Brandenburgische Technische Universität Cottbus - Senftenberg
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Brandenburgische
Technische Universität
Cottbus - Senftenberg

Modulhandbuch für den Studiengang Transfers-Fluids-Materials in Aeronautical and Space Applications (universitäres Profil), Master of Science, Prüfungsordnung 2019

Inhaltsverzeichnis

Total Account
Modules at University of Bordeaux
Material Science and Structures in Aerospace Application
Modules at Universite Catholique de Louvain
Aeronautical Engineering
Compulsory Elective Modules I
Compulsory Elective Modules II
Modules at BTU Cottbus-Senftenberg
12884 Master Thesis Transfers-Fluids-Materials in Aeronautical and Space Applications 3
Advanced Fluid Mechanics, Thermodynamics, Heat Transfer
Compulsory Elective Modules I
11913 Turbulence Modeling 5
12886 Flow Measurements 7
12887 Engineering Acoustics - Sound Fields 9
13519 CFD 1 11
14040 Computational Fluid Dynamics for Engineers 13
14873 Thermodynamics for Engineers 15
Compulsory Elective Modules IIa: Mechanical Engineering, Aeronautical Engineering, Material Science, Aerospace
11913 Turbulence Modeling 17
12233 Experiments in Aerodynamics and Fluid Mechanics 19
12886 Flow Measurements 21
12887 Engineering Acoustics - Sound Fields 23
13254 Image Based Measurement Techniques for Aerodynamics 25
13358 CFD Project 28
13519 CFD 1 30
13717 Decarbonisation of Industrial Processes 32
14040 Computational Fluid Dynamics for Engineers 35
14049 Electrified Aero Engines 37
14725 Industrial Heating Systems and their Defossilization 39
Compulsory Elective Modules IIb: Physics, Mathematics, Computer Science
13299 Dimensional Analysis and Experimentation 43
13361 Stochastic Methods for Flow Simulations 45

13440 Waves and Instabilities in Fluids 47
14873 Thermodynamics for Engineers 49
Erläuterungen **51**

Module 12884 Master Thesis Transfers-Fluids-Materials in Aeronautical and Space Applications

assign to: Modules at BTU Cottbus-Senftenberg

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

Degree	Module Number	Module Form
Master of Science	12884	Mandatory

Modul Title	**Master Thesis Transfers-Fluids-Materials in Aeronautical and Space Applications** Master-Arbeit Transfers-Fluids-Materials in Aeronautical and Space Applications
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 semester
Credits	30
Learning Outcome	The students must show that they were able to learn, understand and elaborate on a problem from modern research under the guidance of their supervisor. They also should develop individual abilities as team work and communication, time management and persistence.
Contents	Elaboration of the subject of the Master Thesis. Written presentation of the results in a scientific accepted form. Elaboration of an oral presentation on the project of the thesis.
Recommended Prerequisites	none
Mandatory Prerequisites	By the time of the registration of a master thesis a student should achieve at least 70 credit points.
Forms of Teaching and Proportion	Research paper/essay - 900 hours
Teaching Materials and Literature	Literature from the scientific field of the master thesis
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Written project report (75% of the final mark) and • oral defense (25% of the final mark) - The written report needs to be passed.
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	No assignment

Module 11913 Turbulence Modeling

assign to: Compulsory Elective Modules I

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

Degree	Module Number	Module Form
Master of Science	11913	Compulsory elective

Modul Title	**Turbulence Modeling** Turbulenzmodellierung
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	The students know different approaches to model turbulent flows. They are able to decide which turbulence model is adequate for different applications.
Contents	In the course we discuss the basic concepts of turbulence modeling. Subjects are: • Conservation equations and canonical flows • Basic concepts of computational fluid mechanics • The problem related to turbulent flow simulation • Algebraic, 1-, and 2 equation models • Reynolds stress models • Reynolds Averaged Navier Stokes (RANS) approaches • Large Eddy Simulation (LES) • Direct numerical simulation (DNS) • Hybrid turbulence models • Stochastic turbulence models
Recommended Prerequisites	Basics in Fluid Mechanics
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	• Pope, S.B.: Turbulent Flows • Geurts, B.J.: Elements of Direct and Large-Edddy Simulation
Module Examination	Final Module Examination (MAP)

Assessment Mode for Module Examination	Oral exam, duration 30-40 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Turbulence modelling (lecture) • Turbulence modelling (exercise) • Turbulence modeling (examination)
Components to be offered in the Current Semester	**350402** Lecture/Exercise Turbulence Modeling - 4 Hours per Term **350478** Examination Turbulence Modeling

Module 12886 Flow Measurements

assign to: Compulsory Elective Modules I

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

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	**350147** Lecture Flow Measurements - 2 Hours per Term **350148** Exercise Flow Measurements - 2 Hours per Term **350186** Examination Flow Measurements

Module 12887 Engineering Acoustics - Sound Fields

assign to: Compulsory Elective Modules I

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

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	**350641** Lecture/Exercise Engineering Acoustics - Sound Fields - 4 Hours per Term **350679** Examination Engineering Acoustics - Sound Fields

Module 13519 CFD 1

assign to: Compulsory Elective Modules I

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

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	• Individual oral examination, 30 - 40 minutes
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 14040 Computational Fluid Dynamics for Engineers

assign to: Compulsory Elective Modules I

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

Degree	Module Number	Module Form
Master of Science	14040	Compulsory elective

Modul Title	**Computational Fluid Dynamics for Engineers** Computational Fluid Dynamics für Ingenieure
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	The participation in the module enables students to understand the topic of industry-related CFD from an analytical and practical point of view. The work with industry-relevant software is brought into focus and enables the students to deal extensively with the content. This is primarily conveyed using practical examples with selected software packages. At the end of the module, the students are able to independently create and evaluate CFD simulations and draw conclusions about their applicability for industry.
Contents	CFD methods in industry • Linux and network architectures • Grid generators and construction of fluid mechanical solvers. • Matlab, toolboxes • Openfoam • Ansys / CFX / Fluent Star CCM+ • Post processing with Paraview
Recommended Prerequisites	This course is an advanced course with respect to numerical fluid mechanics and requires a fundamental knowledge of numerical analysis and fluid mechanics. Therefore, it is suggested to have a prior knowledge in the following taught courses: • Modul 31205 Strömungslehre • Modul 31303 Höhere Strömungsmechanik • Module 13970 Numerical Fluid Mechanics • or comparable knowledge of flow and gas dynamics or numerics.
Mandatory Prerequisites	• no successful participation in 11726 CFD für Ingenieure

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	• Lecture note
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Course Work, 5,000 words. References, table of content, tables and figures are excluded. (70%) • Presentation of results, 12 min excluding examiners questions (30%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• VL, Ü Computational Fluid Dynamics for Engineers
Components to be offered in the Current Semester	**350114** Lecture Computational Fluid Dynamics for Engineers - 2 Hours per Term **350117** Exercise Computational Fluid Dynamics for Engineers - 2 Hours per Term

Module 14873 Thermodynamics for Engineers

assign to: Compulsory Elective Modules I

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

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	**150250** Lecture Thermodynamics for Engineers - 2 Hours per Term **150251** Exercise Thermodynamics for Engineers - 2 Hours per Term **150252** Examination Thermodynamics for Engineers

Module 11913 Turbulence Modeling

assign to: Compulsory Elective Modules IIa: Mechanical Engineering, Aeronautical Engineering, Material Science, Aerospace

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

Degree	Module Number	Module Form
Master of Science	11913	Compulsory elective

Modul Title	**Turbulence Modeling** Turbulenzmodellierung
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	The students know different approaches to model turbulent flows. They are able to decide which turbulence model is adequate for different applications.
Contents	In the course we discuss the basic concepts of turbulence modeling. Subjects are: • Conservation equations and canonical flows • Basic concepts of computational fluid mechanics • The problem related to turbulent flow simulation • Algebraic, 1-, and 2 equation models • Reynolds stress models • Reynolds Averaged Navier Stokes (RANS) approaches • Large Eddy Simulation (LES) • Direct numerical simulation (DNS) • Hybrid turbulence models • Stochastic turbulence models
Recommended Prerequisites	Basics in Fluid Mechanics
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	• Pope, S.B.: Turbulent Flows • Geurts, B.J.: Elements of Direct and Large-Edddy Simulation

Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	Oral exam, duration 30-40 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Turbulence modelling (lecture) • Turbulence modelling (exercise) • Turbulence modeling (examination)
Components to be offered in the Current Semester	**350402** Lecture/Exercise Turbulence Modeling - 4 Hours per Term **350478** Examination Turbulence Modeling

Module 12233 Experiments in Aerodynamics and Fluid Mechanics

assign to: Compulsory Elective Modules IIa: Mechanical Engineering, Aeronautical Engineering, Material Science, Aerospace

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

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	**350124** Lecture Experiments in Aerodynamics and fluid mechanics - 1 Hours per Term **350125** Exercise Experiments in Aerodynamics and fluid mechanics - 3 Hours per Term

Module 12886 Flow Measurements

assign to: Compulsory Elective Modules IIa: Mechanical Engineering, Aeronautical Engineering, Material Science, Aerospace

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

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	**350147** Lecture Flow Measurements - 2 Hours per Term **350148** Exercise Flow Measurements - 2 Hours per Term **350186** Examination Flow Measurements

Module 12887 Engineering Acoustics - Sound Fields

assign to: Compulsory Elective Modules IIa: Mechanical Engineering, Aeronautical Engineering, Material Science, Aerospace

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

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	**350641** Lecture/Exercise Engineering Acoustics - Sound Fields - 4 Hours per Term **350679** Examination Engineering Acoustics - Sound Fields

Module 13254 Image Based Measurement Techniques for Aerodynamics

assign to: Compulsory Elective Modules IIa: Mechanical Engineering, Aeronautical Engineering, Material Science, Aerospace

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

Degree	Module Number	Module Form
Master of Science	13254	Compulsory elective

Modul Title	**Image Based Measurement Techniques for Aerodynamics** Bildgebende Messverfahren in der Aerodynamik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr. rer. nat. Schröder, Andreas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	The students will learn the (laser-) optical and electronic basics as well as suitable digital image processing and evaluation methods for various 2D- and 3D-image based measurement- and visualization methods (e.g. PIV, LPT, LIF, PSP, TSP, BOS, DIC etc.) for aerodynamics. Through relevant applications to unsteady and rotational flows and on surfaces of bodies immersed in such flows, the students will get to know the limits (systematic and signal-to-noise ratio-related measurement uncertainties) and possibilities of different optical (non-intrusive) measurement techniques. Equipped with this knowledge, the students learn the use of (statistical) analysis tools that can be applied to the experimentally achieved instantaneous or time-resolved planar or volumetric flow field data from industrial flow facilities or wind- and water tunnels in order to achieve a deeper understanding of the investigated flow properties and related (dynamical) forces and moments. The quantitative flow measurement data and their analysis should in turn enable the students to directly relate to the underlying Navier-Stokes equations, to validation procedures for (U)RANS and other CFD methods, to different models and dynamics of vortical flow structures, to aero-elastically coupled fluid-structure interactions or to the field of aero-acoustics.
Contents	Due to enormous advances in the field of digital camera, laser and LED technologies for spatially and temporally highly-resolved image acquisition on the one hand and the increased performance of computers and GPU clusters for digital image processing on the other hand, optical measurement techniques are in a rapid upswing

	and are increasingly replacing classic, sensor-based measurement techniques. In the lecture the theoretical, optical and technical basics, as well as current further developments and applications of image based measurement methods in the areas of aerodynamics, fluid mechanics, and aero-elasticity, as well as partly in aeroacoustics will be presented. In addition to methods that aim at the acquisition of aero-dynamically and -elastically relevant measurement variables such as the distribution of pressure, deformation, temperature or wall shear stress on model surfaces, optical methods for the planar and volumetric measurements of scalar quantities in flows, such as density, concentration or temperature are discussed. However, the greater part of the lecture will deal with the theory, application and evaluation of particle-based measurement methods for the planar and volumetric determination of instantaneous and time-resolved velocity, acceleration and pressure fields in unsteady flows, as well as with the possibilities of the subsequent data assimilation and analysis tools.
Recommended Prerequisites	• English language skills • Basic knowledge in fluid mechanics and optics
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	• Raffel et al. PIV a practical guide, 3rd edition (2018) • Tropea C., Yarin A.L., Foss J.F. (Eds.): Handbook of Experimental Fluid Mechanics, Springer Verlag (2007) • Schröder A., Willert C. (Eds.): Particle Image Velocimetry – New developments and recent applications, Springer Verlag (2007) • Selected literature
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Completion of 7 practical training exercises and preparation of the respective reports of about 3 pages each (1/3 of the module grade). • Oral examination of approx. 30 min. duration (2/3 of the module grade)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Lecture Image based measurement techniques for aerodynamics • Exercise Image based measurement techniques for aerodynamics • Exam Image based measurement techniques for aerodynamics
Components to be offered in the Current Semester	**352102** Lecture Image based measurement techniques for aerodynamics - 2 Hours per Term **352103** Exercise/Practical training

Image based measurement techniques for aerodynamics - 2 Hours per Term

Module 13358 CFD Project

assign to: Compulsory Elective Modules IIa: Mechanical Engineering, Aeronautical Engineering, Material Science, Aerospace

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

Degree	Module Number	Module Form
Master of Science	13358	Compulsory elective

Modul Title	**CFD Project** CFD-Projekt
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	Goal of the hands-on training is to convey basic knowledge of scientific computing with a focus on the application of CFD software (commercial, opensource and self written). The students work independantly on separate projects, deepen their basic knowledge of CFD methods and learn the sequence of operations of programming, compiling, excecuting codes, and post processing data.
Contents	• Basics of Scientific Computung • Compiler and Makefiles • Higer program languages (C++ and Fortran) • CFD Software: OpenFoam, adaptive ODT • Postprocessing with Python Scripts, VisIt, ParaView • Scientific Analysis of simulation results
Recommended Prerequisites	• Basic knowledge in CFD and Fluid Mechanics
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	• Ferziger & Peric, Computational Methods for Fluid Dynamics, 2002 • Jasak, Error Analysis and Estimation for the Finite Volume Method with Applications to Fluid Flows, PhD-Thesis, 1996 • Breymann, C++ eine Einführung, Hanser, 1999 • Theis, Einstieg in Python, Galileo Press, 2011

Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• oral exam, 30-45 minutes
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The module appeals to students with some experience in programing.
Module Components	• VL CFD-Project • Proj CFD-Project • P CFD-Project
Components to be offered in the Current Semester	**350404** Lecture/Exercise CFD Project - 4 Hours per Term **350473** Examination CFD Project

Module 13519 CFD 1

assign to: Compulsory Elective Modules IIa: Mechanical Engineering, Aeronautical Engineering, Material Science, Aerospace

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

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	• Individual oral examination, 30 - 40 minutes
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 13717 Decarbonisation of Industrial Processes

assign to: Compulsory Elective Modules IIa: Mechanical Engineering, Aeronautical Engineering, Material Science, Aerospace

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

Degree	Module Number	Module Form
Master of Science	13717	Compulsory elective

Modul Title	**Decarbonisation of Industrial Processes** Dekarbonisierung von Industrieprozessen
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr. rer. nat. habil. Riedel, Uwe
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	Participants of the module will be able to understand the specific challenges of CO_2-reduction in the industrial sectors. Readiness of current and emerging technologies (technology readiness level) and significance for a successful energy transition for various industrial sectors will be discussed. Focus is on the decarbonization of heat as a crosscutting technology and the steel, chemistry, cement sector – each having specific challenges. At the end of the module the students will be able to name the requirements for achieving climate goals in various industrial sectors. Furthermore, students will be able to assess, evaluate, and select different decarbonization strategies for specific industrial processes. Specific cognitive learning goals are: • Apply analysis tools like pinch analysis, techno-economics, and energy-hub designs • Analyze selected industrial processes in case studies • Derive and evaluate suitable decarbonization options in a group-project • Get insights into options for process changes and decarbonization in the sectors steel, chemistry, and cement as well as process heat • Understand the role of Carbon Capture and Use (CCU) and Carbon Capture and Storage (CCS) for unavoidable CO_2-emissions. Affective learning goals are: • Integration in a team and potential conflicts, • deal with feedback in an open presentation session, • deal with potential frustration in a research project.

Contents	The specific topics will be explained in the lecture while the exercise and the project parts will provide more in-depth deeper qualitative and quantitative analyses. The projects will focus on specific industries and their options to reduce their carbon footprint. The lecture part is structured as follows: • Introduction • Techno-Economic Analysis • Pinch Analysis • Renewable Energy Hub Design • Industrial Heat • Steel Industry • Chemical Industry • Cement Industry These lectures are supported by exercises on techno-economic analysis, Pinch Analysis, energy hub design and CCU/CCS. The decarbonization techniques learned will then be applied as part of a study project.
Recommended Prerequisites	Bachelor in Engineering or Natural Sciences
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 1 hours per week per semester Study project - 2 hours per week per semester Self organised studies - 105 hours per week per semester
Teaching Materials and Literature	• Selected literature will be recommended at the beginning of the module. • Handouts for the lecture will be provided. • Options and guidelines for the project work will be given in the first lecture.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	Option A: • A 10-minute electronic presentation of the study project at the beginning of the exam (1/3 weight) and • Oral exam, 20 minutes, questions related to the lecture and the exercise (2/3 weight) Option B: • Multiple-choice test, 20 minutes (30% weight) • Written examination, 60 minutes: Questions related to the lecture, the exercise, and the outcome of study project (70% weight) The lecturer decides and informs at the beginning of the course which option is used as assessment mode.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none

Remarks	none
Module Components	• VL Decarbonization of Industrial Processes • Ü Decarbonization of Industrial Processes • PROJ Decarbonization of Industrial Processes
Components to be offered in the Current Semester	**322201** Lecture Decarbonization of Industrial Processes - 2 Hours per Term **322202** Exercise Decarbonization of Industrial Processes - 1 Hours per Term

Module 14040 Computational Fluid Dynamics for Engineers

assign to: Compulsory Elective Modules IIa: Mechanical Engineering, Aeronautical Engineering, Material Science, Aerospace

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

Degree	Module Number	Module Form
Master of Science	14040	Compulsory elective

Modul Title	**Computational Fluid Dynamics for Engineers** Computational Fluid Dynamics für Ingenieure
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	The participation in the module enables students to understand the topic of industry-related CFD from an analytical and practical point of view. The work with industry-relevant software is brought into focus and enables the students to deal extensively with the content. This is primarily conveyed using practical examples with selected software packages. At the end of the module, the students are able to independently create and evaluate CFD simulations and draw conclusions about their applicability for industry.
Contents	CFD methods in industry • Linux and network architectures • Grid generators and construction of fluid mechanical solvers. • Matlab, toolboxes • Openfoam • Ansys / CFX / Fluent Star CCM+ • Post processing with Paraview
Recommended Prerequisites	This course is an advanced course with respect to numerical fluid mechanics and requires a fundamental knowledge of numerical analysis and fluid mechanics. Therefore, it is suggested to have a prior knowledge in the following taught courses: • Modul 31205 Strömungslehre • Modul 31303 Höhere Strömungsmechanik • Module 13970 Numerical Fluid Mechanics • or comparable knowledge of flow and gas dynamics or numerics.
Mandatory Prerequisites	• no successful participation in 11726 CFD für Ingenieure

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	• Lecture note
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Course Work, 5,000 words. References, table of content, tables and figures are excluded. (70%) • Presentation of results, 12 min excluding examiners questions (30%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• VL, Ü Computational Fluid Dynamics for Engineers
Components to be offered in the Current Semester	**350114** Lecture Computational Fluid Dynamics for Engineers - 2 Hours per Term **350117** Exercise Computational Fluid Dynamics for Engineers - 2 Hours per Term

Module 14049 Electrified Aero Engines

assign to: Compulsory Elective Modules IIa: Mechanical Engineering, Aeronautical Engineering, Material Science, Aerospace

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

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	**352201** Lecture Electrified Aero Engines - 2 Hours per Term **352202** Exercise Electrified Aero Engines - 2 Hours per Term **352271** Examination Electrified Aero Engines

Module 14725 Industrial Heating Systems and their Defossilization

assign to: Compulsory Elective Modules IIa: Mechanical Engineering, Aeronautical Engineering, Material Science, Aerospace

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

Degree	Module Number	Module Form
Master of Science	14725	Compulsory elective

Modul Title	**Industrial Heating Systems and their Defossilization** Industrielle Wärmeversorgungssysteme und ihre Defossilisierung
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr. Stathopoulos, Panagiotis
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	**Cognitive Learning Goals (Knowledge & Understanding)** • Understand the role of industrial heating in different industries and their specific heat demands. (level 1) • Describe various industrial heat distribution systems (steam, thermal oil, hot water, gases) and their efficiency considerations.(level 2) • Explain different fossil heat sources and their applications in industrial heating. (level 1) • Explain the thermodynamic principles of industrial heating (compression, expansion, heat transfer, heat exchangers). (level 3) • Analyze different compressor types used in industrial heat pumps and their performance characteristics. (level 3) • Model thermodynamic cycles for industrial heat pumps and assess efficiency based on working fluids.(level 4) • Compare and contrast heat pumps designed for large temperature glides and steam generation. (level 3) • Explain the working principles and integration strategies of solar thermal and alternative heating technologies. (level 3) • Apply pinch analysis to optimize heat recovery and integrate heat pumps into industrial processes. (level 2) • Evaluate economic and environmental impacts of different industrial heating systems. (level2) **Affective Learning Goals (Attitudes & Values)** • Appreciate the importance of energy efficiency and decarbonization in industrial heating. (level1) • Develop a critical perspective on fossil-based heating systems and their long-term viability.(level 2)

- Recognize the role of regulations (especially EU policies) in shaping industrial heating technologies.(level1)
- Show commitment to sustainable energy solutions by considering alternative heating methods.(levle2)
- Engage in discussions on the trade-offs between economic feasibility and environmental impact. (level3)

Valuing Interdisciplinary Collaboration (Level 4):
- Appreciate the need for collaboration between engineers, policymakers, and business leaders to drive industrial heat pump adoption.

Confidence in Practical Application (Level 5):
- Gain self-efficacy in applying thermodynamic principles and system integration knowledge to real-world heat pump installations.

Psychomotor Learning Goals (Practical & Technical Skills)
- Perform basic thermodynamic calculations related to industrial heat pumps and heating systems.
- Use computational tools to model and evaluate heat pump performance.
- Conduct pinch analysis on industrial processes to identify heat recovery opportunities.
- Design and size a solar thermal system for industrial applications.
- Develop and present an optimized industrial heating system proposal.

Operating Industrial Heat Pump Systems (Level 1):
- Start up, monitor, and shut down an industrial heat pump safely.

Conducting Performance Measurements (Level 4):
- Measure key parameters (temperature, pressure, COP, etc.) and analyze system performance.

Interpreting Technical Diagrams (Level 6):
- Read and understand P&ID (Piping and Instrumentation Diagrams) and system schematics of industrial heat pumps.

Applying Safety Procedures (Level 4):
- Follow proper safety protocols when handling high-temperature heat pumps.

Conducting Efficiency Optimization Tests (Level 4):
- Perform practical tests to improve system efficiency, such as adjusting heat source/sink temperatures or optimizing cycle parameters.

Contents

Chapter 1: Introduction to Industrial Heating Systems
- Overview of Industrial Heating Systems, Environmental & Economic Impacts, and Regulatory Overview
- Industrial Sectors and Their Heat Demand
- Industrial Heat Distribution Systems & Fossil Heat Sources

Chapter 2: Thermodynamic Fundamentals
- Basics of Thermodynamics for Industrial Heating (Compression, Expansion, Cycles)
- Basics of Heat Transfer and Heat Exchangers

	• Compressors in Heat Pump Systems **Chapter 3: Industrial Heat Pump Technologies & Alternative Heating** • Industrial Heat Pumps – Thermodynamic Modeling (Part 1: Vapor Compression, COP, Exergy Analysis) • Industrial Heat Pumps – Thermodynamic Modeling (Part 2: Working Fluids & Environmental Impact) • Industrial Heat Pumps – Thermodynamic Modeling (Part 3: Advanced Cycles & System Integration) • Heat Pumps for Large Temperature Glides • Heat Pumps for Steam Generation • Solar Thermal Systems in Industry • Alternative Heating Technologies (Infrared, Inductive, Resistance, Hybrid Systems) **Chapter 4: Process Integration & Economic Evaluation** • Process Integration Fundamentals & Pinch Analysis • Pinch Analysis for Heat Pump Integration • Economic and Environmental Evaluation of Heating Systems • Final Project and Wrap-Up **Chapter 5: Practical Application & Industry Collaboration** • Interdisciplinary Collaboration in Industrial Heating • Industrial Heat Pump Operation & Safety Lab • Performance Measurement & Efficiency Optimization Lab
Recommended Prerequisites	• Knowledge of thermodynamics, fluid mechanics and heat transfer
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	Will be announced on the Moodle learning platform or during the courses.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Project work with 8-10 pages documentation (70%) and • 3 presentations over ~10 min. in the course of the semester each counting 10%
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	25
Remarks	The module is divided in two parts: The first will take the first 10 weeks of the semester and will focus on knowledge transfer to make sure that the students have all information and data they need to carry out the project. The last part of the semester is dedicated on a project that the students will carry out as their exam. The project will focus on the application of high temperature heat pumps in real world cases, drawn fro the research projects of the chair. The students will be divided in

groups of five. The whole topic will be structures in puzzle groups. The final exam will be organizeas a closure of the puzzle groups t answer the overarching research question.

Module Components

- Lecture Industrial Heating Systems and their Defossilization
- Project Industrial Heating Systems and their Defossilization

Components to be offered in the Current Semester

322302 Study project
Industrial Heating Systems and their Defossilization - 2 Hours per Term
322301 Lecture/Seminar
Industrial Heating Systems and their Defossilization - 2 Hours per Term

Module 13299 Dimensional Analysis and Experimentation

assign to: Compulsory Elective Modules IIb: Physics, Mathematics, Computer Science

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

Degree	Module Number	Module Form
Master of Science	13299	Compulsory elective

Modul Title	**Dimensional Analysis and Experimentation** Dimensionsanalyse und Experiment
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr. rer. nat. habil. Harlander, Uwe
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Goal is to use dimensional analysis to bring together the results of experiments and theory/computations in a concise but exact form. Moreover we will show that many phenomena in nature, engineering or society exhibit the remarkable property of self-similarity. In the lecture we highlight the tight connection between dimensional analysis and scaling laws. The latter is a powerful concept of understanding experimental data of fluid mechanics.
Contents	• Numbers and units • Dimensions and variables • Dimensional analysis • Similarity and intelligent experimentation • Nondimensionalisation of equations • Self-similarity and power laws • Models of fluid mechanics
Recommended Prerequisites	Basics of analysis and fluid dynamics
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	• Book "Dimension analysis and intelligent experimentation" von A.C. Palmer • Book "Scaling" von G.I. Barenblatt
Module Examination	Prerequisite + Final Module Examination (MAP)

Assessment Mode for Module Examination	Prerequisite: • two tests for exercise (ungraded) until 10th lecture week Final Module Examination: • Written exam, 90 minutes
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	VL Dimensional Analysis and Experimentation SEM Dimensional Analysis and Experimentation PRÜ Dimensional Analysis and Experimentation
Components to be offered in the Current Semester	**350141** Lecture Dimensional Analysis and Experimentation - 2 Hours per Term **350142** Exercise Dimensional Analysis and Experimentation - 2 Hours per Term **350178** Examination Dimensional Analysis and Experimentation

Module 13361 Stochastic Methods for Flow Simulations

assign to: Compulsory Elective Modules IIb: Physics, Mathematics, Computer Science

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

Degree	Module Number	Module Form
Master of Science	13361	Compulsory elective

Modul Title	**Stochastic Methods for Flow Simulations** Stochastische Methoden in der Strömungssimulation
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 module participation the students are able to apply stochastic methods to numerical problems in fluid mechanics.
Contents	The theoretically and numerically covered subjects are • stochastic mixing models (e.g. LEM and HIPS) • stochastic turbulence models (e.g. ODT and ODTLES) • pdf methods
Recommended Prerequisites	Attending the “Turbulence Modeling” module in advance or in parallel is recommended.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	• Stephen B. Pope, Turbulent Flows, 2000 • Joel H. Ferziger, Numerische Strömungsmechanik, 2007 • John L. Lumley, Stochastic tools in turbulence, 2007
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Oral examination (30-45 minutes)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none

Remarks	If required, individual questions can also be anwered in German.
Module Components	none
Components to be offered in the Current Semester	**350407** Seminar Stochastic Methods for Flow Simulations - 2 Hours per Term **350479** Examination Stochastic Methods for Flow Simulations

Module 13440 Waves and Instabilities in Fluids

assign to: Compulsory Elective Modules IIb: Physics, Mathematics, Computer Science

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

Degree	Module Number	Module Form
Master of Science	13440	Compulsory elective

Modul Title	**Waves and Instabilities in Fluids** Wellen und Instabilitäten in Flüssigkeiten
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	PD Dr. rer. nat. habil. Borcia, Rodica
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successfully completing the module, students master the foundations of hydrodynamics with regard to theoretical and phenomenological aspects. The topic of the module serves as an example for studying the realization of knowledge and the classification of knowledge within the field of physics. In addition the module supports further competences as e. g. cooperation ability, carefullness, persistance, curiosity, working on one's own initiative.
Contents	1. Hydrodynamic basic equations: Euler, Navier-Stokes, continuity, energy, concentration(s) 2. Surface waves: Potential flow, deep and shallow water, solitons, Tsunamis, capillary waves 3. Instabilities: general principles, bifurcation theory, classification 4. Unstable systems: Kelvin-Helmhotz, Rayleigh-Taylor, convection, mixtures, thin films
Recommended Prerequisites	• Basic level knowledge in theoretical physics (Bachelor-level)
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	• P. K. Kundi, Fluid Mechanics • H. Lamb, Hydrodynamics

	• T. E. Faber, Fluid Dynamics for Physicists
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of exercise assignments (75% must be reached) **Final module examination:** • Written examination, 90 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Physics M.Sc.: Compulsory elective module in complex „Physical Specialization with theoretical focus“, topic area „Theory, Simulation and further topics“ • Study programme Applied Mathematics M.Sc.: Compulsory elective module in complex „Applications“, field „Physics“
Module Components	• Lecture: Waves and Instabilities in Fluids • Accompanying exercise • Related examination
Components to be offered in the Current Semester	**150220** Lecture Waves and Instabilities in Fluids - 2 Hours per Term **150221** Exercise Waves and Instabilities in Fluids - 2 Hours per Term **150223** Examination Waves and Instabilities in Fluids

Module 14873 Thermodynamics for Engineers

assign to: Compulsory Elective Modules IIb: Physics, Mathematics, Computer Science

Study programme Transfers-Fluids-Materials in Aeronautical and Space Applications

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	**150250** Lecture Thermodynamics for Engineers - 2 Hours per Term **150251** Exercise Thermodynamics for Engineers - 2 Hours per Term **150252** Examination Thermodynamics for Engineers

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 10. November 2025 automatisch für den Master (universitär)-Studiengang Transfers-Fluids-Materials in Aeronautical and Space Applications (universitäres Profil), PO-Version 2019, aus dem Prüfungsverwaltungssystem auf Basis der Prüfungsordnung generiert. Es enthält alle zugeordneten Module einschließlich der ausführlichen Modulbeschreibungen mit Stand vom 10. November 2025. 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 10 November 2025, for the Master (universitär) of Transfers-Fluids-Materials in Aeronautical and Space Applications (research-oriented profile). The examination version is the 2019, Catalogue contains all allocated modules including the detailed module descriptions from 10 November 2025. 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.