

Program and Course Description

Renewable Energy Systems (SPO WS 17/18)

Master

Study regulation: WS 17/18

as per: 2023-02-07

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1 Overview

Name of course	Renewable Energy Systems
Type of study & degree	Master of Science full-time
First start date	October 1st, 2017 with an annual start in the winter semester
Normal period	3 semesters (90 ECTS, 46,5 SWS)
Duration of study	3 semesters
Place of study	THI Ingolstadt
Language of instruction	English
cooperation	no

Course director:

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Tel.: +49 (0) 841 / 9348-2820

2 Introduction

The text describes the status of the courses on offer in the Renewable Energy Systems master's program according to the study and examination regulations of July 18, 2016.

A complete overview of the modules, their content and examination **types** can be found in **Part 4 - Module descriptions** for the degree program.

In particular, the curriculum specifies the study goals and content of the individual compulsory modules, the subject-specific elective modules and the practical courses as well as the time layout of the weekly hours per module and study semester.

It also contains the more detailed provisions on course-related performance and participation certificates.

In the event of ambiguity, the subordinate study and examination regulations take precedence.

2.1 Objective

The master's program in Renewable Energy Systems is essentially based on the undergraduate bachelor's program in Energy Systems and Renewable Energies at the Technical University of Ingolstadt and aims to provide students with a deeper and detailed understanding of energy systems and their development. On this basis, the graduates can develop and apply their own ideas in terms of strategy, design, planning, development, control and management of energy systems in practice. The graduates are up to date in the fields of renewable and conventional energy technology as well as in system analysis and are able to expand this independently in the complex subject area. This is done by imparting practical, proven methods and the broadening of theoretical principles as well as scientific working methods and opens up the possibility for students of a subsequent doctorate or research. In addition, they can competently convey their knowledge to laypeople and exchange ideas with scientists in the production area at a scientific level.

The knowledge acquired in the Renewable Energy System master's program enables graduates to take on qualified specialist and managerial tasks in all areas of energy technology and enable them to work in or manage complex projects. The graduates have the intercultural and communicative competencies that an activity in an international context requires. The master's course also gives students the opportunity to pursue a doctorate or work in research.

The program is offered completely in English.

2.2 Admission Requirements

The general legal admission requirements apply. The binding regulations for the curriculum can be found in:

- Study and examination regulations for the Renewable Energy Systems master's program in the version of July 18, 2016 (SPO RES)
- Framework examination regulations (RaPO)
- General examination regulations (APO) of the Technical University of Ingolstadt
- Enrollment statutes of the Technical University of Ingolstadt.

In addition to the general admission requirements, there is also an aptitude assessment procedure, which is described in the study and examination regulations for the Renewable Energy Systems master's program in the version dated July 18, 2016 (SPO RES) and on the documents submitted on the applicant's energy experience is based.

2.3 Target group

The target group of the Renewable Energy Systems master's program is made up of two different groups. On the one hand, the graduates of the ESYS course or similar German bachelor courses, on the other hand international graduates of technical courses that are equivalent to a bachelor's degree at THI and the experience in the field of energy technology through specialization within their studies or their bachelor thesis or through professional activity in the field of power engineering

2.4 Course structure

The students expand their knowledge of regenerative technologies, whereby the focus is not on a single technology, but on the mutual interrelationships with one another and with the structure of requirements.

In order to familiarize all students with the basics of a technology and to establish a uniform starting level, the essential connections and technological aspects of a certain regenerative technology are dealt with in a concentrated form, in an intensive course, at the beginning of the so-called system courses. Most of the course, however, deals with the use of this technology in an energy system. Thereby different methods of engineering activity from simulation and laboratory tests to project development are used. The basic structure of the course is shown in Figure 1. For the EEE graduates of the THI, the short induction phase represents a repetition of the knowledge from the bachelor's degree, which is then deepened in the system-oriented tasks. For the international students, the introduction phase means a phase of intensive examination of partly new technologies, which can then be applied in practice.

The regular study time is 3 semesters, the first two being covered by courses and the third being reserved for the preparation of the master's thesis.

Renewable Energy Systems

3. Semester

Master's thesis

2. Semester

Energy Policies and Economics

Numerical Methods and Computation Simulation

Energy System 2

Energy System 3

1. Semester

Introductory Laboratory Course

System Analysis and Control

Scientific Research Seminar

Elective course
(p.e. Energy Management and Energy Efficiency)

Energy System 1

Three of the four available energy system modules are selected and taught by the course management for each year. In these energy system modules, students have to design and dimension an energy system. Using a project-oriented approach, you will develop solutions for a task and will be advised by a team of specialists who will provide you with the necessary detailed knowledge of technologies. The

students compare different technologies for the required issue and choose the most suitable. In doing so, they learn about the important boundary conditions and requirements for the planning, installation, financing and operation of these technologies. The idea on which the energy system modules are based is that there is no single technology in the foreground, but the integral approach of meeting a specific demand with the best possible regenerative technology. However, depending on the individual prior knowledge of the students, there is often the need to improve this prior knowledge individually by studying literature.

2.5 Advancement Requirements

The topic of the master's thesis is issued at the beginning of the second semester at the earliest. The issue of the topic of the master's thesis requires that at least 30 ECTS credits have been successfully completed.

2.6 Concept and advisory board

The course was developed, among other things, on the basis of discussions with company representatives, whose requirements were taken into account in a special way. The positioning of the course in the direction of sector coupling, interdisciplinarity and systematic thinking with the resulting mix of subjects was not least due to the relevance of these topics for the economy.

The training is intended to enable our master's graduates to take up managerial positions in companies and institutions or to continue their training with a doctorate. The advisory board consists of students alumni, professors from other universities and industry representatives.

3 Qualification profil

3.1 Mission statement

The creation of a climate-friendly, sustainable and secure energy supply is one of the great challenges of our time. Renewable energies play a central role here, as they are a rapidly growing branch of industry with enormous development potential in the regional, national and international environment. The knowledge on which the course is based is that modern energy systems are characterized by the integration of renewable technologies of ever increasing complexity and that great optimization potentials often remain unused because the experts in individual disciplines overlook the possibilities for using synergies. Therefore, individual technologies and various scientific methods are taught, but these are conveyed in the context of an energy system consideration:

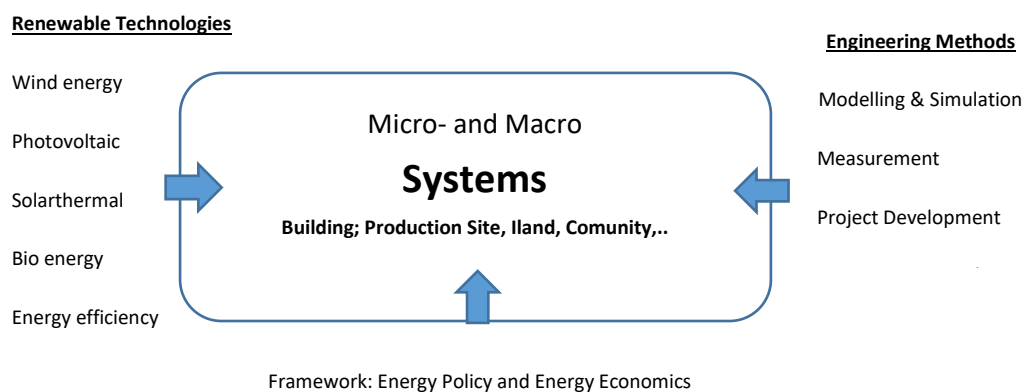


Fig.1: Conceptual representation of the RES master's course at THI

The master's program in Renewable Energy Systems enables students to take on specialist and managerial tasks in an interdisciplinary and international environment, in which in-depth specialist knowledge and its application are conveyed.

3.2 Study objectives

3.2.1 Subject-specific competencies of the degree program

Upon completion of the course, the participants have

- knowledge of the various energy supply technologies and their suitability in different applications
- knowledge of power distribution and load management
- the ability to recognize and assess systematic dependencies in energy systems
- the ability to select, dimension and plan complex energy systems including their dependencies
- the ability to simulate complex systems and interpret simulation results
- the ability to evaluate energy systems economically and ecologically
- the ability to assess political and economic boundary conditions for energy production

3.2.2 Interdisciplinary competencies of the degree program

The following interdisciplinary skills are of particular importance for the course.

- Scientific work
- Working together on larger assignments in teams
- Targeted and sensitive work in an intercultural context
- Fluent English including technical terms
- Conflict management .
- Time management
- Project organization
- self-organisation
- Self-presentation

3.2.3 Examination concept of the course

The examinations are based on the desired learning outcomes of a module, the successful delivery of which is to be checked.

Courses and exams are held in English. Selected modules, including examinations, can be held in German as specified in the module handbook.

All modules are either compulsory or elective modules:

1. Compulsory modules are the modules of the course that are binding for all students. The energy system modules are compulsory, as the three taught out of the four possible modules are selected by the course director.

2. Compulsory elective modules are the modules of the course that are offered individually or alternatively in groups. Each student has to choose one of them. The selected module is treated as a compulsory module.

In the energy system modules, the focus is on imparting current specialist knowledge and its application in practice, as well as improving general skills. Therefore, these are checked by the examination form study or seminar paper including the presentation.

3.2.4 Application relevance of the degree program

In the drafting of the course curriculum, the aspect of application relevance was given high priority. A large number of discussions with company representatives have shown that there is a great need, especially in the interface areas between individual technologies. Interdisciplinary planning and working as well as coordination play an increasingly important role. The range of subjects in the degree program meets these requirements. The three large system modules deal with the use of different technologies in an energy system. Various methods of engineering work are to be used, from simulation and laboratory tests to project development. In the group work there, the students not only acquire specialist knowledge for practical use, but also practice the soft skills that are indispensable for today's working world, working together in teams and planning and managing projects.

The master's theses are usually written in companies. In addition to the practical relevance of the topics, the transfer of knowledge is of outstanding importance.

3.2.5 Contribution of individual modules to the course objectives

In the Energy System modules, the course imparts specialist skills and subject-specific applications. These teaching objectives are flanked by a business assessment of the solutions found. In the smaller modules, in-depth theoretical knowledge in selected areas of energy technology is imparted.

In addition to the specialist skills, the imparting of methodological, social and personal skills rounds off the course. The implementation of the qualification objectives of the course through the modules is described in detail in the module descriptions under learning objectives and content. The objectives-module matrix, which is shown on the following page, provides an overall overview of the competencies imparted per module.

Modules											
Aims Of Course		Energy system 1	Energy system 2	Energy system 3	Sci- entific Rese- arch Semi- nar	Elec- tive, ie Energy Man- age- ment and Energy Effi- ciency	Sys- tem Ana- lysis and Con- trol	Intro- duc- tory Labo- ratory course	Energy Poli- cies and Econo- mics	Nu- meri- cal Meth- ods and Com- puta- tional simu- lation	Mas- ter the- sis
Pro- fessi- onal skills	Knowledge of the various energy supply technologies and their suitability in different applications	++	++	++	+	+	+	++		+	
	Knowledge of power distribution & load management	+	+	+	+	++	++	+	+	+	
	Recognizing and assessing systematic dependencies in energy systems	++	++	++	+						
	Selection, dimensioning and planning of complex energy systems including the dependencies	++	++	++	+		+				
Me- tho-	Simulation of complex systems and interpretation of simulation results	+	+	+	+	+	+	+	+	++	

	Modules										
	Aims Of Course	Energy system 1	Energy system 2	Energy system 3	Sci- entific Rese- arch Semi- nar	Elec- tive, ie Energy Man- age- ment and Energy Effi- ciency	Sys- tem Ana- lysis and Con- trol	Intro- duc- tory Labo- ratory course	Energy Poli- cies and Econo- mics	Nu- meri- cal Meth- ods and Com- puta- tional simu- lation	Mas- ter the- sis
dolo- gical skills	Economic and ecological as- sessment of energy systems	+	+	+	+	++			++		
	Assessment of political and eco- nomic boundary conditions for energy production	+	+	+	+				++		
	Scientific work	+	+	+	++				+	+	++
Social skills	Working together on larger as- signments in teams	+	+	+			+	++			
	Targeted and sensitive work in an intercultural context	+	+	+		+	+	+	+	+	
	Fluent English including tech- nical terms	+	+	+	++	+	+	+	+	+	++
	conflict management	+	+	+			+	+	+		
Per- sonal skills	Time management	+	+	+	+			+	+		+
	Project organization	+	+	+	+			+	+		+
	self-organisation	+	+	+	++		+	+	+	+	++
	Self-presentation	+	+	+	+			+	+		+

3.3 Possible occupational fields

The students should acquire a broad knowledge of regenerative energy systems, so that the graduates of the course are primarily prepared for specialist and managerial tasks in the following areas:

- Planning
- Government / Administration
- Utilities / municipal utilities
- Project development
- Science
- Production

The following sectors are the focus of the graduates' future fields of activity:

- Power engineering
- Building technology
- Environmental technology

However, the master's degree should also qualify and be accredited for academic work, so that a doctorate can also be followed.

4 Dual Studies

In cooperation with selected industry partners, the study program Renewable Energy Systems can also be completed in dual studies model. The dual study model is offered as a study program with in-depth practice, in which the regular study program is supplemented by intensive practical phases in a company.

In dual study model, university and practical phases (especially during semester breaks and for the final thesis) regularly alternate during the course of study. The lecture times in the dual study model correspond to the standard study and lecture times at the THI.

By systematically linking the learning locations of university and company, students gain professional practical experience with selected practice partners as an integral part of their studies.

The curriculum of the two dual degree program models differs from the regular degree program concept in the following points:

- **Final thesis in the cooperation company**

In both dual study models, the final thesis is written at a cooperating company, usually on a practice-relevant topic related to the focus of study.

Organizationally, the two dual degree program models are characterized by the following components:

- **Introduction track**

A separate event for dual students is offered as part of the welcome day(s) at the beginning of the program.

- **Mentoring**

The central contact persons for dual students in the faculty are the respective program head of studies. They organize an annual mentoring meeting with the dual students of the respective study program.

- **Quality management**

In the evaluation and surveys at the THI on the quality assurance of the dual study separate question blocks are included.

- **„Forum dual“**

Organized by the Career Service and Student Counseling (CSS), the “Forum Dual” takes place once a year. The “Forum Dual” promotes the professional-organizational exchange between the dual cooperation partners and the faculty and serves to ensure the quality of the dual study programs. All cooperation partner in the dual study program as well as representatives and dual students of the faculty are invited to the meeting.

Formal-legal regulation for dual studies for all degree programs of the THI are regulated in the APO (see §§ 17, 18 und 21) and the enrollment statutes (see §§ 8b und 18).

5 Description of Modules

5.1 Compulsory Modules

Introductory Laboratory Course			
Module abbreviation:	IntroLabC_M-RES	SPO-No.:	3
Curriculum:	Programme	Module type	Semester
	Renewable Energy Systems (SPO WS 17/18)	Compulsory Subject	1
Modulattribute:	Language of instruction	Duration of module	Frequency of offer
	English	1 semester	only winter term
Responsible for module:	Schrag, Tobias		
Lecturers:	Schrag, Tobias; Steger, Fabian		
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours:	47 h	
	Self-study:	28 h	
	Total effort:	125 h	
Subjects of the module:	3: Introductory Laboratory Course (IntroLabC_M-RES)		
Lecture types:	1: SU/PR - Seminaristischer Unterricht/Praktikum		
Examinations:	3: SA - Seminar paper with oral examination (15min) and written elaboration (8-15 pages) (IntroLabC_M-RES)		
Usability for other study programs:	None		
Prerequisites according examination regulation:			
None			
Recommended prerequisites:			
Bachelor Level of General Engineers: Thermodynamics, Mechanics, Electrical Engineering, Fluid Dynamics			
Objectives:			
The course follows to objectives			
1. To create a common level of knowledge in the fields of thermodynamics, fluid dynamics, mechanics, electrical engineering, bio energy and solar energy			
2. To enable the students to prepare, carry out, calculate and present complex experiments in the energy laboratories			
The students			
• can calculate the error of an value determined in an experiment dependent on the errors of the measurement quantities.			
• are able to create reports on experiments according to a scientific standard			
• are able to carry out complex physical measurements,			
• are familiar with hard and software of different teststands			
• can evaluate different measurement methods as they know the advantages/disadvantages of different methods			
• are have reached a common knowledge basis in the fields of thermodynamics, physics, electrical engineering, fluid dynamics, bio energy and solar radiation.			
• are able to present and discuss measurement results with respect to theory			

Content:

The course consists of ca. 10 experiments.

The experiments and excursions described below can change slightly due to resources available.

The first experiments are carried out in very small groups (ca. 2 Persons) and then follow 2*4 experiments that are carried out in small groups (ca 6 Persons).

In the first sessions several experiments are carried out. The aim is to establish a common level in problem perception, problem solution, calculation, presenting and reporting. The first four experiments aim to establish a common basis in thermodynamics, electronics, solar energy and fluid dynamics.

The second circle of experiments aim to establish an advanced level in the same fields.

The exemplary laboratory course given below reflects the structure, also some experiments may change due to resources:

Initial Experiments in very small groups 2 sessions):

Pressure/Volume

Spring stiffness/energy storage

Gravitational energy/air pressure

PV-driven motors/ efficiency

(mechanical and electrical engineering)

The experiments in small groups

PV-System: MPP-Tracking (elektrical eng.)

DEC-Plant: HVAC-principles and sorption

Heatexchanger: Dependence of heat transfer coefficient through flow rate (thermodynamics)

CHP-Plant (thermodynamics)

Wind channel (fluid dynamics)

Test of solarthermal collector (solar thermal)

Battery measurement (elektrical eng.)

Steam power station (thermodynamics)

Literature:

Compulsory:

None

Recommended:

- BROWNE, Michael E., 2010. *Physics for engineering and science: [788 fully solved problems]*. 2. edition. New York [u.a.]: McGraw-Hill. ISBN 978-0-07-161399-6, 0-07-161399-4
- SPLINTER, Robert, 2017. *Illustrated encyclopedia of applied and engineering physics*. Boca Raton ; London ; New York: CRC Press. ISBN 978-1-4398-6086-1

Additional remarks:

None

System Analysis and Control			
Module abbreviation:	SysAnaCon_M-RES	SPO-No.:	4
Curriculum:	Programme	Module type	Semester
	Renewable Energy Systems (SPO WS 17/18)	Compulsory Subject	1
Modulattribute:	Language of instruction	Duration of module	Frequency of offer
	English	1 semester	only winter term
Responsible for module:	Navarro Gevers, Daniel		
Lecturers:	Navarro Gevers, Daniel		
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours:	47 h	
	Self-study:	78 h	
	Total effort:	125 h	
Subjects of the module:	4: System Analysis and Control (SysAnaCon_M-RES)		
Lecture types:	1: SU/PR - Seminaristischer Unterricht/Praktikum		
Examinations:	4: schrP90 - written exam, 90 minutes (SysAnaCon_M-RES)		
Usability for other study programs:	None		
Prerequisites according examination regulation:			
None			
Recommended prerequisites:			
Mathematics: bachelor level calculus (functions of one and more variables, derivatives, integrals, sequences, series, ordinary differential equations, Laplace transformation), linear algebra (matrices, vector spaces, basis, dimension). Selected topics in Physics: fluid dynamics, thermodynamics, heat transfer. Elementary programming skills. Control techniques. Electric Engineering.			
Objectives:			
The students <ul style="list-style-type: none">• can model a physical system.• Can characterize a control loop understanding what is the controller, the actuator, the measurement device and the system,• Can take a decision on the dynamic needs of a system response• Understands different methods of tuning the controllers to fulfill the dynamic demands• Know the different controller types and can decide which controller is needed for each case.• are able to apply different controller tuning methods and are able to predict the dynamic behavior of a system• are able to evaluate and discuss simulation results with respect to theory and experiments• can take the decision of existing hardware to design a given			
Content:			
<ul style="list-style-type: none">• System description• Definition of a control loop			

- Stability in a control loop
- Transfer function
- Frequency response
- Main control variables
- Root locus method
- Alternative Design Methods
- Design variables in a control system (calculation frequency, sample frequency, variables to be measured etc..)
- Response of first order and second order Systems
- Speed Control of a Wind turbine
- Frequency control in an electrical grid
- Application to practical problems (computer lab Matlab)

Literature:*Compulsory:*

- OGATA, Katsuhiko, 2010. *Modern control engineering*. 5. edition. Boston [u.a.]: Pearson. ISBN 978-0-13-713337-6, 0-13-713337-5

Recommended:

None

Additional remarks:

None

Energy Policies and Economies			
Module abbreviation:	EnPolEc_M-RES	SPO-No.:	5
Curriculum:	Programme	Module type	Semester
	Renewable Energy Systems (SPO WS 17/18)	Compulsory Subject	1
Modulattribute:	Language of instruction	Duration of module	Frequency of offer
	English	1 semester	only summer term
Responsible for module:	Zörner, Wilfried		
Lecturers:	Mehta, Kedar; Zörner, Wilfried		
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours:	45 h	
	Self-study:	80 h	
	Total effort:	125 h	
Subjects of the module:	5: Energy Policies and Economies (EnPolEc_M-RES)		
Lecture types:	S - seminar		
Examinations:	5: SA - Seminar paper with oral examination (15min) and written elaboration (8-15 pages) (EnPolEc_M-RES)		
Usability for other study programs:	None		
Prerequisites according examination regulation:			
none			
Recommended prerequisites:			
none			
Objectives:			
<p>The students</p> <ul style="list-style-type: none">• understand climate protection policies worldwide and their relation to energy issues• are able to critically reflect on and discuss issues of climate change and energy• understand different shaping of energy legislation in selected countries• are able to critically reflect on and discuss issues of energy legislation• understand renewable energies as an economic factor• understand the energy economy in selected countries• are able to critically reflect on and discuss issues of the energy economy			
Content:			
<p>Energy and climate change</p> <ul style="list-style-type: none">• Climate protection policies worldwide, in Germany and other selected countries• Energy legislation in Germany and other selected countries• Renewable energies as economic factor• Energy economy / industry in Germany and other selected countries			

Literature:
<i>Compulsory:</i> None <i>Recommended:</i> None
Additional remarks:
Gemeldet durch Prof. Zörner am 12.2.18 Gemäß der Anlage zur SPO M_RES: Seminararbeit mit Kolloquium: schriftliche Ausarbeitung 8-15 Seiten; Präsentation 15-20 Folien

Numerical Methods and Computation Simulation			
Module abbreviation:	NumMetCS_M-RES	SPO-No.:	6
Curriculum:	Programme	Module type	Semester
	Renewable Energy Systems (SPO WS 17/18)	Compulsory Subject	2
Module attribute:	Language of instruction	Duration of module	Frequency of offer
	English	1 semester	only summer term
Responsible for module:	Bschorer, Sabine		
Lecturers:	Bschorer, Sabine; Horák, Jiří		
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours:	47 h	
	Self-study:	78 h	
	Total effort:	125 h	
Subjects of the module:	6: Numerical Methods and Computation Simulation (NumMetCS_M-RES)		
Lecture types:	1: SU/Ü - Lecture / computer lab		
Examinations:	6: schrP90 - written exam, 90 minutes (NumMetCS_M-RES)		
Usability for other study programs:	None		
Prerequisites according examination regulation:			
None			
Recommended prerequisites:			
Mathematics: bachelor level calculus (functions of one and more variables, derivatives, integrals, sequences, series, ordinary differential equations), linear algebra (matrices, vector spaces, basis, dimension). Selected topics in Physics: fluid dynamics, thermodynamics, heat transfer. Elementary programming skills.			
Objectives:			
The students			
<ul style="list-style-type: none">• can estimate the error of a numerical approximation of derivatives and use a suitable order of approximation for the given application,• understand the influence of the round-off error and conditioning on the numerical solution of linear algebraic equations and can assess which direct or iterative methods are suitable for the given purpose,• recognize the above methods in the finite difference discretization of the heat equation, can explain consistency, stability and convergence, are able to evaluate the merits of the explicit and implicit approaches,• are familiar with simple implementations of the discussed numerical methods in some widely used computer algebra system (e.g. MATLAB) or programming language• are familiar with the mathematical background of the Finite-Volume method• are able to apply different computational methods like Computational Fluid Dynamics and 1D simulation of thermal and hydraulic processes to problems in renewable energy systems• are able to evaluate and discuss simulation results with respect to theory and experiments			
Content:			
<ul style="list-style-type: none">• Numerical approximation of derivatives			

- Numerical solution of large systems of linear algebraic equations, round-off error,
- Numerical solution of the linear heat equation
- Introduction into numerical flow simulation theory (computational fluid dynamics, CFD)
- Finite-volume method and its mathematical background
- Application to 3D fluid simulation with commercial software
- Theory of computational simulation of thermal and hydraulic processes
- Thermal and hydraulic simulation in building services engineering
- Computational simulation of thermodynamic processes
- Application to practical problems (computer lab)

Literature:*Compulsory:*

None

Recommended:

- FERZIGER, Joel H., PERIĆ, Milovan, STREET, Robert L., 2020. *Computational methods for fluid dynamics* [online]. Cham: Springer PDF e-Book. ISBN 978-3-319-99693-6. Available via: <https://doi.org/10.1007/978-3-319-99693-6>.
- FERZIGER, Joel H., PERIĆ, Milovan, STREET, Robert L., 2020. *Computational methods for fluid dynamics* [online]. Cham: Springer PDF e-Book. ISBN 978-3-319-99693-6. Available via: <https://doi.org/10.1007/978-3-319-99693-6>.
- KAJISHIMA, Takeo, TAIRA, Kunihiko, 2017. *Computational fluid dynamics: incompressible turbulent flows* [online]. Cham: Springer PDF e-Book. ISBN 978-3-319-45304-0. Available via: <https://doi.org/10.1007/978-3-319-45304-0>.
- KAJISHIMA, Takeo, TAIRA, Kunihiko, 2017. *Computational fluid dynamics: incompressible turbulent flows* [online]. Cham: Springer PDF e-Book. ISBN 978-3-319-45304-0. Available via: <https://doi.org/10.1007/978-3-319-45304-0>.
- ANDERSON, Dale A. and others, 2021. *Computational fluid mechanics and heat transfer*. F. edition. Boca Raton ; London ; New York: CRC Press, an imprint of Taylor & Francis Group. ISBN 978-0-8153-5712-4, 978-0-3675-6903-7
- MOUKALLED, F., MANGANI, L., DARWISH, M., 2016. *The finite volume method in computational fluid dynamics: an advanced introduction with OpenFOAM and Matlab* [online]. Cham: Springer PDF e-Book. ISBN 978-3-319-16874-6, 978-3-319-16873-9. Available via: <https://doi.org/10.1007/978-3-319-16874-6>.
- REDDY, Junuthula Narasimha and David K. GARTLING, 2010. *The finite element method in heat transfer and fluid dynamics*. 3. edition. Boca Raton, Fla. [u.a.]: CRC Press, Taylor & Francis. ISBN 978-1-4398-8257-3
- TURYN, Larry, 2014. *Advanced engineering mathematics*. Boca Raton [u.a.]: CRC Press. ISBN 978-1-4398-3447-3
- STRANG, Gilbert, 2007. *Computational science and engineering*. Wellesley, Ma.: Wellesley-Cambridge Press. ISBN 978-0-9614088-1-7, 0-9614088-1-2
- STRANG, Gilbert. *Mathematical methods for engineers II* [online]. [Accessed on:]. Available via: <https://ocw.mit.edu/courses/18-086-mathematical-methods-for-engineers-ii-spring-2006/>

Additional remarks:

None

Scientific Research Seminar			
Module abbreviation:	SciResSem_M-RES	SPO-No.:	11
Curriculum:	Programme	Module type	Semester
	Renewable Energy Systems (SPO WS 17/18)	Compulsory Subject	1
Modulattribute:	Language of instruction	Duration of module	Frequency of offer
	English	1 semester	winter and summer term
Responsible for module:	Schrag, Tobias		
Lecturers:	Bschorer, Sabine; Goldbrunner, Markus; Navarro Gevers, Daniel; Schrag, Tobias; Weitz, Peter; Zörner, Wilfried		
Credit points / SWS:	5 ECTS / 2.5 SWS		
Workload:	Contact hours:	5 h	
	Self-study:	120 h	
	Total effort:	125 h	
Subjects of the module:	11: Scientific Research Seminar (SciResSem_M-RES)		
Lecture types:	1: Prj - Projekt		
Examinations:	11: SA - Seminar paper with oral examination (15min) and written elaboration (8-15 pages) (SciResSem_M-RES)		
Usability for other study programs:	None		
Prerequisites according examination regulation:			
None			
Recommended prerequisites:			
None			
Objectives:			
The students <ul style="list-style-type: none">• work independently on a scientific question• use international databases for research• write a scientific paper according to international standards• and present their work in a conference format			
Content:			
Processing of a semester-accompanying scientific question differ from semester to semester. Several topics are offered, from which one can be selected. The task is a scientific question and is handled by the student on his own responsibility. At the end of the semester, the results are summarized in the form of a report (eprox 10-15 pages) and a presentation (eprox 15-30 minutes).			
Literature:			
Compulsory: None			
Recommended:			

None
Additional remarks:
Seminar paper (8-15 pages) and oral presentation (15-30 min)

Master Thesis			
Module abbreviation:	MA_RES	SPO-No.:	12
Curriculum:	Programme	Module type	Semester
	Renewable Energy Systems (SPO WS 17/18)	Compulsory Subject	
Modulattribute:	Language of instruction	Duration of module	Frequency of offer
	English	1 semester	winter and summer term
Responsible for module:	Schrag, Tobias		
Lecturers:	Alle Professorinnen/Professoren,		
Credit points / SWS:	30 ECTS / 0 SWS		
Workload:	Contact hours:	0 h	
	Self-study:	750 h	
	Total effort:	750 h	
Subjects of the module:	12: Master Thesis (MA_RES)		
Lecture types:	1: Master Thesis		
Examinations:	12: Master-Thesis (MA_RES)		
Usability for other study programs:	None		
Prerequisites according examination regulation:			
None			
Recommended prerequisites:			
None			
Objectives:			
<p>The students</p> <ul style="list-style-type: none">can work independently on complex problems from the field of technical development at a high scientific level within a specified period of time using the specialist knowledge acquired as well as scientific methods and findings.are also able to classify the results in technical and interdisciplinary contexts and to present them in the form of a scientific paper.Students are able to work independently on a defined topic and discuss it competently.			
Content:			
<ul style="list-style-type: none">Analysis of the problem and definition of the topicLiterature/patent researchFormulation of the research approach/procedureDefinition of a solution concept/approachPlanning and elaboration of the solution, analysis of the resultsClassification of the subject-related and non-subject-related referencesApplication of scientific working methods, i.e. proceeding systematically, analytically and methodically correct, arguing logically and concisely as well as working goal-oriented and time-critical and presenting the results formally correct.			

For dual students, the thesis must be prepared in cooperation with the respective dual company. The content details and the scientific standard are ensured in cooperation between the company's supervisor and the first examiner at the Technical University.

Literature:*Compulsory:*

- RECKER, Jan, 2021. *Scientific Research in Information Systems: A Beginner's Guide* [online]. Cham: Springer International Publishing PDF e-Book. ISBN 978-3-030-85436-2. Available via: <https://doi.org/10.1007/978-3-030-85436-2>.
- LÖVEI, Gábor L., 2021. *Writing and publishing scientific papers: a primer for the non-English speaker* [online]. Cambridge, UK: Open Book Publishers PDF e-Book. ISBN 978-1-80064-091-7, 978-1-80064-092-4. Available via: <https://doi.org/10.11647/OBP.0235>.

Recommended:

None

Additional remarks:

None

5.2 Core Electives

Building Energy System			
Module abbreviation:	BuildEnerSys_M-RES	SPO-No.:	7
Curriculum:	Programme	Module type	Semester
	Renewable Energy Systems (SPO WS 17/18)	General Elective Subject	1
Modulattribute:	Language of instruction	Duration of module	Frequency of offer
	English	1 semester	only winter term
Responsible for module:	Schrag, Tobias		
Lecturers:			
Credit points / SWS:	10 ECTS / 8 SWS		
Workload:	Contact hours:	93 h	
	Self-study:	107 h	
	Total effort:	250 h	
Subjects of the module:	7: Building Energy System (BuildEnerSys_M-RES)		
Lecture types:	: SU/PR - Seminaristischer Unterricht/Praktikum		
Examinations:	7: SA - Seminar paper with oral examination (15min) and written elaboration (8-15 pages) (BuildEnerSys_M-RES)		
Usability for other study programs:	None		
Prerequisites according examination regulation:			
None			
Recommended prerequisites:			
None			
Objectives:			
<p>The students</p> <ul style="list-style-type: none">are familiar with building energy systems for heat and cold supply such as solar thermal, geothermal, CHP, fossil fuel and heat pump based technologiesunderstand the economic and technical principles of planning, design and operation of different HVAC systemscan strategically combine different energy sources to identify technically, environmentally and economically optimal solutionscan model heating solutions with different energy sources and multiple users in a buildinghave an insight in the specific boundaries and challenges of energy engineering in modelling and simulationare able to formulate and solve complex problems of real-world energy engineeringare able to condense the experience and results of a multifaceted energy engineering project in compact reports and presentations.			
Content:			
<ul style="list-style-type: none">Energy Consumption in BuildingsHVAC-Systems			

<ul style="list-style-type: none"> • Climate adaptive building design • Solar thermal systems • Geothermal systems • Heat-pump based technologies • Building simulation • PVSystems • Economic Analysis • Detailed analysis of selected real-world case of district heating with multiple sources and consumers
Literature:
<p><i>Compulsory:</i></p> <p>None</p> <p><i>Recommended:</i></p> <ul style="list-style-type: none"> • DUFFIE, John A., BECKMAN, William A., BLAIR, Nathan, 2020. <i>Solar engineering of thermal processes, photovoltaics and wind</i> [online]. Hoboken, New Jersey: Wiley PDF e-Book. ISBN 978-1-119-54031-1, 978-1-119-54030-4. Available via: https://onlinelibrary.wiley.com/doi/book/10.1002/9781119540328. • KLEE, Harold and Randall ALLEN, 2018. <i>Simulation of dynamic systems with MATLAB and Simulink</i>. t. edition. Boca Raton: CRC Press. ISBN 978-1-4987-8777-2 • YANG, Jinhuan, YUAN, Xiao, Ji, Liang, 2020. <i>Solar photovoltaic power generation</i> [online]. Berlin ; Boston: De Gruyter PDF e-Book. ISBN 978-3-11-052483-3. Available via: https://doi.org/10.1515/9783110524833. • GRASSI, Walter, 2018. <i>Heat pumps: fundamentals and applications</i> [online]. Cham: Springer PDF e-Book. ISBN 978-3-319-62199-9. Available via: https://doi.org/10.1007/978-3-319-62199-9.
Additional remarks:
None

Industrial Energy System			
Module abbreviation:	IndustEnerSys_M-RES	SPO-No.:	7
Curriculum:	Programme	Module type	Semester
	Renewable Energy Systems (SPO WS 17/18)	Elective subject	2
Modulattribute:	Language of instruction	Duration of module	Frequency of offer
	English	1 semester	only summer term
Responsible for module:	Goldbrunner, Markus		
Lecturers:	Ahmed, Arslan; Goldbrunner, Markus; Yadav, Akhilesh		
Credit points / SWS:	10 ECTS / 8 SWS		
Workload:	Contact hours:	93 h	
	Self-study:	157 h	
	Total effort:	250 h	
Subjects of the module:	7: Industrial Energy System (IndustEnerSys_M-RES)		
Lecture types:	SU/PR - Seminaristischer Unterricht/Praktikum		
Examinations:	7: SA - Seminar paper with oral examination (15min) and written elaboration (8-15 pages) (IndustEnerSys_M-RES)		
Usability for other study programs:	None		
Prerequisites according examination regulation:			
None			
Recommended prerequisites:			
None			
Objectives:			
<p>The students</p> <ul style="list-style-type: none">• have an overview of the most important consumers of electricity, heat and gas in a typical industrial operation• can establish and evaluate the different energy consumptions and efficiency improvement strategies in an industrial operation• are familiar with the biogas process, the construction of biogas plants, the most important components and process parameters and can dimension a biogas plant.• are familiar with the most important procedural basics and concepts of the combustion of solid biomass and the corresponding plant technology for heat and power generation and can design a corresponding power plant• know the most important procedural basics and concepts of the thermal gasification of solid biomass and the corresponding plant technology for heat and power generation• are able to project the energy supply of an industrial company with the acquired knowledge.			
Content:			
<ul style="list-style-type: none">• Energy efficiency• Rating of energy systems• Example project meat processing			

<p>Definition of boundaries</p> <p>Applied thermodynamics for energy efficiency</p> <p>Presentation and Reporting</p> <ul style="list-style-type: none"> • Cross cutting technologies <ul style="list-style-type: none"> Drives and pumps Mechanical power Lighting Thermal Energy Renewable Electricity Integration • Bio energy • Biogas • Anaerobic fermentation • Construction of biogas plants • operating parameters and environmental conditions • substrates and manure • process and plant engineering • process variants • biogas production and storage • Solid biomass • basics of combustion • special features and design of the furnace • combustion concepts • cyclic processes • plants for electricity and heat generation an their components • basics and concepts of gasification • Project • Building an energy-efficient and environmentally friendly energy supply for an industrial company
<p>Literature:</p> <p><i>Compulsory:</i></p> <p>None</p> <p><i>Recommended:</i></p> <p>None</p>
<p>Additional remarks:</p> <p>None</p>

Off-Grid Energy System			
Module abbreviation:	Off-GridEnSy_M-RES	SPO-No.:	7
Curriculum:	Programme	Module type	Semester
	Renewable Energy Systems (SPO WS 17/18)	General Elective Subject	2
Modulattribute:	Language of instruction	Duration of module	Frequency of offer
	English	1 semester	only summer term
Responsible for module:	Navarro Gevers, Daniel		
Lecturers:	Besner, Rebekka; Igiligi, Anthony; Navarro Gevers, Daniel		
Credit points / SWS:	10 ECTS / 8 SWS		
Workload:	Contact hours:	93 h	
	Self-study:	157 h	
	Total effort:	250 h	
Subjects of the module:	7: Off-Grid Energy System (Off-GridEnSy_M-RES)		
Lecture types:	SU/PR Seminaristischer Unterricht		
Examinations:	7: SA - Seminar paper with oral examination (15min) and written elaboration (8-15 pages) (Off-GridEnSy_M-RES)		
Usability for other study programs:	None		
Prerequisites according examination regulation:			
None			
Recommended prerequisites:			
Mathematics: bachelor level calculus (functions of one and more variables, derivatives, integrals, sequences, series, ordinary differential equations, Laplace transformation), Control techniques. Electric Engineering, System Analysis and Control			
Objectives:			
The students <ul style="list-style-type: none">can model an offgrid electrical system Know the main components in an Offgrid System : Generators, Loads, safety devices...know the principles of the grid frequency controlknow the principles of the grid voltage controlare able to determine the stability of an off grid systemknow how to do a power flow analysiscan take the decision of the needed requirements (Hardware an control) to desigm an offgrid systemcan write the project specification for the given system			
Content:			
<ul style="list-style-type: none">Voltage ControlFrequency ControlGenerators (Synchornous, Asynchronous)			

- Converters description
- Load flow calculation
- Load behavior
- Energy Storage
- Energy conversion and transport
- Wind Power description

Literature:*Compulsory:*

None

Recommended:

None

Additional remarks:

None

Urban Area Energy System			
Module abbreviation:	UrbanAreaEnerSys_M-RES	SPO-No.:	7
Curriculum:	Programme	Module type	Semester
	Renewable Energy Systems (SPO WS 17/18)	General Elective Subject	1
Modulattribute:	Language of instruction	Duration of module	Frequency of offer
	English	1 semester	only winter term
Responsible for module:	Schrag, Tobias		
Lecturers:	Klump, David; Schrag, Tobias; Summ, Thorsten; Weitz, Peter		
Credit points / SWS:	10 ECTS / 8 SWS		
Workload:	Contact hours:	93 h	
	Self-study:	157 h	
	Total effort:	250 h	
Subjects of the module:	7: Urban Area Energy System (UrbanAreaEnerSys_M-RES)		
Lecture types:	: S - Seminar		
Examinations:	7: SA - Seminar paper with oral examination (15min) and written elaboration (8-15 pages) (UrbanAreaEnerSys_M-RES)		
Usability for other study programs:	None		
Prerequisites according examination regulation:			
None			
Recommended prerequisites:			
Fundamentals of energy engineering, principles of district heat and cold supply, exemplary insight in existing energy technologies			
Objectives:			
The students			
<ul style="list-style-type: none">are familiar with different energy systems for heat and cold supply such as solar thermal, geothermal, CHP, fossil fuel and heat pump based technologiesunderstand the economic and technical principles of planning, design and operation of different energy supply systemscan strategically combine different energy sources to identify technically, environmentally and economically optimal solutionsknow how to conceptually describe and how to model heating solutions with different energy sources and multiple users in an urban environmenthave an insight in the specific boundaries and challenges of energy engineering in modelling and simulationare able to formulate and solve complex problems of real-world energy engineeringare able to condense the experience and results of a multifaceted energy engineering project in compact reports and presentations.			

Content:
<ul style="list-style-type: none">• District heating networks with focus on renewable sources and efficient fossil energy use (CHP), incl. heat storage• Solar thermal systems• Geothermal systems• Heat-pump based technologies• Fundamental of heating network modelling• Training in heating network model application• Detailed analysis of selected real-world case of district heating with multiple sources and consumers
Literature:
<i>Compulsory:</i> None <i>Recommended:</i> None
Additional remarks:
None

5.3 Individual Elective

Engineering Processes in Automotive Industry			
Module abbreviation:	EngineeProcAuto_M-APE	SPO-No.:	10
Curriculum:	Programme	Module type	Semester
	Renewable Energy Systems (SPO WS 17/18)	General Elective Subject	1
Modulattribute:	Language of instruction	Duration of module	Frequency of offer
	English	1 semester	only winter term
Responsible for module:	Bednarz, Martin		
Lecturers:	Meyer, Roland; Neumann, Alexander		
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours:	47 h	
	Self-study:	78 h	
	Total effort:	125 h	
Subjects of the module:	10: Engineering Processes in Automotive Industry (EngineeProcAuto_M-APE)		
Lecture types:	1: unbestimmt		
Examinations:	10: schrP90 - written exam, 90 minutes (EngineeProcAuto_M-APE)		
Usability for other study programs:	None		
Prerequisites according examination regulation:			
None			
Recommended prerequisites:			
None			
Objectives:			
<p>The students</p> <ul style="list-style-type: none">• know the strong networked and parallel processes in the product and process development of automobiles• can recognise, assess and include in the work interactions between production and product• know the significance and working methods of Simultaneous Engineering (SE) including the involvement of suppliers in product design and product and process quality to meet the requirements of production• can handle tools of project and process management and know the working methods and processes (e.g. for networking, decision-making, escalation, etc.) in large automotive and supplier companies• know the significance of prototype, pilot production and release processes and here applied tools• know about the significance of lean development methods and cost management			
Content:			
<ul style="list-style-type: none">• Product and process development in the automotive industry• Automotive project- and process-management and according methods• Requirements and quality management tools• Pre-series process• Cost management			

<ul style="list-style-type: none"> Lean development
Literature:
<p><i>Compulsory:</i></p> <ul style="list-style-type: none"> STAMATIS, Diomidis H., 2001. <i>Advanced quality planning: a commonsense guide to AQP and APQP</i>. 1. edition. New York, NY: Productivity Press. ISBN 1-56327-258-X COOPER, Robert G., 2017. <i>Winning at new products: creating value through innovation</i>. F. edition. New York, NY: Basic Books. ISBN 0-465-09332-9, 978-0-465-09332-8 WOMACK, James P., Daniel T. JONES and Daniel ROOS, 2007. <i>The machine that changed the world: [how lean production revolutionized the global car wars]</i>. [. edition. London [u.a.]: Simon & Schuster. ISBN 978-1-84737-055-6, 1-8473-7055-1 WOMACK, James P. and Daniel T. JONES, 2003. <i>Lean thinking: banish waste and create wealth in your corporation</i>. London [u.a.]: Simon & Schuster. ISBN 978-0-7432-3164-0 ROTHER, Mike and John SHOOK, 2009. <i>Learning to see: value-stream mapping to create value and eliminate muda</i>. Version 1. edition. Cambridge, Mass.: Lean Enterprise Inst.. ISBN 978-0-9667843-0-5, 0-9667843-0-8 MORGAN, James M. and Jeffrey K. LIKER, 2006. <i>The Toyota product development system: integrating people, process, and technology</i>. New York, NY: Productivity Press. ISBN 1-56327-282-2, 978-1-563-27282-0 REINERTSEN, Donald G., 2009. <i>The principles of product development flow: second generation lean product development</i>. Redondo Beach, Calif: Celeritas. ISBN 978-1-935401-00-1, 1-935401-00-9 CHANG, Kuang-Hua, 2013. <i>Product manufacturing and cost estimating using CAD/CAE</i>. Burlington: Elsevier Science. ISBN 978-0-12-404600-9, 0-12-404600-2 MITAL, Anil, ©2008. <i>Product development: a structured approach to consumer product development, design, and manufacture</i>. Amsterdam: Elsevier/Butterworth-Heinemann. ISBN 978-0-08-055641-3, 0-08-055641-8 <p><i>Recommended:</i></p> <p>None</p>
Additional remarks:
<p>Bonus system:</p> <p>In the course, tasks can be set that lead to bonus points for the examination performance for each qualitatively completed task. The maximum crediting of bonus points takes place according to the APO.</p>

Entrepreneurship Coaching			
Module abbreviation:	MVM_EC	SPO-No.:	10
Curriculum:	Programme	Module type	Semester
	Renewable Energy Systems (SPO WS 17/18)	Allgemeines Wahlpflichtfach	
Modulattribute:	Language of instruction	Duration of module	Frequency of offer
	Deutsch	1 Semester	nur Wintersemester
Responsible for module:	Bader, Martin		
Lecturers:	Bader, Martin		
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours:	47 h	
	Self-study:	78 h	
	Total effort:	125 h	
Subjects of the module:	10: Entrepreneurship Coaching (MVM_EC)		
Lecture types:	10: S - Seminar (MVM_EC)		
Examinations:	10: PA (MVM_EC)		
Usability for other study programs:	Keine		
Prerequisites according examination regulation:			
Keine			
Recommended prerequisites:			
Keine			
Objectives:			
<p>Nach erfolgreicher Teilnahme an der Modulveranstaltung sind die Studierenden in der Lage,</p> <ul style="list-style-type: none">eine Geschäftsidee selbst zu entwickeln, zu beurteilen und zu einem konsistenten Businessplan auszudifferenzieren.die Erfolgsfaktoren für bestimmte Geschäftsarten zu identifizieren und entsprechende Maßnahmen für die Umsetzung abzuleiten.die Umsetzung konsequent vorzubereiten und die Geschäftsidee durch eine Gründung im Markt anzubahnen bzw. tatsächlich einzuführen.sich auf die Teilnahme in Gründungswettbewerben gezielt vorzubereiten und die dort auftauchenden Herausforderungen zu erfüllen.			
Content:			
<ul style="list-style-type: none">IdeationValue Proposition DesignBusiness Model CanvasBusiness Model InnovationMinimal Viable Product & Preto-/PrototypingBusiness PlanningPitching			

Literature:*Verpflichtend:*

- AULET, Bill, Thomas DEMMIG und Marius URSACHE, 2013/2016. *Disciplined entrepreneurship (engl.)/Startup mit System: In 24 Schritten zum erfolgreichen Entrepreneur*. Hoboken, NJ: Wiley. ISBN 978-1-118-69228-8, 978-1-118-72088-2
- BAYSTARTUP GBMH, . *Handbuch Businessplan-Erstellung, Der Weg zum erfolgreichen Unternehmen* [online]. , 2022 [Zugriff am: 18.07.2022]. Verfügbar unter: <https://www.baystartup.de/startups/handbuch-businessplan-erstellung>; https://www.baystartup.de/fileadmin/Dokumente/Downloads/Handbuch_Businessplan_Erstellung.pdf

Empfohlen:

- KAWASAKI, Guy, 2015. *The art of the start 2.0: The time-tested, battle-hardened guide for anyone starting anything*. . London: Portfolio Penguin. ISBN 978-0-241-18726-5, 978-1-59184-811-0
- RIES, Eric, 2017. *The lean startup: how today's entrepreneurs use continuous innovation to create radically successful businesses*. New York: Currency. ISBN 978-1-5247-6240-7
- FUEGLISTALLER, U. und andere, 2019. *Entrepreneurship: Modelle – Umsetzung – Perspektiven Mit Fallbeispielen aus Deutschland, Österreich und der Schweiz*. . 5. Auflage. Wiesbaden: SpringerGabler. ISBN 978-3-658-26799-5
- GASSMANN, Oliver, Karolin FRANKENBERGER und Michaela CSIK, 2017. *Geschäftsmodelle entwickeln: 55 innovative Konzepte mit dem St. Galler Business Model Navigator*. . 2. Auflage. München: Hanser. ISBN 978-3446451759
- GASSMANN, Oliver, Karolin FRANKENBERGER und Michaela CHOUDURY, 2020. *Business Model Navigator: The Strategies Behind the Most Successful Companies*. . 2. Auflage. Harlow: Pearson. ISBN 978-1292327129
- OSTERWALDER, Alexander und Yves PIGNEUR, 2010. *Business Model Generation: Ein Handbuch für Visionäre, Spielveränderer und Herausforderer*. ISBN 978-3-593-39474-9
- OSTERWALDER, Alexander und Yves PIGNEUR, 2014. *Value Proposition Design: How to Create Products and Services Customers Want*. ISBN 978-1118968055

Additional remarks:

Das Coaching wird (soweit möglich) in Kooperation mit einem Business-Partner als Wirtschaftspaten durchgeführt. Durch diese Kooperation erhält jedes Team neben der Betreuung durch den THI-Dozierenden einen Praxis-Paten.

Fahrzeugsicherheit			
Module abbreviation:	FzgSich_M-FT	SPO-No.:	10
Curriculum:	Programme	Module type	Semester
	Renewable Energy Systems (SPO WS 17/18)	Pflichtfach	1
Modulattribute:	Language of instruction	Duration of module	Frequency of offer
	Deutsch	1 Semester	nur Sommersemester
Responsible for module:	Helmer, Thomas		
Lecturers:	Helmer, Thomas		
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours:	47 h	
	Self-study:	78 h	
	Total effort:	125 h	
Subjects of the module:	10: Fahrzeugsicherheit (FzgSich_M-FT)		
Lecture types:	1: unbestimmt		
Examinations:	10: schrP90 - schriftliche Prüfung, 90 Minuten (FzgSich_M-FT)		
Usability for other study programs:	Keine		
Prerequisites according examination regulation:			
Keine			
Recommended prerequisites:			
Keine			
Objectives:			
<p>Die Studierenden</p> <ul style="list-style-type: none">• kennen die Bereiche Unfallvermeidung und Unfallfolgenmilderung (aktive und passive Sicherheit)• verstehen die Ursachen von Unfällen und können Risiken bewerten• kennen die Einwirkungen auf Fahrzeuge bei Unfällen• verstehen die Vorschriften aus Gesetzen und Verbraucherschutz• kennen Schutzmaßnahmen für Insassen, äußere Verkehrsteilnehmer und zur Verbesserung der Kompatibilität• verstehen die Grundlagen der Biomechanik• kennen Versuchs- und Berechnungsmethoden			
Content:			
<ul style="list-style-type: none">• Einführung in die Fahrzeugsicherheit• Unfallstatistik und -forschung• Risikobewertung• Mechanische Grundlagen bei Unfällen• Gesetzgebung und Verbraucherschutz in der Fahrzeugsicherheit• Testverfahren in der passiven Sicherheit• Insassenschutz			

<ul style="list-style-type: none">• Kompatibilität und äußere Verkehrsteilnehmer• Biomechanik• Konstruktive Ausführung von Sicherheitssystemen• Versuchsdurchführung, Simulationsmethoden und Bewertungsverfahren• Anforderungen zur Sicherheit bei Elektrofahrzeugen und alternativen Antrieben
Literature:
<p><i>Verpflichtend:</i></p> <p>Keine</p> <p><i>Empfohlen:</i></p> <ul style="list-style-type: none">• KRAMER, Florian, 2013. <i>Integrale Sicherheit von Kraftfahrzeugen: Biomechanik - Simulation - Sicherheit im Entwicklungsprozess</i>. 4. Auflage. Wiesbaden: Springer Vieweg. ISBN 978-3-8348-2607-7, 3-8348-2607-3• SEIFFERT, Ulrich und Lothar WECH, 2007. <i>Automotive Safety Handbook</i>. 2. Auflage. Warrendale, Pa.: SAE Internat.. ISBN 978-0-7680-1798-4• JOHANNSEN, Heiko, 2013. <i>Unfallmechanik und Unfallrekonstruktion: Grundlagen der Unfallaufklärung ; mit 21 Tabellen</i>. 3. Auflage. Wiesbaden: Springer Vieweg. ISBN 978-3-658-01593-0, 978-3-658-01594-7
Additional remarks:
Keine Anmerkungen

Korrosion- und Oberflächentechnik			
Module abbreviation:	WModul-KorOT_M-RES	SPO-No.:	10
Curriculum:	Programme	Module type	Semester
	Renewable Energy Systems (SPO WS 17/18)	Allgemeines Wahlpflichtfach	2
Modulattribute:	Language of instruction	Duration of module	Frequency of offer
	Deutsch	1 Semester	nur Sommersemester
Responsible for module:	Oberhauser, Simon		
Lecturers:	Oberhauser, Simon		
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours:	47 h	
	Self-study:	78 h	
	Total effort:	125 h	
Subjects of the module:	10: Korrosion- und Oberflächentechnik (WModul-KorOT_M-RES)		
Lecture types:	10: SU/Ü - seminaristischer Unterricht/Übung		
Examinations:	10: LN - schriftliche Prüfung, 90 Minuten (WModul-KorOT_M-RES)		
Usability for other study programs:	Keine		
Prerequisites according examination regulation:			
Keine			
Recommended prerequisites:			
Keine			
Objectives:			
<p>Die Studierenden</p> <ul style="list-style-type: none">kennen den Mechanismus der Korrosion einschließlich seiner relevanten thermodynamischen und kinetischen Einflussfaktoren, können verschiedene Korrosionsformen erkennen und den jeweiligen Korrosionsursachen zuordnen.kennen die wichtigsten Korrosionsprüfungen einschließlich elektrochemischer Methoden und können ihre Ergebnisse sinnvoll interpretieren.kennen wichtige korrosionsbeständige Werkstoffe aus der Gruppe der Leichtmetalle, der hochlegierten Stähle sowie der Nickel und Kupferbasiswerkstoffe. Sie kennen deren Einsatzmöglichkeiten und Grenzen und können auf dieser Basis für konkrete Anwendungsfälle eine technisch und wirtschaftlich sinnvolle Werkstoffauswahl treffen.sind informiert über die verbreitetsten Möglichkeiten, wenig korrosionsbeständige Werkstoffe mit Hilfe von Beschichtungen und Überzügen zu schützen. Sie kennen die einschlägigen Methoden und Prozesse und sind in der Lage zu entscheiden, welches Verfahren zu einem gegebenen Bauteil und den dort herrschenden Anforderungen passt.kennen die Grundregeln des konstruktiven Korrosionsschutzes und sind daher in der Lage korrosionsbedingte Schwachstellen bereits in der Konzept- und Konstruktionsphase zu vermeiden			
Content:			
<ul style="list-style-type: none">Theoretische Grundlagen Korrosion, Methoden der Elektrochemie, KorrosionsprüfungMechanische Einflüsse auf das Korrosionsgeschehen			

- Korrosionsbeständige Werkstoffe mit ihren Möglichkeiten, Grenzen und ihren Sonderkorrosionsformen
- Korrosionsschutz durch Beschichtungen, Vorbehandeln und Vorbereiten, Beschichtungsprozesse, Beschichtungsstoffe
- Korrosionsschutz durch Überzüge, Verfahren und Materialien
- Grundbegriffe des konstruktiven Korrosionsschutzes
- Fügetechnik und Korrosion

Literature:*Verpflichtend:*

- WENDLER-KALSCH, Elsbeth, GRÄFEN, Hubert, 1998. *Korrosionsschadenkunde* [online]. Berlin, Heidelberg: Springer Berlin Heidelberg PDF e-Book. ISBN 978-3-642-30431-6, 978-3-662-22074-0. Verfügbar unter: <https://doi.org/10.1007/978-3-642-30431-6>.

Empfohlen:

Keine

Additional remarks:

Prüfungsart gemäß der Anlage zur SPO Master WT und Master TE

Mechatronik			
Module abbreviation:	Mechatro_M-LT	SPO-No.:	10
Curriculum:	Programme	Module type	Semester
	Renewable Energy Systems (SPO WS 17/18)	Pflichtfach	2
Modulattribute:	Language of instruction	Duration of module	Frequency of offer
	Deutsch	1 Semester	nur Wintersemester
Responsible for module:	Müller, Dieter		
Lecturers:	Müller, Dieter		
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours:	47 h	
	Self-study:	78 h	
	Total effort:	125 h	
Subjects of the module:	10: Mechatronik (Mechatro_M-LT)		
Lecture types:	10: SU/PR - Seminaristischer Unterricht/Praktikum (Mechatro_M-LT)		
Examinations:	10: schrP90 - schriftliche Prüfung, 90 Minuten (Mechatro_M-LT)		
Usability for other study programs:	Keine		
Prerequisites according examination regulation:			
Keine			
Recommended prerequisites:			
Keine			
Objectives:			
<p>Die Studierenden</p> <ul style="list-style-type: none">• kennen und verwenden die fachspezifische Terminologie sicher,• benennen die Eigenschaften von Sensoren und Aktoren,• können die Eigenschaften eines Mikrocontrollers benennen,• besitzen das mathematische Hintergrundwissen zur Lösung von mechatronischen Problemstellungen• beurteilen die Vor-/ und Nachteile verschiedener Bussysteme,• entwerfen einen zeitdiskreten Regelkreis mit Hilfe der z- Transformation und kennen Techniken, Regler auf einem Mikrocontroller zu implementieren,• wenden gelernte Methoden auf ähnliche Probleme der Mechatronik an,• lösen Aufgaben auch in einer Kleingruppe, und können dabei Fachliches kommunizieren und erklären,• arbeiten sich selbstständig und im Team in Themen der Mechatronik ein und können über diese kompetent diskutieren,• verstehen, wie der eigene Lernstil verbessert werden kann und verstehen, wie die Zusammenarbeit mit anderen verbessert werden kann.			
Content:			
<p>Grundstruktur der Mechatronik</p> <ul style="list-style-type: none">• Definition, Merkmale und Grundprinzipien der Mechatronik			

Sensoren

- Klassifikation und Eigenschaften, Signalformen, Signalaufbereitung
- Messkette, integrierte und intelligente Sensorik
- Messung von Weg, Lage, Näherung, Geschwindigkeit, Beschleunigung, Kraft, Druck, Durchfluss, Temperatur, Licht
- Sensoren im Kraftfahrzeug

Aktoren

- Übersicht, Klassifikation, Eigenschaften, Einsatzbereiche
- Elektromotoren: Gleichstrom, Synchron-, Asynchronmotoren, Schrittmotor
- Beispiele aus der Kraftfahrzeugtechnik

Modellbildung

- Prinzipien der Modellbildung
- Bausteine für die Modellbildung mechanischer, elektrischer, hydraulischer und pneumatischer Systeme

Beobachter

- Theorie des Luenberger-Beobachters
- Einsatz zur Schätzung von Zustandsgrößen
- erweiterter Beobachter zur Schätzung von Offsets

Abtastregelung

- Näherungsweise Lösung mit Hilfe von Differenzenquotienten,
- z-Transformation
- Berücksichtigung des Halteglieds
- Aufbau eines abgetasteten Regelkreises
- Approximation mit Tustin und Euler-Differenzengleichung,
- Entwurf von Reglern unter Berücksichtigung der Stabilität,
- Deadbeat-Controller
- zeitdiskreter Zustandsraum, zeitdiskreter Beobachter

Mikrocontroller

- Aufbau,
- Schnittstellen und A/D-Wandlung
- Implementation einer Abtastregelung im Mikrocontroller

Literature:*Verpflichtend:*

- RODDECK, Werner, 2019. *Einführung in die Mechatronik* [online]. Wiesbaden: Springer Vieweg PDF e-Book. ISBN 978-3-658-27775-8. Verfügbar unter: <https://doi.org/10.1007/978-3-658-27775-8>.
- BOLTON, William, 2006. *Bausteine mechatronischer Systeme*. 3. Auflage. München ; Boston <<[u.a.]>>: Pearson Studium. ISBN 978-3-8273-7262-8, 3-8273-7262-3
- BERNSTEIN, Herbert, 2004. *Grundlagen der Mechatronik*. 2. Auflage. Berlin [u.a.]: VDE-Verl.. ISBN 3-8007-2754-4
- ISERMANN, Rolf, 2008. *Mechatronische Systeme: Grundlagen ; mit 103 Tabellen* [online]. Berlin [u.a.]: Springer PDF e-Book. ISBN 978-3-540-32336-5, 3-540-32336-8. Verfügbar unter: <https://doi.org/10.1007/978-3-540-32512-3>.

Empfohlen:

- LUTZ, Holger und Wolfgang WENDT, 2019. *Taschenbuch der Regelungstechnik: mit MATLAB und Simulink*. 11. Auflage. Haan-Gruiten: Verlag Europa-Lehrmittel. ISBN 978-3-8085-5869-0, 3-8085-5869-5
- UNBEHAUEN, Heinz, LEY, Frank, 2014. *Das Ingenieurwissen: Regelungs- und Steuerungstechnik* [online]. Berlin [u.a.]: Springer PDF e-Book. ISBN 978-3-662-44026-1. Verfügbar unter: <https://doi.org/10.1007/978-3-662-44026-1>.

Additional remarks:
Keine Anmerkungen