Hochschule Düsseldorf
University of Applied Sciences

Fachbereich Maschinenbau
und Verfahrenstechnik
Faculty of Mechanical
and Process Engineering

MODULE MANUAL
MECHANICAL ENGINEERING

TABLE OF CONTENTS

Elective Course I-IV are to be chosen from the list of elective courses.

Abbreviations:

sem. = semester
SoSe = summer semester; WiSe = winter semester
SWS = credit hours per week
IWI = International Industrial Engineering; SET = Simulation and Experimental Engineering; ME = Mechanical Engineering

Engineering Mathematics					
Module no.		**Workload**	**Credits**	**Semester**	**Offered in**
		180 h	6	Sem. 1/2	Each SoSe
1	**Courses** a) Lecture 3 SWS b) Practical Training 2 SWS		**Attendance** 5 SWS / 75 h	**Self-study** 105 h	**Duration** 1 sem.
2	**Learning outcomes / competences** The participants have • a solid understanding of and scientific insight into the mathematical foundations of computational engineering, including numerical and algorithmic aspects of modern software tools. • the ability to ○ derive and extend basic numerical algorithms, ○ implement, test and apply algorithms and numerical solution schemes in the context of engineering problems, ○ identify, characterise and assess the computational performance of algorithmic and numerical problems. The participants are familiar with • the basic mathematics of computational methods • modelling issues and error sources of the computational models • the basic aspects of verification and validation and error control				
3	**Contents** • Linear & non-linear systems of equations (properties, numerical solution method, algorithmic aspects) • The engineering eigenvalue problem (algebraic properties, solution strategies, numerical solution methods and algorithmic aspects) • Numerical algorithms (numerical interpolation, numerical differentiation, numerical integration in 1D, 2D and 3D) • Algebra of relations (Boolean algebra, transitive closure), Graph theory (types of graphs and applications) • Paths in networks (path algebra, weighted graphs)				
4	**Forms of teaching and learning** Flipped classroom including lecture, exercise, seminar, discussion + weekly feedback sessions (on site & digital)				
5	**Prerequisites** **Formal prerequisites:** /				

	Subject-related prerequisites:	Java (essential and necessary prerequisite) & Matlab Programming Skills, Foundations of Engineering Mathematics and Mechanics
6	**Types of examination** Assessment in two parts according to the following weighting for the final grade: I. Worked and defended practical: 30% of the final grade II. Written exam (90 min.): 70% of the final grade The students must pass each of the two parts with a minimum of 50% of the used grading scheme. The practical involves software implementations as well as exercises with regard to the presented lecture content.	
7	**Requirements for award of credits** Passed examination	
8	**Module allocated to other study programmes** SET	
9	**Weighting for overall grade** 6/90	
10	**Person responsible for the module and examiner(s)** Prof. Dr.-Ing. habil. Martin Ruess	
11	**Language of instruction** English	
12	**Further information and recommended literature** Lecture slides and lecture notes in form of a reader (partly) are provided	

Simulation of Mechanical Systems				
Module no.	**Workload**	**Credits**	**Semester**	**Offered in**
	180 h	6	Sem. 1	Each WiSe
Courses		**Attendance**	**Self-study**	**Duration**
a) Lecture 2 SWS b) Exercise 2 SWS c) Practical Training 1 SWS		5 SWS / 75 h	105 h	1 sem.

1	**Learning outcomes / competences** The students know • the theoretical and practical foundations for modelling mechanical systems. They can • build up and simulate models of kinematic chains, open or closed by kinematic or control means, as well as optimise them by simple parameter variation, • carry out scientific work in this area.
2	**Contents** Modelling and simulating mechanical systems
3	**Forms of teaching and learning** • Oral presentation with slides, computer based simulations • Programming examples and exercises • Practical evaluation of simulations by students themselves • Guidance to independent scientific work, e. g. in regular meetings and consulting hours during the second part of the course
4	**Prerequisites** **Formal prerequisites:** / **Subject-related prerequisites:** Study of mechanics or technical mechanics (approximately 12 CP on bachelor's level)
5	**Types of examination** Modelling and simulating of a given mechanical system with software at home or in the laboratory, 50% Oral examination and presentation of simulation results (30 min.), 50%
6	**Requirements for award of credits** Passed examination
7	**Module allocated to other study programmes** /
8	**Weighting for overall grade** 6/90

9	**Person responsible for the module and examiner(s)** Dean, lecturer: Dr.-Ing. Andrej Batos
10	**Language of instruction** English
11	• pdf-files of lecture slides in MOODLE learning platform, including exercises • pdf-files of former exercises, partly with solutions in MOODLE learning platform Recommended literature (latest edition): • Henning, Jahr, Mrowka: Technische Mechanik mit Mathcad, Matlab und Maple. Vieweg Verlag, Wiesbaden, 2004 • John J. Craig: Introduction to Robotics. Pearson Education Limited, Upper Saddle River, 4. Edition, 2020 • Kevin M. Lynch, Frank C. Park: Modern Robotics: Mechanics, Planning, and Control. Cambridge University Press, Cambridge, 2017 • specific software literature, special scientific papers MATLAB Simscape Multibody: http://de.mathworks.com/help/physmod/sm/getting-started-with-simmechanics.html

Signal Processing for Mechanical and Process Engineering				
Module no.	**Workload** 180 h	**Credits** 6	**Semester** Sem. 1/2	**Offered in** Each SoSe
Courses a) Lecture 2 SWS b) Practical Training 3 SWS		**Attendance** 5 SWS / 75 h	**Self-study** 105 h	**Duration** 1 Sem.

1 Learning outcomes / competences

After successful completion of the module, the students are able to

- analyse and verify signals in the time and frequency domain,
- know the advantages and disadvantages of different data acquisition systems (rms-voltmeter, sound boards versus AD converter),
- operate accelerometers, microphones, oscilloscopes and rms-voltmeter,
- distinguish between steady-state, transient and dynamic data,
- check self-designed programmes and circuits by simulations, e.g. verify overall levels in the time and frequency domain (Parseval theorem),
- distinguish between correlation measurement techniques in time and frequency domain and apply the concept of coherence, phase spectrum and time delay,
- apply mathematical formulations (e.g. of the Fourier principle and statistical methods),
- develop approaches and strategies to independently gather experimental data,
- establish concepts to relate signal components to its physical origin,
- reflect and generalise fundamental principles to transfer them to various experimental problems.

2 Contents

- Overview of the typical measurement principles for determining position, velocity, current, pressure, sound pressure and vibration
- Fundamental principles in signal processing (Fourier-, uncertainty- and symmetry principle)
- Data acquisition, including rudimentary concepts in signal processing
- Signal analysis in time and frequency domain including transfer operations (Parseval theorem)
- Advanced operations in signal processing (windowing, averaging, overlapping)
- Signal Conditioning, Digital Filtering (low-, high- and bandpass filtering, octave band analysis)
- Applications to aeroacoustics and vibroacoustics (rotating machinery, Campbell diagram)
- Correlation techniques in time and frequency domain (auto correlation, cross correlation, coherence, phase analysis)

3 Forms of teaching and learning

	• Lecture with PC presentations, videos (In-house productions), • Practical training using provided hard- and software (e.g. Dasylab, Matlab, PAK)
4	**Prerequisites** **Formal prerequisites:** None **Subject-related prerequisites:** Basics of data acquisition and numerical mathematics (e.g. fluid mechanics and acoustics from Bachelor programme of HSD)
5	**Types of examination** Final term paper at the end of the course (60% of the final grade). Study-accompanying practical work term papers (40% of the final grade) in groups of two (3/5 of the 40%) and as single work (written or oral) (2/5 of the 40%).
6	**Requirements for award of credits** Passed examination
7	**Module allocated to other study programmes** SET, ME
8	**Weighting for overall grade** 6/90
9	**Person responsible for the module and examiner(s)** Prof. Dr.-Ing. Frank Kameier
10	**Language of instruction** English
11	**Further information and recommended literature** Lecture notes, presentation slides, software applications on moodle or stroemungsakustik.de Recommended literature: • Karrenberg, Ulrich, Signals, Processes, and Systems, An Interactive Multimedia Introduction to Signal Processing, 3rd edition, Berlin 2013. • Schmid, Hanspeter, How to use the FFT and Matlab's pwelch function for signal and noise simulations and measurements, FHNW/IME, August 2012 https://pdfs.semanticscholar.org/82f7/98aef6346a0e14bc52f0e4eca93a8f06ff27.pdf • Hewlett Packard, The Fundamentals of Signal Analysis, Application Note 243, 1994 http://www.hpmemoryproject.org/an/pdf/an_243.pdf

Finite Element Method				
Module no.	**Workload**	**Credits**	**Semester**	**Offered in**
	180 h	6	Sem. 2	WiSe

1	**Courses** a) Lecture 3 SWS b) Practical Training 2 SWS	**Attendance** 5 SWS / 75 h	**Self-study** 105 h	**Duration** 1 sem.

2 Learning outcomes / competences

The participants have

- a solid understanding of and scientific insight into the fundamentals of the finite element method, including all aspects of the simulation pipeline. Moreover, they are familiar with numerical and algorithmic aspects of modern software tools.
- the ability to
  - derive the set of equations governing physical field problems
  - develop, implement and test various types of finite elements
  - choose and assess the performance properties of finite elements
  - pre- and postprocess analysis-suited models and assess the numerical results with regard to accuracy, reliability and computational performance

The participants are familiar with

- the basic functionality of commercial finite element platforms
- modelling issues and error sources of the computational model
- the basic aspects of verification and validation

3 Contents

- Introduction to the basic principles of the Finite Element Method for the solution of problems based on ordinary/partial differential equations (fe-analysis pipeline, fields of applications)
- Derivation of the governing set of equations for various physical problems (thermal, elasticity, flow problems, etc., governing differential, integral and algebraic equations, method of weighted residuals, Galerkin formulation)
- Element formulations (approximation spaces, algebraic & numerical properties), assembly, mesh generation, enforcement of constraints, solution methods and solution properties, accuracy and convergence measures/properties, model errors, algorithmic aspects, modeling aspects and software implementation aspects for linear analyses
- Modelling and solution of engineering problems with commercial software packages

4 Forms of teaching and learning

Lecture content: flipped classroom including lecture, exercise, seminar, discussion + weekly feedback sessions (on site & digital)

Practical training: commercial software-based problem solving, video-based & guided tutorials

5 Prerequisites

	Formal prerequisites: / **Subject-related prerequisites:** Java (essential and necessary prerequisite) & Matlab Programming Skills, Foundations of Engineering Mathematics and Mechanics
6	**Types of examination** Assessment in two parts according to the following weighting for the final grade: I. Worked and defended practical: 30% of the final grade II. Written exam (90 min duration): 70% of the final grade The students must pass each of the two parts with a minimum of 50% of the used grading scheme. The practical involves modelling problems as well as exercises with regard to the presented lecture content.
7	**Requirements for award of credits** Passed examination
8	**Module allocated to other study programmes** Knowledge of contents needed for all design and analysis-based modules of engineering
9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)** Prof. Dr.-Ing. habil. Martin Ruess
11	**Language of instruction** English
12	**Further information and recommended literature** • Lecture slides and lecture notes in form of a reader (partly) are provided • K.-J. Bathe. Finite Element Procedures, Prentice Hall, 1995 • R.D. Cook, D.S. Malkus, M.E. Plesha. Concepts and Applications of Finite Element Analysis, John Wiley & Sons, 1989 • T.J.R. Hughes. The Finite Element Method – Linear Static and Dynamic FEA, Prentice Hall, 2000 • Gebhardt, Ch. Praxisbuch FEM mit ANSYS Workbench, Hanser Verlag München 2018

Computational Fluid Dynamics (CFD)				
Module no.	**Workload** 180 h	**Credits** 6	**Semester** Sem. 1/2	**Offered in** Each SoSe
Courses a) Lecture 3 SWS b) Exercise 1 SWS c) Practical Training 1 SWS		**Attendance** 5 SWS / 75 h	**Self-study** 105 h	**Duration** 1 Sem.

1 Learning outcomes / competences

After successful completion of the module, the students are capable of

- understanding the differential equations that describe the transport of momentum, heat and mass in the single-phase flow of Newtonian fluids as well as their boundary conditions.
- understanding different physical flow states with corresponding mathematical and numerical implications.
- understanding discretisation principles, gridding techniques and numerical solution procedures.
- applying the learned material to solve technical flow problems, via a commercial CFD software, and analysing and evaluating the results competently.
- communicating in English on the course subject.

2 Contents

- Introduction
- Continuum mechanics fundamentals
- Governing equations
- Simplifications of governing equations
- Discretisation methods
- Finite Volume Method (FVM) for diffusion problems in 1D
- FVM for diffusion problems in 2D/3D
- FVM for convection-diffusion problems
- Higher order schemes for the convection terms
- FVM for unsteady flows
- Solution of the Navier-Stokes equations by FVM
- FVM for unstructured grids
- Introduction to turbulence modelling
- Concluding remarks and guidelines for the solution of practical flow problems

3 Forms of teaching and learning

Lecture (Power point, overhead, blackboard), seninar, discussion, independent elaboration

4 Prerequisites

	Formal prerequisites: / **Subject-related prerequisites:** Thermodynamics, Fluid Mechanics, Heat Transfer, Mathematics
5	**Types of examination** • Written examination, or e-examination, or e-open-book-examination in English (in parts or in full multiple-choice, 90 min.), or oral examination (30 min.), 80% Applicable type of examination be announced at the beginning of the course • Practical training with oral or written examination, 20% Applicable type of examination to be announced at the beginning of the course
6	**Requirements for award of credits** Passed examination
7	**Module allocated to other study programmes** SET
8	**Weighting for overall grade** 6/90
9	**Person responsible for the module and examiner(s)** Prof. Dr.-Ing. Ali Cemal Benim
10	**Language of instruction** English
11	**Further information and recommended literature** • C. Hirsch, “Numerical Computation of Internal and External Flows, Volume I: Fundamentals of Discretization“, Wiley. • C. Hirsch, “Numerical Computation of Internal and External Flows, Volume I: Computational Methods for Inviscid and Viscous Flows“, Wiley.

Projects F&E

Project (Research & Development)

Project Seminar

Modul no.	Workload	Credits	Semester	Offered in
	180 h	6	Sem. 1/2	Each Sem.

1	**Courses**	**Attendance**	**Self-study**	**Duration**
	Seminar 2 SWS	2 SWS / 30 h	150 h	1 sem.

2 Learning outcomes / Competences

The students

- can apply and extend the methodical and specialised technical knowledge acquired during their studies.
- have faced interdisciplinary questions, goal and deadline-oriented work in teams and, thus, strengthening of their social competences, promotion of structured, cross-disciplinary thinking, rhetoric and presentation

3 Contents

Either independent work on a specific, motivating task with a practical orientation from the fields of production, process, energy or environmental technology; or an interdisciplinary task in groups (min. 2 students).

Special emphasis is on

- teamwork,
- the necessity of obtaining data and documents by themselves, and
- the obligation of presenting the results in written and oral form.

4 Forms of teaching and learning

Introductory presentation and explanations, self-study, teamwork, regular supervision and discussion with the lecturer

5 Prerequisites

Formal prerequisites: Subject-related bachelor's degree as well as courses relevant to the specific project from the fields of process, energy and/or environmental technology, management techniques, production

Subject-related prerequisites: None

6 Types of examination

Written documentation, project work, presentation, oral examination

7 Requirements for award of credits

Participation in the project and successful presentation of the results

8 Module allocated to other study programmes

Part of all master's programmes

9 Weighting for overall grade

	6/90
10	**Person responsible for the module and examiner(s)** Various
11	**Language of instruction** German / English
12	**Further information and recommended literature** Relevant literature will be recommended depending on the task.

Engineering Conferences				
Modul no.	**Workload** 180 h	**Credits** 6	**Semester** Sem. 2	**Offered in** Each sem.
1	**Courses** Seminar 4 SWS	**Attendance** 4 SWS / 60 h	**Self-study** 120 h	**Duration** 1 sem.
2	**Learning outcomes / competences** Students who have passed the course • can understand how scientific and engineering conferences work • know what to do to submit their own work to an international conference, • can employ common techniques of producing a scientific paper • can identify relevant work of other researchers in relation to their own work and extract similarities and distinctions • can digest, condense, select and express information relevant to produce a thread of their own research work • can assess a scientific paper in oral form or as a poster			
3	**Contents** • Group work on selected conference papers, to train the technical understanding, recognition of structure, distillation of core content and critical review • Exercises in writing up scientific or technical work • Exercises in scientific (poster and oral) presentation, using modern technical means • Discussion and assessment of scientific presentations • Tutorials and exercises in online search for relevant information in connection with publishing research at an international conference • Small mock conference with poster session and short oral presentations			
4	**Forms of teaching and learning** Seminar and small mock conference			
5	**Prerequisites** Formal prerequisites: None Subject-related prerequisites: None			
6	**Types of examination** Special type of examination, consisting of • submission of a scientific paper (mandatory, 50%) • participation in review process (voluntary, max. 10% bonus) • poster preparation and presentation (mandatory, 50%)			
7	**Requirement for award of credits** Passed examination			

8	**Module allocated to other study programmes** Part of each master's programme
9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)** Prof. Dr.-Ing. Thomas Zielke, Prof. Dr.-Ing. Matthias Neef
11	**Language of instruction** English
12	**Further information and recommended literature** Course material available on moodle List of recommended literature: • Alley, Michael (2013): The craft of scientific presentations. Critical steps to succeed and critical errors to avoid. Second edition. New York: Springer. • Alley, Michael (2014): The craft of scientific writing. 4. ed. New York, NY: Springer. • Cargill, Margaret; O'Connor, Patrick (2013): Writing scientific research articles. Strategy and steps. 2. ed. Chichester: Wiley-Blackwell. • Hofmann, Angelika H. (2014): Scientific writing and communication. Papers, proposals, and presentations. 2. ed. New York, NY: Oxford Univ. Press. • Holst, Bodil: (2015): Scientific Paper Writing - A Survival Guide, CreateSpace Independent Publishing Platform, Bergen List of important/popular conferences within the scope of our master courses: • http://icpr-eame.com • CIRP Conference on Industrial Product Service Systems • ISES Solar World Congress • Solar Heating and Cooling for Buildings and Industry conference (SHC) • ASME Turbo Expo (https://www.asme.org) IEEE engineering publications: http://ieeexplore.ieee.org

Master's Thesis					
Modul no.		**Workload** 630 h	**Credits** 21	**Semester** Sem. 3	**Offered in** Each sem.
1	**Courses** /		**Attendance** /	**Self-study** 630 h	**Duration** 1 sem.
2	**Learning outcomes / Competences** The students are able to work on a complex problem from their field – independently and in a professional manner, in accordance with scientific methods, within a prescribed period of time				
3	**Contents** The thesis serves to work on a scientific assignment, within a prescribed extent and period of time: 16 weeks. The subject of the thesis can be of theoretical or experimental nature and can originate from any teaching or research field of the faculty				
4	**Forms of teaching and learning** /				
5	**Prerequisites** **Formal prerequisites:** The students must have successfully passed all modules except for a maximum of three. Those three modules can only be from the list of electives, Project R&D or Engineering Conferences. **Subject-related prerequisites:** None				
6	**Types of examination** The thesis is a piece of written examination work.				
7	**Requirement for award of credits** /				
8	**Module allocated to other study programmes** Part of all master's programmes				
9	**Weighting for overall grade** 21/90				
10	**Person responsible for the module and examiner(s)** Dean, various supervisors				
11	**Language of instruction** German / English				
12	**Further information and recommended literature** Alternatively, the students can write their theses in the research department of an industrial enterprise or in another scientific organisation of the professional field, if the thesis can be sufficiently supervised.				

Colloquium					
Modul no.		**Workload** 90 h	**Credits** 3	**Semester** Sem. 3	**Offered in** Each sem.
1	**Courses** /		**Attendance** /	**Self-study** 90 h	**Duration** 1 sem.
2	**Learning outcomes / Competences** The candidates are able to present the results of their theses incl. technical principles, interdisciplinary correlations and non-technical references orally, justify the theses independently, defend them against objections and assess its importance for the practical application				
3	**Contents** The colloquium is an oral examination complementing the thesis. The examiners of the thesis jointly conduct and evaluate the colloquium. The colloquium can include a short presentation by the student on the thesis contents and results				
4	**Forms of teaching and learning** /				
5	**Prerequisites** **Formal prerequisites**: Examiners' confirmation that they graded the thesis with the minimum passing grade or better **Subject-related prerequisites**: None				
6	**Types of examination** The colloquium is an oral examination; duration: 45 min.				
7	**Requirement for award of credits** /				
8	**Module allocated to other study programmes** Part of all master programmes				
9	**Weighting for overall grade** 21/90				
10	**Person responsible for the module and examiner(s)** Dean, various supervisors				
11	**Language of instruction** German / English				
12	**Further information and recommended literature** /				

Course Schedule: Start in Summer

Module	V	Ü*	P	S	SWS	CP				Number of exams
	*Ü = exercise						1	2	3	
							SS	WS	SS	
General Studies										
Engineering Mathematics	3	1	1		5	6	6			**2**
Simulation of Mechanical Systems	2	2	1		5	6		6		**2**
Signal Processing for Mechanical and Process Engineering	2		3		5	6	6			**2**
Finite Element Method (FEM)	3		2		5	6		6		**2**
Computational Fluid Dynamics (CFD)	3	1	1		5	6	6			**2**
Specialisation										
Elective Course I*				4	4	6	6			**1**
Elective Course II*				4	4	6	6			**1**
Elective Course III*				4	4	6		6		**1**
Elective Course IV* or Project R&D II				4	4	6		6		**1**
Projects, R&D										
Project (Research & Development)						6		6		**1**
Project Seminar				2	2					
Engineering Conferences				4	4	6			6	**1**
Master Thesis					0	21			21	**1**
Colloquium					0	3			3	**1**
					Credits		**90**			
	Credits per sem.						30	30	30	
						Total credits	90			

Course Schedule: Start in Winter

Module	V	Ü*	P	S	SWS	CP				Number of exams
	*Ü = exercise						1	2	3	
							WS	SS	WS	
General Studies										
Engineering Mathematics	3	1	1		5	6		6		**2**
Simulation of Mechanical Systems	2	2	1		5	6	6			**2**
Signal Processing for Mechanical and Process Engineering	2		3		5	6		6		**2**
Finite Element Method (FEM)	3		2		5	6	6			**2**
Computational Fluid Dynamics (CFD)	3	1	1		5	6		6		**2**
Specialisation										
Elective Course I*				4	4	6	6			**1**
Elective Course II*				4	4	6	6			**1**
Elective Course III*				4	4	6		6		**1**
Elective Course IV* or Project R&D II				4	4	6		6		**1**
Projects, R&D										
Project (Research & Development)						6	6			**1**
Project Seminar				2	2					
Engineering Conferences				4	4	6			6	**1**
Master Thesis					0	21			21	**1**
Colloquium					0	3			3	**1**
					Credits		**90**			
					Credits per sem.		30	30	30	
						Total credits	90			