools . (50%)
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	• Presentation with hand out. • Webpages of EASA, FAA and EUROCAE.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• One group homework which include a presentation and discussion approximately 30 min, (20%) and • one individual homework which need to be presented in 15 min. (35%). • Final written exam, 60 min. (45%).
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	50
Remarks	none
Module Components	VL + Ü + PRÜ Testing and Certifications of Flight Propulsion Systems
Components to be offered in the Current Semester	**350344** Lecture/Exercise Testing and Certifications of Flight Propulsion Systems - 4 Hours per Term

Module 14050 Environmental Impact of Aero Engines

assign to: Main Focus Electric Drive Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	14050	Compulsory elective

Modul Title	**Environmental Impact of Aero Engines** Umweltauswirkungen von Luftfahrtantrieben
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr. rer. nat. Enghardt, Lars
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	In a first step, students learn about the emissions of conventional aircraft engines – including NOx, CO2 and noise – based on examples and some basic mathematical equations. In a second step, it will be detailed how the electrification of the aircraft power train will affect the emissions. This will include the generation of contrails but also the generation of noise by the new components of the electric propulsion system, such as electric motors. In the accompanying exercises, students will solve some basic mathematical problems related to the emissions of conventional and electrical aircraft propulsion systems. In addition, the students will have the chance to work on a self-chosen topic and present it to their peers at the end of the module.
Contents	• aircraft emissions • cloud formation and contrails • aircraft effect on global warming • aircraft noise measurements • sources of noise in conventional aircraft engines • effect of electrification on the noise generation • noise from the electric components • noise reduction measures • introduction to relevant acoustic measurements and simulations • review of current research projects on novel engines concepts and their implications on emissions
Recommended Prerequisites	none
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Script based on lecture slides.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• 4 short multiple-choice tests, each lasting 15 minutes (10% each) • Written partial assessment lasting 80 minutes (60%).
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	VL + Ü Environmental Impact of Aero Engines
Components to be offered in the Current Semester	**352201** Lecture/Exercise Environmental Impact of Aero Engines

Module 14055 Thermal Management Systems in Hybrid-Electric Propulsion Aviation

assign to: Main Focus Electric Drive Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	14055	Compulsory elective

Modul Title	**Thermal Management Systems in Hybrid-Electric Propulsion Aviation** Wärmemanagementsysteme in der Luftfahrt mit hybridelektrischem Antrieb
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Höschler, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After a successful completion of this module, the students aquire the knowledge on the whole thermal management system (TMS) and the subsystems and components involved. They will be able to analyse the system and design a TMS for a specific appication. In general, the students will gain the knowledge and skills on how to handle the heat generated by the components in a hybrid-electric propulsion systems, and make the whole system more efficient.
Contents	The following topics will be addressed in this module: • Introduction to TMS and heat transfer mechanisms • General concepts, applications and examples • Thermal management in electric motors and generators • Thermal management in batteries • Thermal management in power electronics • Thermal management in fuel cells • Thermal management in power distribution systems • Heat exchangers • Pumps, fans and heat exchanger intakes • Cooling fluid and storages • TMS design, integration and control
Recommended Prerequisites	none
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Literature will be recommended in the course.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Oral examination, 60 minutes OR Written examination, 120 minutes In the first lecture it will be announced, if he examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	VL + SEM +PRÜ Thermal Management Systems in Hybrid-Electric Propulsion Aviation
Components to be offered in the Current Semester	**350343** Lecture/Exercise Thermal Management Systems in Hybrid-Electric Propulsion Aviation - 4 Hours per Term **350383** Examination Thermal Management Systems in Hybrid-Electric Propulsion Aviation

Module 14514 Lecture Series Hybrid-Electric Propulsion

assign to: Main Focus Electric Drive Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	14514	Compulsory elective

Modul Title	**Lecture Series Hybrid-Electric Propulsion** Ringvorlesung Hybrid-Elektrische Antriebe
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr. rer. nat. Enghardt, Lars
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The module will give an overview into selected topics referring to hybrid-electric propulsion systems from experts in the field - including current research from DLR, CHESCO and BTU, plus invited guests. Each lecture will cover a specific topic chosen by the corresponding lecturer and will give deep insights into current problems and solutions concerning hybrid-electric propulsion systems and their components. Students will thus require expert knowledge on selected, very specific topics from current research areas with suggestions on how to obtain additional (background) information as well as contacts to representatives from academia and industry.
Contents	The lectures are given by experienced researchers from different research institutions. A full list of lectures will be presented at the beginning of the summer semester.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Study project - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	The lecture slides will be made available after each lecture if the lecturer agrees and the intellectual property rights situation permits.
Module Examination	Continuous Assessment (MCA)

Assessment Mode for Module Examination	• Students will write a 15 page report on one topic of their choice (70 %) to be chosen from a provided preselection list and • a corresponding presentation of approximately 30 minutes at the end of the semester (30 %).
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The module is not currently being offered.
Module Components	VL, PROJ Lecture Series Hybrid-Electric Propulsion
Components to be offered in the Current Semester	No assignment

Module 14642 Machine Learning for Engineers

assign to: Main Focus Electric Drive Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	14642	Compulsory elective

Modul Title	**Machine Learning for Engineers** Maschinelles Lernen für Ingenieure
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Härtel, Sebastian
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	At the end of the module the students are able to build and apply a collection of machine learning models, ranging from simple linear predictors to deep neural networks to common engineering problems. Selection of case studies is focused on manufacturing processes. Students are able to implement data-driven algorithms of increasing complexity directly in Python. Advanced neural network architectures for image processing or time series will be based on Pytorch.
Contents	Brief introduction to statistical learning theory and empirical risk minimization. Supervised and unsupervised learning framework with an optional part on reinforcement learning. Supervised Learning models include linear predictors, support vector machines and neural networks. Unsupervised Learning models include dimensionality reduction via matrix decompositions (singular value decomposition, principal component analysis) or autoencoders, clustering algorithms and empeddings (t-distributed stochastic neighbour embedding).
Recommended Prerequisites	Mathematics for Engineers (Multivariate Calculus, Linear Algebra) Programming in Python
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Study project - 30 hours Self organised studies - 90 hours
Teaching Materials and Literature	none

Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	Prerequisite: • Successful completion of homework assignments. Final Module Examination: • Oral exam (45 min) including presentation with discussion (15 slides)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	Machine Learning for Engineers (Lecture) Machine Learning for Engineers (Exercise)
Components to be offered in the Current Semester	**340588** Examination Machine Learning for Engineers

Module 14726 Mathematical Optimization Techniques and Applications

assign to: Main Focus Electric Drive Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	14726	Compulsory elective

Modul Title	**Mathematical Optimization Techniques and Applications** Mathematische Optimierungstechniken und Anwendungen
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Fügenschuh, Armin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Upon successful completion of the module, students will have acquired an understanding of core mathematical tools used in modern optimization. They will be able to identify optimization structures in real-world problems, formalize these problems in mathematical terms, and apply suitable algorithms to obtain and interpret solutions.
Contents	Foundations of optimization theory, global vs. local optimality, geometry of optimization, optimization for graph problems, fundamentals of linear programming, duality principles, advanced simplex methods, discrete optimization, interior point and ellipsoid methods, nonlinear optimization, applied modeling. Emphasis is placed both on theoretical insights and algorithmic implementation.
Recommended Prerequisites	Knowledge of subject matters of the modules • 11103: Analysis I • 11104: Analysis II • 11101: Lineare Algebra und analytische Geometrie I or of the modules • 11112: Mathematik IT-1 (Diskrete Mathematik) • 11113: Mathematik IT-2 (Lineare Algebra) • 11213: Mathematik IT-3 (Analysis)
Mandatory Prerequisites	• No successful participation in module 13862 Optimierung und Operations Research.

Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 90 hours
Teaching Materials and Literature	• V. Chvatal, Linear Programming, Bedford St Martins Pr 3PL, 2016 • R.J. Vanderbei: Linear Programming - Foundations and Extensions, 5th Edition, Springer, 2020
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• 4 intermediate tests of 30 minutes each, written during the lecture period. The best 3 count 1/3 each for the final grade.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Angewandte Mathematik M.Sc.: Compulsory elective module in complex „Optimierung" • Study programme Mathematics M.Sc.: Compulsory elective module in complex „Optimization" • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Advanced Mathematical Methods in Data Science" • Study programme Artificial Intelligence Science M.Sc.: Compulsory elective module in complex „Advanced Methods" • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Software-basierte Systeme" • Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject"
Module Components	• Lecture: Optimization and Operations Research • Accompanying exercise
Components to be offered in the Current Semester	No assignment

Module 14815 Systems Engineering

assign to: Main Focus Electric Drive Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	14815	Compulsory elective

Modul Title	**Systems Engineering** Systemtechnik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Höschler, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successfully completing the module, students have extensive knowledge of systems engineering. Knowledge in detail: • Basics and technical terms in the teaching content • Change and challenges in the design of the systems • Holistic view of a system from various perspectives • Systems engineering in companies The students will have skills in: • Confident use of technical terms • Classification and use of the approaches in the topic area • Reflection on your own experiences in product development • Systematic approach to describing systems Through interactive group exercises, students acquire the following skills: • Systems thinking • Abstraction • Visualization of specific views • Building consensus within the group • Reflection and transfer
Contents	Cars, household appliances or machines and systems - they are all basic mechanical products that have new, intelligent functions and thus develop into intelligent technical systems. The design of these systems has become an interdisciplinary issue. Systems engineering addresses the systemic and systematic approach to implementing complex systems. It provides the means to view the systems holistically and

	in an interdisciplinary manner, as well as to orchestrate the specialist disciplines involved. In this module, students are taught the basics of systems engineering. The following topics are addressed: • Introduction to the topic of systems engineering • Challenges in the design of intelligent technical systems • Systems thinking • Requirements engineering • System architecture • Model-Based Systems Engineering • Processes and procedures • Challenges in introducing systems engineering company-wide
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Gausemeier - Innovationen für die Märkte von morgen: Strategische Planung von Produkten, Dienstleistungen und Geschäftsmodellen • Haberfellner - Systems Engineering: Grundlagen und Anwendung, 2018 • INCOSE Systems Engineering Handbuch • More literature will be announced at the event.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• 80% Group homework, with 4 parts (2 intermediate Reviews, final presentation, report; each 20%) • 20% written exam, 40min
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	30
Remarks	none
Module Components	• Lecture Systems Engineering Current Description • Exercise Systems Engineering Current Description
Components to be offered in the Current Semester	No assignment

Module 14905 Control of Electrified Aero Engines

assign to: Main Focus Electric Drive Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	14905	Compulsory elective

Modul Title	**Control of Electrified Aero Engines** Regelung Elektrifizierter Luftfahrtantriebe
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Schiffer, Johannes Prof. Dr. rer. nat. Enghardt, Lars
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The students will get a deeper understanding of the challenges presented by the need to control electrified aeronautical propulsion systems. They will learn to formulate mathematical models of the components involved in the control system, analyze the behavior of those models, and develop controllers for such components using linear and non-linear methods.
Contents	Air transport of the future will have to be more climate friendly. The lecture provides an overview of the technological development required to guarantee the reliable, safe, and environmentaly friendly performance of novel hybrid or purely electrified engines for civil aircraft. In parallel, the course will introduce control theoretical topics motivated by the application. • Motivation - FADEC and the Control of Aeronautical Propulsion • Modeling and Control of Individual Components • High-level control • Integration with the Aircraft Control System • Certification Requirements and Processes
Recommended Prerequisites	• Modul 11494 Control Engineering I OR • Modul 12894 Regelungstechnik I
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester

	Self organised studies - 120 hours
Teaching Materials and Literature	• Script based on lecture slides
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	Prerequisite: • There will be bi-weekly homework assignments. The estimated time required for each assignment is about 4 hours. To be allowed for the final exam, students must submit at least 75% of the assignments. Final exam: • 90 mins written OR 20 min oral presentation. At the start of the semester it will be announced, if the examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• VL Control of Electrified Aero Engines • ÜB Control of Electrified Aero Engines • PRÜ Control of Electrified Aero Engines
Components to be offered in the Current Semester	**352221** Lecture/Exercise Control of Electrified Aero Engines - 4 Hours per Term **352272** Examination Control of Electrified Aero Engines

Module 35437 Power Electronic Applications in Drive Systems

assign to: Main Focus Electric Drive Technology

Study programme Hybrid Electric Propulsion Technology

Degree	Module Number	Module Form
Master of Science	35437	Compulsory elective

Modul Title	**Power Electronic Applications in Drive Systems** Leistungselektronik in Antriebssystemen
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Möhlenkamp, Georg
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Students learn the specific items of power electronics in drive applications. They know the typical topologies, power circuit and control structures and can rate and design a drive converter.
Contents	• Voltage source inverter systems • Converter and control design for dc drives • Reversing operation dc drives • Three-phase asynchronous and synchronous drives • Direct torque control and vector control • Pulse-width-modulation for drive converter • Drives with recuperation • Dimensioning of converter systems
Recommended Prerequisites	• Urgently recommended: module 11221 *Fundamentals in Power Electronics* • Electrical Machines • Control Engineering
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 1 hours per week per semester Laboratory training - 1 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Will be given in lecture
Module Examination	Final Module Examination (MAP)

Assessment Mode for Module Examination	• Written examination, 90 minutes
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Power Electronic Applications in Drive Systems (lecture) • Power Electronic Applications in Drive Systems (exercise) • Power Electronic Applications in Drive Systems (laboratory)
Components to be offered in the Current Semester	**320545** Lecture/Seminar Power Electronic Applications in Drive Systems - 4 Hours per Term **320576** Examination Power Electronic Applications in Drive Systems

Erläuterungen

Das Modulhandbuch bildet als Teil der Prüfungsordnung die Rechtsgrundlage für ein ordnungsgemäßes Studium. Darüber hinaus soll es jedoch auch Orientierung bei der Gestaltung des Studiums geben.

Dieses Modulhandbuch wurde am 07. April 2026 automatisch für den Master (universitär)-Studiengang Hybrid Electric Propulsion Technology (universitäres Profil), PO-Version 2024, aus dem Prüfungsverwaltungssystem auf Basis der Prüfungsordnung generiert. Es enthält alle zugeordneten Module einschließlich der ausführlichen Modulbeschreibungen mit Stand vom 07. April 2026. Neben der Zusammensetzung aller Veranstaltungen zu einem Modul wird zusätzlich das Veranstaltungsangebot für das jeweils aktuelle Semester gemäß dem Veranstaltungsverzeichnis der BTU ausgegeben.

The module catalogue is part of the examination regulation and as such establishes the legal basis for studies according to the rules. Furthermore, it should also give orientation for the organisation of the studies.

This module catalogue was generated automatically by the examination administration system on the base of the examination regulation on the 7 April 2026, for the Master (universitär) of Hybrid Electric Propulsion Technology (research-oriented profile). The examination version is the 2024, Catalogue contains all allocated modules including the detailed module descriptions from 7 April 2026. Apart from the composition of all components of a module, the list of lectures, seminars and events for the current semester according to the catalogue of lectures of the BTU is displayed.