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Importance of the grade for the final grade

FAK = 1,0

DIV = 176

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Modeling of environmental processes (UI-P2, 6 ECTS, each winter semester).....	100
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2) MSc Environmental Engineering Compulsory Optional Courses Environmental Technology and Planning (CE), ECTS: 52

Importance of the grade for the final grade

FAK = 1,5

DIV = 176

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Traffic Engineering (BI-WP30/UI-WPC3, 6 ECTS, each summer semester).....	172
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3) MSc Environmental Engineering Optional Courses, ECTS: 16

Importance of the grade for the final grade

FAK = 1,0

DIV = 176

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Project Management in Plant Engineering (139200, 5 ECTS, each winter semester).....	117
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Non-motorized traffic (BI-W67, 2 ECTS, each summer semester).....	110
Planning, Speaking, Writing : project management and scientific work in engineering (BI-W28, 3 ECTS, each semester).....	115
Seminar for transportation and traffic engineering (BI-W61, 2 ECTS, each semester).....	135
Environmental aspects and sustainability in road construction (BI-W42, 1 ECTS, each summer semester).....	148
Environmental law (excursion) (W10, 1 ECTS, each summer semester).....	156
Wind effects – Engineering Structures and Wind Turbines (BI-WP45, 6 ECTS, each summer semester).....	178
Communication for civil engineers (W14, 2 ECTS, each summer semester).....	40
Selected Topics of Geotechnical and Geoenvironmental Engineering (BI-W30/SE-O-21, 2 ECTS, each semester).....	20
Climate-Resilient Urban Planning (BI-W76, 2 ECTS, each summer semester).....	84
Contact-Based Sensors for Structural and Environmental Monitoring (BI-W77, 3 ECTS, each winter semester).....	86
Non-Destructive Testing and Diagnostics of Structures and Environmental Systems (BI-W78, 3 ECTS, each summer semester).....	180

4) MSc Environmental Engineering Master's Thesis, ECTS: 30

Importance of the grade for the final grade

FAK = 2,0

DIV = 176

Master's Thesis (UI-MA, 30 ECTS, each semester).....	92
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Waste, Gas and Wastewater Treatment Abluft-/Abwasserreinigung					
Module number 137470	Credits 5 CP	Workload 150 h	Semester[s] 2./3. Sem.	Duration 2 Semester[s]	Group size no limitation
Courses a) Abluft-/ Abwasserreinigung			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marcus Grünwald a) Dr.-Ing. Maria Polyakova					
Admission requirements Recommended previous knowledge: keine					
Learning outcome, core skills Die Studierenden kennen im Bereich der Abluft- und Abwasserreinigung exemplarisch den Stand moderner ingenieurwissenschaftlicher Forschung. Sie sind somit im Bereich der Abluftreinigung in der Lage • die verfahrenstechnischen Auslegungskriterien aller gängigen Abluftreinigungssysteme zu verstehen • die Einsatzbereiche bestimmter Abluftreinigungsverfahren zu erkennen • die behördlichen Auflagen zu verstehen Hinsichtlich der Abwasserreinigung sind die Studierenden in der Lage • die verfahrenstechnischen Auslegungskriterien aller gängigen Abwasserreinigungssysteme zu verstehen • die Einsatzbereiche bestimmter Abwasserreinigungsverfahren zu erkennen • die behördlichen Auflagen zu verstehen Die Bearbeitung des Moduls erfolgt in Zusammenarbeit mit der Universität Oulu in Finnland. Die Studierenden haben dabei die Fähigkeit zu vernetztem und kritischem Denken ausgebaut und sind in der Lage etablierte Methoden und Reinigungsverfahren auszuwählen und anzuwenden. Sie können entsprechende Erkenntnisse/ Fertigkeiten auf konkrete und neue Problemstellungen der Abluft- und Abwasserreinigung übertragen.					
Contents a) Die in den letzten Jahren gestiegene Forderung nach einer umweltfreundlichen Produktion von Gütern in der Industrie sowie das Bewusstsein, dass unsere Lebensqualität nur durch ein hohes Maß an Umweltschutz gehalten werden kann, hat dazu geführt, dass ständig innovative Techniken neben Standardlösungen eingesetzt werden. In der Vorlesung werden mechanische, biologische und chemische Abwasserreinigungsverfahren angesprochen; so z.B. Adsorption, Desorption, Membranverfahren, Oxidationsverfahren, Filtersysteme, Fällung, Flockung, Siebung, Ionenaustausch, Biofilter, Biowäsche usw. In der Vorlesung werden Abluftreinigungsverfahren wie z.B. Adsorptionsverfahren, Chemisorptionsverfahren, katalytische und biologische Verfahren, Membranverfahren, Verbrennungsverfahren, Kondensationsverfahren usw. besprochen.					
Educational form / Language a) Lecture (2 WLH) / Tutorial (2 WLH) / German / English					

Examination methods

- Portfolio exam 'Abluft-/Abwasserreinigung' (80 min., Part of modul grade 100 %, Präsentation (englisch) (2 x 20 min, Anteil an der Modulnote 60%); mündliche Prüfung (2 x 20 min, Anteil an der Modulnote 40 %))

Requirements for the award of credit points

Bestandene Modulabschlussprüfung: Portfolioprüfung (2 x Präsentation + mündliche Prüfung)

Module applicability

MSc. Maschinenbau

MSc. Umweltingenieurwesen

Weight of the mark for the final score

Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Physical Geology and Laboratory Training Soil Mechanics					
Allgemeine Geologie und praktische Bodenmechanik					
Module number UI-WPD9	Credits 6 CP	Workload 180 h	Semester[s] 3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Physical Geology for non-geologists b) Soil mechanics laboratory course			Contact hours a) 1.34 WLH (20.1 h) b) 2 WLH (30 h)	Self-study a) 70 h b) 60 h	Frequency a) each winter b) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Torsten Wichtmann a) Prof. Dr. Tobias Backers b) Dr.-Ing. Wiebke Baille					
Admission requirements Recommended previous knowledge: Completed module in soil mechanics and foundation engineering					
Learning outcome, core skills The students • have a thorough understanding of the System Earth and its complexities, and understand the societal and engineering relevance of geological processes and materials • be able to assess and solve practical and scientific engineering challenges against this background • are familiar with the essential tests of soil mechanics, their principles, the equipment technology, and the necessary measuring equipment, • have an overview of sample preparation and the time required to carry out the tests, • are able to independently design experimental strategies for solving application-oriented problems and analyse their results.					
Contents a) This course consists of two components (i) basics: self study of course material and (ii) application and discussion: two days field camp. It covers topics in geology that are relevant to civil engineering: • Formation of rocks, geological features (e.g., stratification, faults, joints, folds), plate tectonics, and geological formations • Weathering, erosion and mass wasting and the influence of climate • Basic concepts of hydrogeology and engineering geology. • The human impact on Earth's environment b) The laboratory practical course introduces the essential soil mechanics testing techniques and selected tests are carried out independently: • Measurement methods in geotechnical laboratory and field tests • Carrying out classification tests (including grain size distribution curve, water content, densities at loosest and densest packing, grain density)					

• Tests for shear strength, compressibility, permeability
Educational form / Language a) Excursion / Inverted Classroom / German / English b) Internship / German
Examination methods • Test 'Physical Geology for non-geologists' (15 h., Part of modul grade 50 %, weekly online interrogation and two days field camp) • Term paper 'Soil mechanics laboratory course - Homework' (15 h., Part of modul grade 50 %, with oral Examination)
Requirements for the award of credit points • Passing online interrogation for a) • Participation on two field camps for a) • Passing homework with oral exam for b)
Module applicability • M.Sc. Environmental Engineering
Weight of the mark for the final score Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.
Further Information

Occupational and Plant Safety Arbeits- und Anlagensicherheit					
Module number 137110	Credits 3 CP	Workload 90 h	Semester[s] 1./3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Arbeits- und Anlagensicherheit			Contact hours a) 2 WLH (30 h)	Self-study a) 60 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marcus Grünwald a) Dr.-Ing. Joachim Neumann					
Admission requirements Die Vorlesung findet an der TU Dortmund statt. Recommended previous knowledge: keine					
Learning outcome, core skills Nach dem erfolgreichen Abschluss des Moduls können/haben Studierende • im sicherheitstechnischen Bereich exemplarisch den Stand moderner ingenieurwissenschaftlicher Forschung darstellen • die Fähigkeit zu vernetztem und kritischem Denken ausgebaut und sind in der Lage etablierte Methoden und Verfahren im technischen und organisatorischen Arbeitsschutz auszuwählen und auf analoge Beispiele systematisch und praxisgerecht anzuwenden • dabei auch eine interdisziplinäre Methodenkompetenz erworben und können diese anwenden					
Contents a) Arbeitsschutzorganisation, Gefahrstoffe, Primäre und Sekundäre Schutzsysteme, Risikoanalyse, Zuverlässigkeit, Brand- und Brandschutz, Sicherheitstechnische Kenngrößen, Explosionen und Explosionsschutz, Schall und Lärmschutz, Zertifizierung von Sicherheit und Gesundheit bei der Arbeit ISO 45001					
Educational form / Language a) Lecture (2 WLH) / German					
Examination methods • Written exam 'Arbeits- und Anlagensicherheit' (90 min., Part of modul grade 100 %) • Voraussetzung für die Teilnahme an der Prüfung ist eine Teilnahme an mindestens 9 Veranstaltungsterminen an der TU Dortmund. Die Anwesenheit wird in jeder Veranstaltung überprüft.					
Requirements for the award of credit points Bestandene Modulabschlussprüfung: Klausur					
Module applicability MSc. Umweltingenieurwesen					
Weight of the mark for the final score Percentage of total grade [%] = $3 \cdot 100 \cdot \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents.					

DIV: The values can be taken from the table of contents.
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Further Information

Occupational Health & Safety 1 Arbeitssicherheit I – Baustellenorganisation					
Module number BI-W21	Credits 2 CP	Workload 60 h	Semester[s] ab dem 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Occupational Health & Safety 1			Contact hours a) 2 WLH (30 h)	Self-study a) 30 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Markus Thewes a) Prof. Dr.-Ing. Markus Thewes, Dipl.-Ing. Ralf Germann					
Admission requirements					
Learning outcome, core skills Students • Will develop a fundamental understanding of the importance of occupational health and safety on construction sites, • are introduced to the basic knowledge of appropriate preventive measures in construction planning and execution, • will recognise the special significance of construction management for health and safety aspects from a legal perspective, • will learn to deal with issues in these areas in a practical manner, • will be able to critically examine occupational health and safety issues and implement it in construction organisation					
Contents a) The lecture comprehensively covers the basics of occupational safety. This includes: • Fundamentals of occupational safety • Legal and insurance aspects • Basic knowledge of accident prevention regulations for building construction and civil engineering • Special features of compressed air and blasting work					
Educational form / Language a) Lecture (2 WLH) / German					
Examination methods • Written exam 'Occupational Health & Safety 1' (60 min., Part of modul grade 100 %, Die Klausur findet im Sommersemester vorlesungsnah nach Beendigung der Veranstaltung noch während der Vorlesungszeit statt.)					
Requirements for the award of credit points • Passed module final exam: Written exam					
Module applicability • B.Sc. Civil Engineering • B.Sc. Environmental Engineering • M.Sc. Civil Engineering					

- M.Sc. Environmental Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $2 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Note: With the Occupational Health & Safety 1 module, students can acquire the first part of the theoretical training to become a health and safety coordinator (SiGe coordinator) with regard to occupational safety knowledge (SiGe occupational safety – occupational safety knowledge in accordance with RAB 30, Appendix B). Continuing from this first module Occupational Health & Safety 1, the second part of the theoretical knowledge of a SiGe coordinator is taught in a further master module W22.

After consultation with the lecturer, students of the Bachelor's programme may also voluntarily participate in the Master's module W22 in order to complete this component of the theoretical training for health and safety coordinators (SiGe coordinators).

In addition to the two modules W21 and W22 on occupational health and safety, training in specific coordinator skills (in accordance with RAB 30, Annex C) is required for the complete theoretical training as a health and safety coordinator. This is not part of the W21 or W22 modules offered here.

Occupational Health & Safety 2 Arbeitssicherheit II - Arbeitsschutzfachlicher Theoriekurs					
Module number BI-W22	Credits 2 CP	Workload 60 h	Semester[s] ab dem 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Environmental Engineering			Contact hours a) 2 WLH (30 h)	Self-study a) 30 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Markus Thewes a) Prof. Dr.-Ing. Markus Thewes, Dipl.-Ing. Ralf Germann					
Admission requirements Recommended previous knowledge: Participation in the Occupational Safety I module is recommended.					
Learning outcome, core skills Students • develop an advanced understanding of the importance of occupational health and safety protection on construction sites, • acquire further knowledge of appropriate preventive measures in construction planning and execution, • recognise the special importance of construction management from a legal perspective, • learn how to deal with issues in these areas in a practical manner • are able to critically examine occupational safety issues and implement this task in construction management					
Contents a) The lecture comprehensively covers the basics of occupational safety. This includes: • In-depth study of legal and insurance-related aspects • In-depth knowledge of accident prevention regulations for building construction and foundation engineering • Fire protection during the construction phase • Fundamentals of health and safety planning and coordination • Tasks of the health and safety coordinator in planning and construction					
Educational form / Language a) Lecture (2 WLH) / German					
Examination methods • Written exam 'Occupational Health & Safety 2' (60 min., Part of modul grade 100 %)					
Requirements for the award of credit points • Passed module final exam: Written exam					
Module applicability • B.Sc. Civil Engineering • B.Sc. Environmental Engineering • M.Sc. Civil Engineering					

- M.Sc. Environmental Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $2 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Note: With the Occupational Health & Safety 2 module, students can acquire the second part of the theoretical training to become a health and safety coordinator (SiGe coordinator) with regard to occupational safety knowledge (SiGe occupational safety – occupational safety knowledge in accordance with RAB 30, Appendix B). Continuing from the previous module, Occupational Health & Safety 1, the second part of the theoretical knowledge of a SiGe coordinator is taught in this master module.

In addition to the two modules W21 and W22 on occupational health and safety, training in specific coordinator skills (in accordance with RAB 30, Annex C) is required for the complete theoretical training as a health and safety coordinator. This is not part of the W21 or W22 modules offered here.

Selected Topics of Geotechnical and Geoenvironmental Engineering Ausgewählte Kapitel aus Grundbau und Umweltgeotechnik					
Module number BI-W30/SE-O-21	Credits 2 CP	Workload 60 h	Semester[s] ab dem 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Selected Topics of Geotechnical and Geoenvironmental Engineering (128223)			Contact hours a) 1 WLH (15 h)	Self-study a) 45 h	Frequency a) each sem.
Module coordinator and lecturer(s) Prof. Dr.-Ing. Torsten Wichtmann a) Dr.-Ing. D. König					
Admission requirements Recommended previous knowledge: Completed modules in soil mechanics and foundation engineering					
Learning outcome, core skills The students - gain an impression of the complexity of practical construction tasks and learn about solutions to specific problems, - are able to engage with innovative ideas and solution strategies, - can transfer the solutions learned to other situations.					
Contents a) In this course, current construction projects and methods are presented by experts e.g. from construction industry. The tasks, technical constraints, planning and design principles, construction works, difficulties encountered, and solutions are explained.					
Educational form / Language a) Lecture (1 WLH) / German					
Examination methods Oral exam 'Selected Topics of Geotechnical and Geoenvironmental Engineering' (0 min., ungraded, Colloquium)					
Requirements for the award of credit points - Participation - Passed module examination: oral exam					
Module applicability - M.Sc. Civil Engineering - M.Sc. Subsurface Engineering - M.Sc. Environmental Engineering					
Weight of the mark for the final score Percentage of total grade [%] = 0, ungraded					
Further Information					

Perhaps excursion/conference participation

Construction and Engineering Contract law Bau- und Ingenieurvertragsrecht					
Module number BI-W02	Credits 3 CP	Workload 90 h	Semester[s] ab dem 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Construction and Engineering Contract law			Contact hours a) 2 WLH (30 h)	Self-study a) 60 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Markus Thewes a) Prof. Dr.-Ing. Markus Thewes, Prof. Dr. jur. M.M. Lederer					
Admission requirements Recommended previous knowledge: Knowledge in the field of construction operations and construction process engineering, as well as construction contract law and construction management					
Learning outcome, core skills Students • will be introduced to the basics of construction and engineering contract law, • acquire in-depth basic knowledge of the regulatory structures governing contracts for construction services and for engineering contract fees and, building on this, will be able to allocate risk during contract negotiations and construction in order to minimise potential conflicts and maximise cooperation-based project implementation • deal with the different interests of clients and contractors as well as the authorities and organisations involved that must be included in contract management, • acquire the ability to independently handle standard tasks in the areas of construction and engineering contract law, • acquire a basic understanding of the correct handling of regulations and laws governing contract law and statutory price law.					
Contents a) The lecture comprehensively covers the basic knowledge of construction and engineering contract law based on the German Civil Code (BGB), the German Construction Contract Procedures (VOB/B) and the German Fee Structure for Architects and Engineers (HOAI). This includes: • the basics of the general part of the BGB on the formation of contracts (offer and acceptance, powers of representation, conditions, etc.), • the BGB law on contracts for work and services (§§ 631 ff. BGB) and the VOB/B • supplementary agreement management and dealing with obstacles in the construction process • the acceptance of construction work • the law on defects • Securities in construction contract law in accordance with Section 648a BGB and Section 17 VOB/B Moot Court In addition, a moot court (simulated court hearing) will be held as part of this course, in which students will apply the knowledge they have acquired by working on a case study.					

Educational form / Language a) Seminar / Lecture (2 WLH) / German
Examination methods • Written exam 'Construction and Engineering Contract law' (30 min., Part of modul grade 100 %, Exam covering the entire module) • Seminar 'Moot Court' (5 h., Part of modul grade 0 %)
Requirements for the award of credit points • Passed module final exam: Written exam • Participation in moot court
Module applicability • M.Sc. Civil Engineering • M.Sc. Environmental Engineering
Weight of the mark for the final score Percentage of total grade [%] = $3 * 100 * \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.
Further Information

Earthworks – Soil mechanical background and practice					
Bodenmechanik und Baupraxis des Erdbaus					
Module number BI-WP61/UI-WPD8	Credits 6 CP	Workload 180 h	Semester[s] 3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Soil-water interaction and its practical significance for earthworks b) Site investigation and earthworks c) Behaviour of innovative retaining structures and foundations			Contact hours a) 2 WLH (30 h) b) 1 WLH (15 h) c) 1 WLH (15 h)	Self-study a) 60 h b) 30 h c) 30 h	Frequency a) each winter b) each winter c) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Torsten Wichtmann a) Dr.-Ing. Wiebke Baille b) Dr.-Ing. Wiebke Baille, Dr.-Ing. Henning Wolf c) Dr.-Ing. Oliver Detert					
Admission requirements Recommended previous knowledge: Completed modules in soil mechanics and foundation engineering					
Learning outcome, core skills The students • are familiar with the behaviour of soil under partially saturated conditions, have in-depth knowledge of soil investigation and description, and are familiar with earthwork methods and the load-bearing behaviour of innovative retaining and foundation structures, • have the ability to engage with innovative ideas, research results, and current and changing regulations, • are able to assess the effects of changes in soil water content and develop and evaluate innovative solutions for ground improvement.					
Contents a) The course covers the principles of soil mechanics of partially saturated soils and phenomena in soils that can be caused by changes in water content, as well as their practical significance in construction. The following topics are covered: • Saturated and partially saturated soils • Soft cohesive and organic soils, consolidation behavior • Swelling and shrinking cohesive soils and their physicochemical properties • Collapsible soils • Compaction and structure of compacted soils • Structures on problematic soils / case studies • Laboratory experiments to illustrate the above phenomena b)					

The course covers strategies for investigating building sites and the planning, execution, and monitoring of earthworks:

- Concepts for site investigation and preparation of site reports
- Earthwork classifications
- Appropriate and economical construction of earthworks (e.g., dams, cuts for transport routes, dikes)
- Testing methods
- Methods for soil improvement and soil stabilization
- Soil management concepts

c)

The course covers the description of load-bearing behaviour and the design of innovative support and foundation structures:

- Detailed retaining structures - construction methods and special features (e.g. geotextile reinforcement, gabion walls, ...)
- Detailed foundation structures - construction methods and special features (e.g. stone columns, vibro compaction piles, ...)
- Geotextiles: types, areas of application, properties
- Load-bearing behaviour and design of retaining structures with geosynthetics
- Foundations on soft soils – examples and design approaches

Educational form / Language

a) Lecture (2 WLH) / German

b) Lecture (1 WLH) / German

c) Lecture (1 WLH) / German

Examination methods

- Written exam 'Earthworks – Soil mechanical background and practice' (120 min., Part of modul grade 100 %)

Requirements for the award of credit points

- Passed final module examination: written examination

Module applicability

- M.Sc. Civil Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Business Development Business Development					
Module number 139010	Credits 5 CP	Workload 150 h	Semester[s] ab dem 1. Sem.	Duration Semester[s]	Group size no limitation
Courses a) Business Development			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Manfred Renner a) Prof. Dr.-Ing. Manfred Renner					
Admission requirements					
Learning outcome, core skills Das Modul Business Development richtet sich an Studierende, die im industriellen Umfeld die strategische Geschäftsmodellentwicklung gestalten wollen. Die Studierenden erlangen umfassendes Grundlagenwissen zur methodischen Erschließung und Entwicklung neuer Geschäftsfelder und ein grundsätzliches Verständnis des kontinuierlichen Wandels in dem sich moderne am internationalen Markt erfolgreiche Unternehmen stets befinden. Das Erlernte wird an konkreten Beispielen erläutert. Die Business Model CANVAS nach Osterwalder bietet die Grundlage, auf der Szenarien aufgebaut werden. Die Einbringung Ihrer fachlichen Kompetenzen ist gewünscht, um in möglichst interdisziplinären Gruppen aktiv Fallbeispiele bzw. Szenarien zu bearbeiten, zu diskutieren und zu präsentieren					
Contents a) Technische Produktinnovationen und die Erschließung neuer Geschäftsmodelle und -felder bieten immense Chancen und zeitgleich Risiken. Die Lehrveranstaltung vermittelt einen Leitfaden für die Entwicklung und Evaluation von Ideen und deren Überführung in neue Geschäftsmodelle bzw. in die Weiterentwicklung bestehender Geschäftsmodelle. Die Basis bildet die Definition von Faktoren, die ein Unternehmen dazu bewegen, das bestehende Geschäftsmodell zu verändern. Darauf aufbauend wird erarbeitet, wie Geschäftsfelder zielführend erweitert oder erschlossen werden. Beispielhaft genannt werden die Business Model CANVAS, der Stage-Gate-Prozess, die 635-Methode, Design Thinking, die Osborne-Checkliste etc.					
Educational form / Language a) Lecture with tutorial / German					
Examination methods Written exam 'Business Development' (120 min., Part of modul grade 100 %)					
Requirements for the award of credit points					
Module applicability M. Sc. Maschinenbau M. Sc. Sales Engineering and Product Management					
Weight of the mark for the final score Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.					

Further Information

Gemäß den Grundsätzen des forschenden Lernens wird in den Gruppen mit bedarfs- und bedürfnisgerechten Materialien gearbeitet, für deren Recherche die Studierendenteams selbst verantwortlich sind. Der kritische Umgang mit Quellen wird angeleitet.

Carbon Dioxide Capture from Industrial Processes					
Carbon Dioxide Capture from Industrial Processes					
Module number 138330	Credits 5 CP	Workload 150 h	Semester[s] 1./3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Carbon Dioxide Capture from Industrial Processes			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. V. Scherer a) Priv.-Doz. Dr.-Ing. Martin Schiemann					
Admission requirements					
Learning outcome, core skills Objective: The lecture provides a basic understanding of CO₂ as a greenhouse gas and associated CO₂ sources. The state of development and perspectives of separation processes are discussed. The influence of separation on transport and storage will be addressed and economic, legislative and social aspects will be discussed. Competences: Students acquire the ability to evaluate and critically classify the individual process steps of CO₂ capture and storage or use. You will be able to make references to other lectures and to apply what you have learned there. The newly acquired knowledge is applied in a smaller project work accompanying the lecture.					
Contents a) Based on the definition, causes and effects of climate change, types of CO ₂ sources and alternative energy sources are considered. The concept of CO ₂ capture and storage is explained. Technical measures for CO ₂ capture such as post-combustion, oxy-fuel combustion and pre-combustion capture will be discussed. Legal aspects and costs are considered. Transport by pipeline and ship is dealt with. Risks, security aspects and monitoring are discussed for the mentioned procedures. Geological storage and storage in the ocean are considered as storage types. Carbonate formation and the material use of CO ₂ are discussed. Finally, component costs and carbon capture-and-sequestration usage scenarios are considered.					
Educational form / Language a) Lecture (2 WLH) / Tutorial (2 WLH) / English					
Examination methods Written exam 'Carbon Dioxide Capture from Industrial Processes' (90 min., Part of modul grade 100 %, if there are less than 10 registrations the examination mode can be switched to an oral examination)					
Requirements for the award of credit points Passed final exam: Written exam					
Module applicability Msc. Umweltingenieurwesen					
Weight of the mark for the final score Percentage of total grade [%] = 5 * 100 * FAK / DIV FAK: The weighting factors can be taken from the table of contents.					

DIV: The values can be taken from the table of contents.

Further Information

Chemical Energy Storage and Carbon-Based Feedstocks					
Chemical Energy Storage and Carbon-Based Feedstocks					
Module number 139250	Credits 5 CP	Workload 150 h	Semester[s] 1./3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Chemical Energy Storage and Carbon-Based Feedstocks			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Thomas Ernst Müller a) Dr.-Ing. Kevin Stark, Prof. Thomas Ernst Müller					
Admission requirements Recommended previous knowledge: Basic knowledge of natural sciences and engineering fundamentals, in particular chemistry and thermodynamics as well as energy systems, is recommended.					
Learning outcome, core skills Today's energy and chemical feedstock supply and storage systems are based largely on fossil resources. They need to be converted in the next decades into energy supply and feedstock systems that rely to a large extent on renewable feedstock. Most renewable sources are of intermittent nature, and this will lead to completely new system design requirements to maintain reliable energy systems and a continuous feedstock supply for the chemical industry and other industries. Knowledge of these new systems and their development and implementation will be essential for graduates in the future. Understanding that the reliability of the transformed energy systems and feedstock supply chain will rely on primarily on the three pillars energy storage, renewable (over)production, and carbon-based feedstocks Ability to assess the different possibilities to deal with and balance the time-offset between power generation and power demand, know different technologies to store energy and distinguish different storage solutions and applying them to a given storage or feedstock Understanding of the different types of carbon-based feedstocks and the application and industry where they are most suitable. Ability to do a basic life cycle assessment of chemical feedstock supplies and chemical storage systems and their respective chances and boundary conditions for large scale adoption and implementation. After successful completion of the module students should be able to • Have enhanced subject and method competences in the area of chemical energy storage and carbon-based feedstocks • Be familiar with current developments and technical principles in the area of chemical energy storage and carbon-based feedstocks • Compare different chemical energy storage concepts and carbon-based feedstocks and assess the suitability of these concepts in a process-chain analysis and under consideration of process technology aspects and applications • Assess and discuss thermodynamic and kinetic aspects of chemical energy storage and carbon-based feedstocks					

- Explain, estimate and calculate potentials, energy densities and efficiencies of storage technologies and concepts
- Be familiar with interdisciplinary thinking at the interface of engineering and chemistry and can tackle actual and future problem definitions in the chemical industry, regarding sustainability and use of renewable resources such as CO₂ and others
- Enter industrial R&D in a cutting-edge field in the area of the „Energiewende“ and „Wasserstoffrepublik Deutschland“

Contents

a)

Since the beginning, human beings have made use of energy storage; history of energy storage from the perspective of the carbon cycle

- Thermodynamic basics of chemical energy storage
- Overview of energy storage technologies (including non-chemical)
- Technology and characteristics of conventional power plants
- Biogenic energy carriers; photosynthesis as the first energy storage process; fossil energy as a form of ancient biomass; solid (wood, coal), fluid (oils, crude oil) and gaseous (natural gas) biogenic energy carriers
- Chemical energy carriers in the energy system, power-to-gas (e.g. methane) and power-to-liquid (e.g. methanol); energy storage via fuels
- Electrochemical basics and applications for electrochemical energy storage; systems for electrochemical energy conversion and storage (batteries, electrolysis, fuel cells)
- Hydrogen storage technologies (generation, compression, liquefaction, adsorption, chemical binding to a carrier)
- Energy storage as heat
- Energy scenarios and modelling; Life Cycle Assessment
- What is a Feedstock? Renewable vs. depleting feedstock; renewable carbon-based feedstocks, CO₂, biomass, bio coal; current feedstock consumption
- Value chain of fuels and chemicals; agricultural and industrial applications
- Renewable carbon-based feedstock for energy; biofuels from first generation corn-based, ethanol, biodiesel; second generation biofuels, cellulosic, oils, grasses; third and fourth generation, biofuels, algae
- Chemical conversion of carbon dioxide
- Biorefinery; production of aromatics from lignin; renewables as feedstock for polymers

Educational form / Language

a) Lecture (2 WLH) / Tutorial (2 WLH) / English

Examination methods

- Written exam 'Chemical Energy Storage and Carbon-Based Feedstocks' (120 min., Part of modul grade 100 %)

During the tutorial, students may complete coursework during the semester, in particular a short scientific presentation and discussion on a selected topic related to the course content.

These activities may be rewarded with bonus points of up to 20 % of the points achievable in the written exam. The bonus points are added to the exam score.

Bonus points cannot compensate for a failed written exam.

Students are not entitled to the awarding of bonus points.

Requirements for the award of credit points
• Passed final module exam: written exam
Module applicability
M. Sc. Mechanical Engineering
M. Sc. Sales Engineering and Product Management
M. Sc. Umweltingenieurwesen
Weight of the mark for the final score
Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$
FAK: The weighting factors can be taken from the table of contents.
DIV: The values can be taken from the table of contents.
Further Information

Chemical Processes for Closed Carbon Cycles					
Chemical Processes for Closed Carbon Cycles					
Module number 138160	Credits 5 CP	Workload 150 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Chemical Processes for Closed Carbon Cycles			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Thomas Ernst Müller a) Prof. Thomas Ernst Müller					
Admission requirements Recommended previous knowledge: Basic understanding of chemical concepts is recommended, as well as previous knowledge of chemical reaction engineering or chemical process engineering					
Learning outcome, core skills Knowledge of the main chemical-technological conversion processes for closed carbon cycles, sustainable use and utilization of renewable raw materials and renewable raw material sources. Ability to fundamentally simulate and evaluate reactor models with regard to boundary conditions and large-scale implementation. Understanding of the use of (pseudo)homogeneous and heterogeneous catalytic reactions on a large-industrial scale and the applicable framework conditions. After successful completion of the module, students • Master the basics of the process engineering design of reactors for different chemical reactions, in particular heterogeneous catalytic reactions for chemical processes in closed carbon cycles, • Determine kinetic data for the design of reactors from reaction engineering measurements, • Competently apply (pseudo)homogeneous and heterogeneous reactor models for different reactions and accelerated approaches in order to optimally select and design chemical reactors in terms of process technology under production engineering specifications and economic boundary conditions, • Can use simulation programs for this purpose and integrate them effectively into the engineering work flow.					
Contents a) • Resources for closed carbon cycles, use and utilization of renewable raw materials and sustainable raw material sources. • Renewable raw materials, including CO₂, biomass, biochar as a feedstock for chemical production. • Renewable carbon-based feedstock for energy generation. • Chemical processes for closed carbon cycles, industrial applications, processes and value chains, selected processes. • Transport phenomena in heterogeneous catalytic reactions and in multiphase systems. • Micro- and macro-kinetics of different reaction systems, especially heterogeneous catalytic reactions. • Apparatus for (pseudo)homogeneous and heterogeneous catalytic reactions.					

• Setting up of calculation modules with MATLAB or comparable software for calculating, graphically representing and optimizing physicochemical processes in chemical reactors.
Educational form / Language a) Lecture (2 WLH) / Tutorial (2 WLH) / English
Examination methods • Written exam 'Chemical Processes for Closed Carbon Cycles' (120 min., Part of modul grade 100 %) During the tutorial, students may complete coursework during the semester, in particular a short scientific presentation and discussion on a selected topic related to the course content. These activities may be rewarded with bonus points of up to 20 % of the points achievable in the written exam. The bonus points are added to the exam score. Bonus points cannot compensate for a failed written exam. Students are not entitled to the awarding of bonus points.
Requirements for the award of credit points Passed final module examination: written exam
Module applicability • MSc. Mechanical Engineering • MSc. Sales Engineering and Product Management • MSc. Environmental Engineering
Weight of the mark for the final score Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.
Further Information

Circular Economy, Bioeconomy and Biomimetics: Nature as a Model?					
Circular Economy, Bioökonomie und Bionik: Natur als Vorbild?					
Module number 139180	Credits 5 CP	Workload 150 h	Semester[s] ab dem 1. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Circular Economy, Bioeconomy and Biomimetics: Nature as a Model?			Contact hours a) 3 WLH (45 h)	Self-study a) 105 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Manfred Renner a) Dr. rer. nat. Thomas Marzi					
Admission requirements Recommended previous knowledge: Interesse an interdisziplinären Perspektiven auf ingenieurwissenschaftliche Themen					
Learning outcome, core skills Das übergeordnete Lernziel des Moduls ist, die Studierenden in die Lage zu versetzen, eine kritische, disziplinenübergreifende Reflexion umweltwissenschaftlicher Themen vorzunehmen. Die Teilnehmenden lernen am Beispiel der Bioökonomie, Circular Economy und Bionik Denkmuster zu erkennen, die die Konzepte prägen. Ihre Einschätzung können sie begründet vertreten. Im Kurs lernen die Studierenden Konzepte der Circular Economy, Bioökonomie und Bionik kennen. Anschließend wissen sie, wie sie sich entwickelt haben, was sie trennt und was sie verbindet. Sie erfahren mehr über ihre theoretischen Grundlagen und darüber, welche Vorstellungen sie prägen. Darüber hinaus erhalten die Studierenden einen Zugang zu technik- und naturphilosophischem Denken, das sie auf die Ingenieurs- und Naturwissenschaften anwenden. Eine weitere Perspektive, die die Studierenden kennenlernen ist die der Systemwissenschaften. Technik, Ökonomie und Natur begegnen ihnen dabei als Technosphäre, Biosphäre und Ökosysteme.					
Contents a) Der anthropogene Ressourcenverbrauch gefährdet heute sowohl Menschen als auch andere Lebewesen. In den letzten Jahrzehnten wurde deshalb eine Reihe von Alternativen diskutiert, die sowohl die Art und Weise wie wir wirtschaften betrifft als auch die, wie wir Technik entwickeln. Hierzu gehören u.a. die Circular Economy, die Bioökonomie und die Bionik. Bei der Circular Economy und Bioökonomie handelt es sich um Wirtschaftsmodelle, bei denen Wiederverwertung und nachwachsende Rohstoffe im Vordergrund stehen. Dieser Ansatz ist keineswegs neu. Vor allem die Circular Economy hat ihren Ursprung in ökologisch motivierten Ökonomie-Schulen der 1960er und 70er Jahre. Die Bionik ist im Wesentlichen eine wissenschaftliche Disziplin, die biologische Zusammenhänge auf technische Entwicklungen übertragen möchte. Das scheint vordergründig etwas anderes zu sein als die Circular Economy oder Bioökonomie. Wir werden im Kurs jedoch sehen, dass Zusammenhänge zwischen den Konzepten hergestellt werden. Die Circular Economy, beispielsweise, wird auch aus der Bionik heraus abgeleitet. Material- und Produktkreisläufe sollen nach dem Vorbild natürlicher Kreisläufe geschlossen werden, heißt es dort. Ob es richtig ist, diesen Zusammenhang herzustellen, werden wir im Kurs bewerten.					

Leitmotive, wie die sich am Vorbild Natur zu orientieren, zu erkennen und zu hinterfragen, ist nicht nur von theoretischem Interesse. Die dahinterstehenden Denkmuster sind praktisch außerordentlich relevant, weil sie die Art und Weise prägen, wie wir ökonomische Systeme und Technologien bewerten und wie wir mit der Realität umgehen.

Um die Vorstellungen, die mit der Circular Economy und Bioökonomie verbunden werden, einzuordnen, setzen wir uns im Kurs damit auseinander, was es bedeutet, wenn etwas aus der Natur in einen anderen Zusammenhang übertragen werden soll. Was sind Natur, Technik und Ökonomie überhaupt, unterscheiden sie sich voneinander und wenn ja, worin? Der Kurs berücksichtigt deshalb auch bio- und technikphilosophische Aspekte. Ingenieurinnen und Ingenieure sollten Technik nicht nur entwickeln und anwenden, sondern auch eine Vorstellung davon haben, was Technik eigentlich ist.

Inhalte der Veranstaltung sind:

- Einführung (Hintergründe und Inhalte der Vorlesung, Einführung in die Thematik, Lernziele)
- Bionik, Circular Economy und Bioökonomie
- Wirtschafts-ökologischer Hintergrund (Grenzen des Wachstums)
- Entwicklung der Circular Economy
- Entwicklung bioökonomischer Konzepte
- Denkschulen der Circular Economy und Bioökonomie
- Grundlegende Vorstellungen, die die Konzepte prägen
- Biosphäre und Technosphäre (Was ist Natur?, Was ist Kultur? Was bedeutet die Natur-Kultur-Trennung, Was können wir über die Natur und ihre Naturprinzipien wissen, Was sind Bio- und Technosphäre?)
- Das Vorbild Natur in Bionik, Circular Economy und Bioökonomie
- Übertragungen aus der Natur? (Metaphern, Analogien und Modellübertragung)
- Das Kreislaufmotiv (historische Entwicklung, Kreislaufmodelle)
- Kreisläufe in der Bioökonomie und Circular Economy.
- Wieviel Kreislauf ist möglich?

Educational form / Language

a) Lecture with tutorial / German

Examination methods

- Mündliche Prüfung (Grundsätzlich kann die Prüfungsleistung semesterbegleitend oder in der vorlesungsfreien Zeit erbracht werden. Sie besteht im letzteren Fall in einer mündlich präsentierten Hausarbeit.)

Requirements for the award of credit points

Bestandene Modulabschlussprüfung: mündliche Prüfung

Module applicability

M.Sc. Umweltingenieurwesen

M.Sc. Maschinenbau

M.Sc. Sales Engineering and Product Management

Weight of the mark for the final score

Percentage of total grade [%] = $5 \cdot 100 \cdot \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Der Kurs enthält sowohl Vorlesungs- als auch Übungselemente. Bei Letzteren lesen wir beispielsweise einen Text und diskutieren ihn gemeinsam. Es kann aber auch ein Experiment oder eine Denkaufgabe sein, worüber wir sprechen. Im Vordergrund steht das gemeinsame Nachdenken. Dies erfolgt bestenfalls sowohl zwischen den Studierenden als auch zwischen Studierenden und Dozent.

Circular Process Engineering Circular Process Engineering					
Module number 138320	Credits 5 CP	Workload 150 h	Semester[s] 1./3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Circular Process Engineering			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Manfred Renner a) Dr.-Ing. Philip Biessey					
Admission requirements					
Learning outcome, core skills After successful completion of the module, students will be able to • understand the basic principles and boundary conditions of the Circular Economy and to identify interdisciplinary challenges for circular process engineering • describe the basic principles and operation modes of sustainable technologies and processes for closing material cycles in the process industry • apply the methods presented in the lecture for process balancing and scaling in relation to selected processes and evaluate them regarding established sustainability indicators • identify boundary conditions and limitations of the sustainable technologies and processes considered and derive scenarios for large-scale implementation					
Contents a) The course addresses technologies and processes for closing material cycles in the process industry and thus the transformation of this sector towards a sustainable Circular Economy. For this purpose, recycling technologies for plastics are discussed as examples in-depth. Within the lectures, basic ideas and operation modes of the considered technologies and processes will be presented; based on this, relevant material and heat transfer phenomena as well as the balancing of selected processes will be considered in detail in order to derive scaling strategies and design approaches and to be able to evaluate the technologies in terms of suitable sustainability indicators. • Motivation, concepts and boundary conditions of the Circular Economy for closed material cycles in the process industry • current technologies and processes especially for mechanical, physical and chemical plastics recycling as enablers for a circular economy of plastics • balancing of selected processes and scaling strategies for design • Key figures and methods for sustainability assessment of technologies and processes					
Educational form / Language a) Lecture (2 WLH) / Tutorial (2 WLH) / English					
Examination methods Portfolio exam in the form of two assignments during the semester (each accounting for 10% of the module grade) and a group project including written documentation (accounting for 60% of the module grade) and					

a final presentation (accounting for 20% of the module grade). The individual components are assessed separately for each participant. All components must be passed. Compulsory attendance (80% attendance required to pass).

Requirements for the award of credit points

- Passed module exam: Portfolio exam.
- All semester exercises must be passed.
- Sufficient attendance.

Module applicability

- MSc. Mechanical Engineering
- MSc. Sales Engineering and Product Management
- MSc. Umweltingenieurwesen

Weight of the mark for the final score

Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

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Further Information

Communication for civil engineers Communication for civil engineers					
Module number W14	Credits 2 CP	Workload 60 h	Semester[s] ab dem 2. Sem.	Duration Semester[s]	Group size 20
Courses a) Communication for civil engineers (128404)			Contact hours a) 2 WLH (30 h)	Self-study a) 30 h	Frequency a) each summer
Module coordinator and lecturer(s) M.A. Julia Salzinger a) M.A. Julia Salzinger					
Admission requirements Recommended previous knowledge: Level B2 (Common European Framework of Reference for Languages)					
Learning outcome, core skills Students • enhance their language skills in technical areas. • practise expressing technical content using appropriate technical vocabulary for experts. • learn to express technical contexts in simple language for non-specialists. • will be enabled to act in the foreign language with a view to their future professional activities. • can work on a manageable task conceptually and independently in technical English within a given time frame. • can discuss subject-related content.					
Contents a) In the seminar, participants practice talking about specialist topics with experts and non-experts in regard to their future professional life. Pair and group work, TED talks and discussions integrated in the course.					
Educational form / Language a) Seminar / German / English					
Examination methods • Compulsory attendance 'Communication for civil engineers - Compulsory attendance' (ungraded, Attendance at least 75% of the appointments, Preliminary requirement for participation in the oral examination) • Oral exam 'Communication for civil engineers' (15 min., Part of modul grade 100 %, Presentation)					
Requirements for the award of credit points • Passed module final exam: Written exam • Attendance at at least 75% of the appointments					
Module applicability • BSc. Civil Engineering • MSc. Civil Engineering • BSc. Environmental Engineering • MSc. Environmental Engineering					

Weight of the mark for the final score

Percentage of total grade [%] = $2 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Additional material will be provided on Moodle.

Computer Aided Process Design Computer Aided Process Design (Beispiele der simulationsgestützten Prozessentwicklung)					
Module number 138605	Credits 5 CP	Workload 150 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Computer Aided Process Design			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marcus Grünewald a) Dr.-Ing. Maria Polyakova					
Admission requirements Recommended previous knowledge: basic knowledge in Aspen Plus® or other flowsheet simulation tool in chemical engineering					
Learning outcome, core skills After successful completion of the module, students are able to • Develop processes for the manufacture of chemical products and assess their impact on the environment and society, • Identify the necessary information needs for these tasks, find sources of information, and obtain the relevant information, • Implement a complex process in common flowsheet simulation environment (Aspen Plus®), perform simulations and critically evaluate their results using parameter and sensitivity analysis, and derive further need for action from the results, • Familiarize themselves independently and systematically with new tasks in a short period of time.					
Contents a) The course teaches simulation methods for complex processes in the chemical industry. In particular, the following topics are addressed: • Tasks of and requirements for successfully implement and run process simulations, • Simulation types and their advantages and disadvantages, • Criteria for selecting models to represent common unit operations, as well as the required data basis and limitations of the models, • Solution strategies for complex recycle loops, • Process analysis tools such as sensitivity analysis, design specs and optimization, • Simulation-based options for heat and resource integration, • Analysis and preparation of simulation data for the presentation of relevant results.					
Educational form / Language a) Lecture (2 WLH) / Tutorial (2 WLH) / German / English					
Examination methods • Oral exam 'Computer Aided Process Design' (45 min., Part of modul grade 100 %, in small groups)					

Requirements for the award of credit points

Passed final module exam: Oral examination in small groups

Module applicability

- MSc. Mechanical Engineering
- MSc. Sales Engineering and Product Management
- MSc. Umweltingenieurwesen

Weight of the mark for the final score

Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Computer Simulation of Fluid Flow Computersimulation von Fluidströmungen					
Module number 138500	Credits 5 CP	Workload 150 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Computersimulation von Fluidströmungen			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr. Francesca di Mare a) Dr.-Ing. David Engelmann					
Admission requirements Recommended previous knowledge: fundierte Kenntnisse der: Mathematik, insbesondere Differentialrechnung (partielle Ableitungen, Taylorreihen-Entwicklung), Integralrechnung, mathematische Operanden; Mechanik, insbesondere Begrifflichkeiten wie Impuls, Kraft und Masse, Newton'sche Gesetze; Thermodynamik, insbesondere Begrifflichkeiten wie Energie, Enthalpie und Entropie, Erster und zweiter Hauptsatz; Grundlagen der Strömungsmechanik, insbesondere laminare und turbulente Strömungen, Funktionsweise von Strömungsmaschinen bzw. Fluidenergiemaschinen					
Learning outcome, core skills Nach erfolgreichem Abschluss des Moduls beherrschen die Studierenden die theoretischen Grundlagen der numerischen Strömungsmechanik für inkompressible Medien. - Die Studierenden sind in der Lage, mit Hilfe der Erhaltungsgleichungen für Masse, Impuls und Energie, Lösungen für strömungsmechanische Fragestellungen zu erarbeiten. - Die Studierenden können die Erhaltungsgleichungen klassifizieren, diskretisieren, iterativ lösen und erkennen geeignete Randbedingungen oder Vereinfachungen. - Die Studierenden sind in der Lage, die Funktionsweise von numerischen Strömungslösern zu analysieren und kritisch zu hinterfragen. - Die Studierenden können numerische Ergebnisse visualisieren, analysieren und anhand von Qualitätskriterien beurteilen.					
Contents a) - Einführung in die CFD - Vergleich von Numerik und Experiment - Historisches zur numerischen Strömungsmechanik - Weg von der strömungsmechanischen Problemstellung zur numerischen Lösung - Vorstellung der Erhaltungsgleichungen (Masse, Impuls, Energie) - Vereinfachungen und Klassifizierung der Erhaltungsgleichungen - Diskretisierung mittels Finite-Differenzen- und Finite-Volumen-Verfahren in Raum und Zeit (inkl. Stabilitätsanalyse und -kennzahlen, Druckkorrekturverfahren und Randbedingungen) für inkompressible Fluide - Gittergenerierung (Netzstruktur und Elementtypen) - Iterationsprozess mit Fokus auf Genauigkeit und Abbruchkriterien - Aufbau von Strömungslösern					

Educational form / Language a) Lecture (3 WLH) / Tutorial (1 WLH) / German
Examination methods • Written exam 'Computersimulation von Fluidströmungen' (120 min., Part of modul grade 100 %)
Requirements for the award of credit points • Bestandene Modulabschlussprüfung: Klausur
Module applicability • MSc. Maschinenbau • MSc. Sales Engineering and Product Management • MSc. Umweltingenieurwesen
Weight of the mark for the final score Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.
Further Information

Data Analysis and Simulation in Traffic Engineering					
Datenanalyse und Simulation im Verkehrswesen					
Module number BI-W46	Credits 2 CP	Workload 60 h	Semester[s] ab dem 1. Sem.	Duration 1 Semester[s]	Group size 30
Courses a) Data Analysis and Simulation in Traffic Engineering			Contact hours a) 2 WLH (30 h)	Self-study a) 30 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Justin Geistefeldt a) Prof. Dr.-Ing. Justin Geistefeldt					
Admission requirements Recommended previous knowledge: Traffic engineering					
Learning outcome, core skills Students have in-depth knowledge of • in processing and analyzing traffic-related data, • in the use of simulation tools for traffic engineering applications.					
Contents a) In the lecture, relevant methods of data analysis and simulation in traffic engineering are presented, which are then applied by the students in computer exercises using practical examples. The focus is on the use of relevant programs to simulate the flow of traffic on motorways and urban roads, taking into account modern traffic control systems (route control systems and traffic lights) as well as the computer-aided processing and analysis of the underlying traffic data. Structure of the lecture: • Data analysis with Excel / VBA (Visual Basic for Applications) • Traffic simulation with VISSIM and Aimsun • Planning of traffic signal controls with CROSSIG					
Educational form / Language a) Lecture (2 WLH) / German					
Examination methods • Term paper 'Data Analysis and Simulation in Traffic Engineering' (10 h., ungraded)					
Requirements for the award of credit points • Passed module final exam: written exam					
Module applicability • M. Sc. Environmental Engineering • M. Sc. Civil Engineering					
Weight of the mark for the final score Percentage of total grade [%] = 0, ungraded					
Further Information					

Durability and Repair of Concrete Structures Dauerhaftigkeit und Instandsetzung von Betonbauwerken					
Module number BI-WP13/UI-WPC6	Credits 6 CP	Workload 180 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Durability and Repair of Concrete Structures			Contact hours a) 4 WLH (60 h)	Self-study a) 120 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. habil. Iurie Curosu a) Prof. Dr.-Ing. habil. Iurie Curosu					
Admission requirements Recommended previous knowledge: Knowledge of construction materials and building physics					
Learning outcome, core skills The students • can explain the diverse effects of the environment on the durability of concrete structures. • can derive prophylactic measures and illustrate approaches to service life assessment. • are able to develop suitable measures to increase the durability of new structures in advance, to investigate any damage that occurs and to design suitable repair concepts.					
Contents a) The physical and chemical effects from the environment and their possible effects on concrete structures are presented (exposure classes, concrete and reinforcement corrosion). In particular, the transport processes within the microstructure and the corrosion processes are discussed. • Potential impacts • Transport of pollutants • Corrosion processes • Prophylactic measures • Probabilistic lifetime design In the event of damage, the structural analyses required for a diagnosis, including suitable test methods, are first presented. Furthermore, appropriate repair measures, in particular the choice of suitable construction materials and repair systems, including their application limits, are explained. Design aspects of the repair and upgrading of concrete structures are also discussed. • Structural investigations and testing methods • Development of repair concepts and repair measures for special design features, e.g. reinforcements In the laboratory exercises, the durability-relevant examination methods and selected repair concepts developed in the lectures are carried out and explained.					
Educational form / Language a) Lecture (3 WLH) / Tutorial (1 WLH) / German					
Examination methods					

• Written exam 'Durability and Repair of Concrete Structures' (90 min., Part of modul grade 100 %)
Requirements for the award of credit points • Passed written examination of the module
Module applicability • M.Sc. Civil Engineering • M.Sc. Environmental Engineering
Weight of the mark for the final score Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.
Further Information

Demand and Supply in Energy Markets Demand and Supply in Energy Markets					
Module number 138190	Credits 5 CP	Workload 150 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Demand and Supply in Energy Markets			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr. rer. pol. Valentin Bertsch a) Prof. Dr. rer. pol. Valentin Bertsch, Dr. Silke Johanneiter					
Admission requirements Recommended previous knowledge: Recommended prior knowledge: Basic knowledge of energy economics, such as that covered in the B.Sc. module Energy Economics. Furthermore, solid prior knowledge of investment appraisal is advantageous. For participation in the exercises, a (mobile) computer with a spreadsheet program (e.g. Excel) is advantageous.					
Learning outcome, core skills After successful completion of this module the students are able to: • name different types of energy markets and explain their purpose and functionality. • name the main technological, socio-economic and political drivers of energy demand and explain how they each change energy demand over time or between energy carriers. • assess how the expansion of renewable energy sources, energy efficiency and energy systems integration across sectors and scales impact energy demand and supply within and across energy carriers. • apply the concepts learnt to complex case studies, analyse and interpret the corresponding results and draw conclusions for the transformation of the energy system. • work independently in project groups and present results of their group work in an understandable way. Moreover, the students will have • developed the ability to think in a networked and critical way and are able to select and apply established methods and procedures, • acquired in-depth and interdisciplinary methodological competence and are able to apply it in a situationally appropriate manner. The students practice scientific learning and thinking and can • develop complex problems in technical systems in a structured way and solve them in an interdisciplinary way using suitable methods, • transfer knowledge/skills to concrete systems engineering problems.					
Contents a) - Basics of economics - Fundamentals of energy markets - Energy demand: • Energy demand by sector and energy carriers at global and regional level					

• Bottom-up analysis of energy demand • Top-down analysis of energy demand - Energy supply: • Investment appraisal • Investing in supply expansion - Group work on complex case studies focussing on how policy, regulation and markets affect energy demand (between sectors, over time) and supply During the lecture and exercise, students work in project groups on concrete case studies, prepare a written paper and present their results at the end of the term.
Educational form / Language a) Lecture (2 WLH) / Project / Tutorial (2 WLH) / English
Examination methods • Project report 'Demand and Supply in Energy Markets' (80 h., Part of modul grade 100 %, group work consisting of a written report, presentation and data/model code and documentation – details will be announced at the beginning of the semester) Course-related tasks: Group work (40 hours, deadlines will be announced at the beginning of the semester) (If the group work is completed before the final module exam, optional bonus points are possible for the exam).
Requirements for the award of credit points • Passed written exam (Note: The grade is based on the written exam only) • Successful completion of the group work (details will be announced at the beginning of the semester)
Module applicability • MSc. Mechanical Engineering • MSc. Sales Engineering and Product Management • MSc. Umweltingenieurwesen
Weight of the mark for the final score Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.
Further Information

Design of roads, material models and practical aspects in road construction technology Dimensionierung, Stoffmodelle und Praxisaspekte in der Straßenbautechnik					
Module number BI-WP28/UI-WPC1	Credits 6 CP	Workload 180 h	Semester[s] 3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Design and material models in road construction b) Road construction internship c) Seminar on road construction			Contact hours a) 3 WLH (45 h) b) 1 WLH (15 h) c) 1 WLH (15 h)	Self-study a) 60 h b) 15 h c) 30 h	Frequency a) each winter b) each winter c) each winter
Module coordinator and lecturer(s) Vertr.-Prof.'in Dr.-Ing. Nina Nytus a) Vertr.-Prof.'in Dr.-Ing. Nina Nytus b) Vertr.-Prof.'in Dr.-Ing. Nina Nytus c) Vertr.-Prof.'in Dr.-Ing. Nina Nytus					
Admission requirements Recommended previous knowledge: Pavement Construction and Maintenance or Environmental Engineering in Pavement Construction					
Learning outcome, core skills After successfully completing the module, students will be able to • select, apply and evaluate the material models required for the dimensioning of a road superstructure, • apply the experimental laboratory tests required for the material models themselves and verify and evaluate the test results obtained, • generate and defend the construction contract processes (specifications, quotation and post-calculation) that are important for the practical handling of road construction measures in small groups.					
Contents a) In this lecture series, basic knowledge of mix design and the dimensioning of traffic routes is imparted. The following aspects are highlighted as essential components: • Fundamentals of traffic loads, construction methods and load-bearing capacity • Material models for predicting asphalt performance based on mix properties • Dimensioning of the subgrade and unbound layers • Dimensioning of asphalt roads • Dimensioning of concrete roads • Dimensioning of paving and slab pavements • Special features of airfield construction b) In the form of a laboratory practical lasting several days, students are taught elementary knowledge of asphalt testing technology. The laboratory tests shown in the road construction practical course serve as a					

basis for the dimensioning of asphalt and thus illustrate the elements learnt in the course Dimensioning and material models in road construction. The following content is covered during the practical course:

- Determination of specific parameters of aggregates
- Conventional and performance-orientated test methods for binders
- Requirements for asphalt and asphalt mix production in the laboratory
- Test methods for determining asphalt performance
- Proctor and CBR tests and aggregate composition of unbound layers

c)

After the presentation of the necessary work steps for the realisation of a road construction project by external experts, the students should work on the following contents in small working groups during the seminar:

- Preparation of a bill of quantities based on a practical example
- Carrying out work preparation for a practical example
- Partial calculation of a construction site
- Preparation of a final report
- Presentation of the results

Educational form / Language

a) Lecture (2 WLH) / Tutorial (1 WLH) / German

b) Internship / German

c) Seminar / German

Examination methods

- Written exam 'Design of roads, material models and practical aspects in road construction technology' (120 min., Part of modul grade 100 %, written examination on a) and b) (120 minutes))
- Internship 'Practical training for road construction' (15 h., Part of modul grade 0 %, minutes of the practical course)
- Term paper 'Traffic Infrastructure Engineering - Seminar' (30 h., Part of modul grade 0 %, seminar paper (submission deadline will be announced at the beginning of the semester))

Requirements for the award of credit points

- Passed final module examination: Written examination on a) and b)
- b) Three passed protocols
- c) Passed seminar paper

Module applicability

- M.Sc. Environmental Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Railway engineering Eisenbahnwesen					
Module number BI-W53	Credits 2 CP	Workload 60 h	Semester[s] ab dem 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Railway engineering			Contact hours a) 2 WLH (30 h)	Self-study a) 30 h	Frequency a) each summer
Module coordinator and lecturer(s) Vertr.-Prof.'in Dr.-Ing. Nina Nytus a) Vertr.-Prof.'in Dr.-Ing. Nina Nytus					
Admission requirements The module cannot be selected if BI-WP29 " Digitalisation in road construction and the basics of railway engineering" is taken.					
Learning outcome, core skills After successfully completing this module, students will be able to design and assess the geometric, mechanical and dynamic properties that are important for the routing, construction and operation of railway tracks.					
Contents a) The course deals with the basic knowledge of railway engineering. In detail, it deals with • the legal foundations, • the economic and social significance of railways in the transport sector, • the superstructure, • the switches, • route design, • aspects of driving dynamics, • and the basics of railway operation					
Educational form / Language a) Lecture (1 WLH) / Tutorial (1 WLH) / German					
Examination methods • Written exam 'Railway engineering' (60 min., Part of modul grade 100 %)					
Requirements for the award of credit points • Passed module final examination: written exam					
Module applicability • M.Sc. Civil Engineering • M.Sc. Environmental Engineering					
Weight of the mark for the final score Percentage of total grade [%] = $2 \cdot 100 \cdot \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.					
Further Information					

Energy Storage Technologies and Applications Energiespeichertechnologien und -anwendung					
Module number 139030	Credits 5 CP	Workload 150 h	Semester[s] 1./3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Energiespeichertechnologien und -anwendung			Contact hours a) 60 h	Self-study a) 90 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Christian Doetsch a) Prof. Christian Doetsch					
Admission requirements Recommended previous knowledge: keine					
Learning outcome, core skills Nach dem erfolgreichen Abschluss des Moduls • kennen Studierende die meistverwendeten sektoralen und cross-sektoralen Energiespeicher, ihre Vor- und Nachteile und Grenzen. • verstehen Studierende warum spezielle Technologien in bestimmten Anwendungen eingesetzt werden und können diesen Einsatz qualitativ bewerten • können Studierende das Wissen in der Form anwenden, dass sie selbständig geeignete Technologien für verschiedenen Einsatzszenarien vorschlagen können, sie können Energiespeicher dimensionieren, wichtige Kenngrößen berechnen und die Anwendung quantitativ bewerten.					
Contents a) Die Vorlesung vermittelt einen anwendungsorientierten Überblick über das gesamte Feld der Energiespeicherung. Aufbauend auf den Grundlagen der Speicherung und der Energiesysteme sowie der Rolle von Speichern in denselben, werden drei Technologiebereiche abgedeckt: Elektrische Speichersysteme (auf Basis mechanischer, elektrischer, elektrochemischer Speicherung/Wandlung, Thermische Speichersysteme und Chemische Speichersysteme. Darüber hinaus noch Märkte und Business Cases für Energiespeichersystemen in verschiedenen Anwendungen sowie die techno-ökonomische Situation dieser. Im Detail werden folgende Themen adressiert: Grundlagen der Energiebereitstellung/Speicherung, Elektrische Speicher (Pumpspeicher, Druckluftspeicher, Supercaps, Supraleitende magnetische Spulen, Lithium-/Blei-Batterien, Flow-Batterien); thermische Speicher (sensible, latente etc.); chemische Speicher (Wasserstoff, Methan, andere Fluide); Märkte für Speicher und Bewertung verschiedener Anwendungen unter techno-ökonomischen Gesichtspunkten.					
Educational form / Language a) Lecture (2 WLH) / Tutorial (2 WLH) / German / English					
Examination methods • Written exam 'Energiespeichertechnologien und -anwendung' (120 min., Part of modul grade 100 %)					
Requirements for the award of credit points Bestandene Modulabschlussprüfung: Klausur					
Module applicability					

no information

Weight of the mark for the final score

Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Die Veranstaltung zählt als online-Veranstaltung gemäß HDVO.

Energy Systems Analysis Energy Systems Analysis					
Module number 139170	Credits 5 CP	Workload 150 h	Semester[s] 1./3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Energy Systems Analysis			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr. rer. pol. Valentin Bertsch a) Prof. Dr. rer. pol. Valentin Bertsch					
Admission requirements Recommended previous knowledge: Recommended prior knowledge: Basic knowledge of energy economics, such as that covered in the B.Sc. module Energy Economics. Furthermore, solid prior knowledge in operations research as well as investment appraisal are advantageous. Exercises are organised as computer tutorials. If possible, these take place in the CIP pool(s) on campus. If students want to work on the exercises outside the CIP pool hours, they need a (mobile) computer on which they can install an open-source energy system model, which is provided by the chair.					
Learning outcome, core skills After successful completion of this module the students are able to • name categories of energy systems models and explain the methodological concepts behind the different categories. • explain and apply approaches for generating energy systems model input data in a structured way. • apply selected methods and models to practical problems (e.g. unit commitment optimisation). • interpret results from energy systems models and draw conclusions to support decision making. • discuss strengths and weaknesses of the methods and models used and to discuss and derive potential for improvement. Moreover, the students will have • developed the ability to think in a networked and critical way and are able to select and apply established methods and procedures, • acquired in-depth and interdisciplinary methodological competence and are able to apply it in a situationally appropriate manner. The students practice scientific learning and thinking and can • develop complex problems in technical systems in a structured way and solve them in an interdisciplinary way using suitable methods, • transfer knowledge/skills to concrete systems engineering problems.					
Contents a) Modelling and Simulation of Energy Systems • Introduction and overview of energy systems analysis					

- Fundamental optimisation models for power systems analysis
 - Optimal unit commitment (short-term planning)
 - Optimal capacity expansion (long-term planning)
- Scenario planning approaches
 - Introduction to scenario planning
 - Combination of scenario planning and power systems analysis
- Investment appraisal
- Selected case studies

Decision Analysis and Assessment of Strategies

- Types of decision environments and models
- Structuring decision problems
 - Generating objectives and hierarchies
 - Generating and preselecting alternatives
- Preference elicitation
- Aggregation functions and sensitivity analysis
- Selected case studies

During the exercises, students work on concrete case studies using an open source energy systems model to be installed on their (mobile) computers, and practise preparing input data, processing model results and drawing conclusions.

Educational form / Language

a) Lecture (3 WLH) / Tutorial (1 WLH) / English

Examination methods

- Written exam 'Energy Systems Analysis' (90 min., Part of modul grade 100 %, onsite or online)
- Assignments accompanying the course: Computer tutorials / exercises (details will be announced at the beginning of the semester).

Requirements for the award of credit points

- Passed written exam (Note: The grade is based on the written exam only)
- Successful completion of the computer exercises (details will be announced at the beginning of the semester)

Module applicability

- MSc. Mechanical Engineering
- MSc. Sales Engineering and Product Management
- MSc. Umweltingenieurwesen

Weight of the mark for the final score

Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Design of Urban Traffic Facilities Entwurf von Verkehrsanlagen					
Module number UI-W1	Credits 3 CP	Workload 90 h	Semester[s] ab dem 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Entwurf von Verkehrsanlagen (124007)			Contact hours a) 2 WLH (30 h)	Self-study a) 60 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Justin Geistefeldt a) Prof. Dr.-Ing. Justin Geistefeldt					
Admission requirements					
Learning outcome, core skills Die Studierenden • verfügen über grundlegende Kenntnisse der Zusammenhänge in der Bauleitplanung und dem Entwurf von Stadtstraßen, • sind in der Lage, Standardaufgaben nachzuvollziehen und selbstständig zu bearbeiten, • können die Qualität von Verfahren des Straßenentwurfs beurteilen.					
Contents a) Gegenstand der Vorlesung sind der Entwurf und die verkehrsgerechte Gestaltung von Anlagen des Straßenverkehrs einschließlich des öffentlichen Personennahverkehrs, vorwiegend für den städtischen Bereich. Im Einzelnen werden behandelt: • Flächennutzungsplan und Bebauungsplan • Querschnitte von Straßen • Entwurf von plangleichen Knotenpunkten • Anlagen für den Fuß- und Radverkehr • Anlagen für den ruhenden Verkehr Die technischen Grundlagen für die Gestaltung der Verkehrsanlagen werden in den Vorlesungen behandelt und anhand der Zielsetzungen Sicherheit, Leistungsfähigkeit, Umweltverträglichkeit und Wirtschaftlichkeit diskutiert. In den Übungen werden Entwurfstechniken an praktischen Beispielen geübt.					
Educational form / Language a) Lecture (1 WLH) / Tutorial (1 WLH) / German					
Examination methods • Oral exam 'Entwurf von Verkehrsanlagen' (45 min., Part of modul grade 100 %, Rechenteil 20 Min., Fragenteil 25 Min.)					
Requirements for the award of credit points • Bestandene Modulabschlussprüfung: Mündliche Prüfung					
Module applicability • M.Sc. Umweltingenieurwesen • B.Sc. Umweltingenieurwesen					

Weight of the mark for the final score

Percentage of total grade [%] = $3 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Das Modul BI-14 „Verkehrsplanung und Verkehrstechnik“ oder eine zum Teil „Entwurf von Verkehrsanlagen“ des Moduls BI-14 äquivalente Leistung darf nicht gleichzeitig belegt werden oder im zugangsrelevanten Bachelorstudium belegt worden sein.

Interdisciplinary Project Fachübergreifendes Projekt					
Module number UI-PA1	Credits 6 CP	Workload 180 h	Semester[s] 1.-3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Fachübergreifendes Projekt (129110)			Contact hours	Self-study a) 180 h	Frequency a) each sem.
Module coordinator and lecturer(s) Alle Professorinnen und Professoren des Studiengangs a) Alle Professorinnen und Professoren des Studiengangs					
Admission requirements					
Learning outcome, core skills Die Studierenden • sollen unter Anleitung zum selbstständigen wissenschaftlichen Arbeiten in einem Fach aus dem Umweltingenieurwesen befähigt werden, • sind in der Lage internationale Literatur zu recherchieren und diese zu verstehen, • können bei der dazugehörigen Präsentation, fachliche Themen passend aufarbeiten und verständlich präsentieren, • sollen in die Lage versetzt werden, die Zusammenhänge des Faches zu überblicken und die Fähigkeit zu erlangen, Probleme des vertieften Fachgebietes mit wissenschaftlichen Methoden zu bearbeiten sowie wissenschaftliche Erkenntnisse anzuwenden, Die Projektarbeit dient als qualifizierende Vorbereitung zur Master-Arbeit.					
Contents a) Die Projektarbeit kann theoretisch, praktisch, konstruktiv oder auch organisatorisch ausgerichtet sein. Das Thema wird vom Prüfenden formuliert, die Kandidatin / der Kandidat hat dabei ein Vorschlagsrecht. Es ist möglich die Projektarbeit in einem externen Unternehmen zu schreiben. In dem Fall übernimmt die fachliche Betreuung und Bewertung das externe Unternehmen. Der betreuende Lehrstuhl steht administrativ zur Seite und übernimmt die Bewertung der wissenschaftlichen Ausfertigung. Die Ergebnisse sind im Detail in schriftlicher und bildlicher Form darzustellen. Dazu gehören insbesondere auch eine Zusammenfassung und ein Ausblick sowie eine Kurzfassung, eine Gliederung und ein Verzeichnis der in der Arbeit verwendeten Literatur.					
Educational form / Language a) Project / German / English					
Examination methods • Term paper 'Interdisciplinary Project' (180 h., Part of modul grade 100 %, mit Präsentation)					
Requirements for the award of credit points • Bestandene Projektarbeit • Abgelegte Präsentation					
Module applicability • M.Sc. Umweltingenieurwesen					

Weight of the mark for the final score
Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.
Further Information

Foundation Engineering and Utility Pipe Construction: Design – Engineering – Technologies

Foundation Engineering and Utility Pipe Construction: Design – Engineering – Technologies

Module number BI-WP10/SE-CO-1	Credits 6 CP	Workload 180 h	Semester[s] ab dem 1. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Design, engineering and technologies in Foundation Engineering and Utility Pipe Construction			Contact hours a) 4 WLH (60 h)	Self-study a) 120 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Markus Thewes a) Prof. Dr.-Ing. Markus Thewes, Dr.-Ing. Britta Schößler					
Admission requirements Recommended previous knowledge: Bachelor-level knowledge of construction operations and construction process engineering, Bachelor-level knowledge of foundation engineering and soil mechanics					
Learning outcome, core skills The module intends to provide students with a comprehensive understanding of the field of design, engineering and technology regarding Foundation Engineering and Utility Pipe construction. They will acquire in-depth knowledge for special areas of foundation engineering for the accomplishment of engineering tasks on areas planning, construction and operation. Foundation engineering is the field of civil engineering, which deals with the design and construction of subsurface structures which typically are built in open excavation pits. The students will learn to work on tasks from these areas and to develop an understanding of the methods. They will be enabled to independently solve the common problems of foundation engineering and utility pipe construction. Connections of this field with other areas of the building industry as interdisciplinary task are recognized and integrated into the solutions of project processing. The students acquire knowledge that is necessary for the preparation and processing of construction projects in construction management. The methods commonly used in practice shall be applied.					
Contents a) The lecture deals with the extended basic knowledge of construction process engineering.					
Design, engineering and technologies in Foundation Engineering • Dewatering / Water management • Construction pit system (Girder System, Diaphragm Wall, Bored Pile Wall, etc.) • Caisson systems • Grout injection techniques (low and high pressure methods, etc.) • Injected piles • Underpinning • Cut and Cover method • Conventional sealing methods (waterproofing) • Construction of jointing					

- Open trench methods in Pipeline Construction

Pipeline Construction (Trenchless Construction Techniques - unmanned)

- Technical principals of unmanned techniques – steerable
- Technical principals of unmanned techniques – non-steerable
- HDD Horizontal Directional Drilling, Direct Pipe

Educational form / Language

a) Lecture (2 WLH) / Tutorial (2 WLH) / English

Examination methods

- Written exam 'Design, engineering and technologies in Foundation Engineering and Utility Pipe Construction' (120 min., Part of modul grade 100 %, optionally English or German)
- Term paper 'Process Technology and Construction Management - Homework' (30 h., Part of modul grade 0 %, optionally English or German)

Requirements for the award of credit points

- Presentation of the results of the homework assignment
- Passed written examination of the module

Module applicability

- M.Sc. Civil Engineering
- M.Sc. Environmental Engineering
- M.Sc. Subsurface Engineering
- M.Sc. Geosciences

Weight of the mark for the final score

Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Global Water Resources Globale Wasserressourcen					
Module number BI-W37	Credits 3 CP	Workload 90 h	Semester[s] ab dem 1. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Global Water Resources			Contact hours a) 1 WLH (15 h)	Self-study a) 75 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Martina Flörke a) Prof. Dr.-Ing. Martina Flörke					
Admission requirements Recommended previous knowledge: Knowledge of deterministic hydrology, water management					
Learning outcome, core skills Students • learn how to work with scientific publications in the English language and develop an in-depth understanding of descriptive and analytical concepts relating to the issue of global water resources • evaluate knowledge of water availability, shortages or surpluses in terms of their temporal and spatial distribution in different regions of the world and are able to critically discuss the concepts used • analyse global, large-scale interrelationships between climate, globalization, and water budget and can classify small- and large-scale differences • present their findings in summaries and presentations in English (optionally in German) to the other participants and learn scientific discourse.					
Contents a) The overuse of global water resources is already presently shaping the earth's appearance. The seminar deals with the descriptions and developments of approaches for a consistent and comprehensive evaluation of the state of global water resources and the associated ecosystems. The topics are addressed under the aspects of water management and political relevance and are intended to complement the courses "Hydrology" and "Sustainable Water Resources Management." The seminar will focus on topics that change annually. The following content will be covered: • Introduction to Internet-based literature research and computer-assisted literature management • Compilation of fundamental scientific publications on current water management topics (e.g., conflicts of use, transboundary river basins, long-distance effects) • Conducting literature research individually • Leading a scientific discussion, as is customary at conferences, for example.					
Educational form / Language a) Seminar / German					
Examination methods • Seminar 'Global Water Resources' (30 h., Part of modul grade 100 %)					

- Writing a summary of the topic (max. 2 pages) in English (15 hours, deadline to be announced at the beginning of the semester)
- Presentation on the topic (20 minutes) and Discussion (10 minutes) (15 hours, date to be announced at the beginning of the semester)
- Summary of the discussion (Report)

Requirements for the award of credit points

- Passed module final exam (writing a summary of the topic, presentation on the topic, discussion, and summary of the discussion)

Module applicability

- M.Sc. Civil Engineering
- M.Sc. Environmental Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $3 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

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Further Information

Individual or group work (2 people) depending on the number of participants

High Pressure Process Technology Hochdruckverfahrenstechnik					
Module number 136290	Credits 5 CP	Workload 150 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Hochdruckverfahrenstechnik			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marcus Grünewald a) Dr. rer. nat. Sabine Kareth					
Admission requirements Recommended previous knowledge: Thermodynamik					
Learning outcome, core skills Nach dem erfolgreichen Abschluss des Moduls • kennen die Studierenden den Stand der Forschung zu Hochdrucksystemen und Hochdruck-Phasengleichgewichten sowie die modernsten Methoden und Verfahren im Bereich der thermo- und fluiddynamischen Stoffdatenermittlung in der Hochdruckverfahrenstechnik. • können die Studierenden Hochdruckphasengleichgewichte interpretieren. • haben die Studierenden die Fähigkeit zu vernetztem, kritischem und interdisziplinärem Denken ausgebaut und sind in der Lage die speziellen Eigenschaften von Hochdrucksystemen zu nutzen, etablierte Methoden und Verfahren auszuwählen und auf komplexe verfahrenstechnische Problemstellungen anzuwenden. • können die Studierenden die gewonnenen Erkenntnisse auf konkrete und neue Problemstellungen übertragen und so das Verhalten von Stoffgrößen wie z.B. Viskosität, Grenzflächenspannung und Dichte von Reinstoffen und Gemischen unter hohen Drücken beurteilen.					
Contents a) In der Vorlesung Grundlagen der Hochdruckverfahrenstechnik werden zunächst die speziellen Eigenschaften von Hochdrucksystemen vorgestellt. Schwerpunkte sind Thermo- und Fluiddynamik von Einkomponenten- und Mehrkomponentensystemen sowie entsprechende Berechnungsverfahren. Die Kenntnis dieser Eigenschaften ist für die ingenieurtechnische Gestaltung von Gesamtverfahren essentiell. Dieser Zusammenhang wird anhand von Beispielen aus dem Gebiet der Kältetechnik und der Hochdruckverfahrenstechnik (Extraktion, Adsorption, Absorption, Kristallisation) verdeutlicht.					
Educational form / Language a) Lecture (3 WLH) / Tutorial (1 WLH) / German					
Examination methods • Oral exam 'Hochdruckverfahrenstechnik' (30 min., Part of modul grade 100 %)					
Requirements for the award of credit points Bestandene Modulabschlussprüfung: mündliche Prüfung					
Module applicability					

- BSc. Maschinenbau
- MSc. Umweltingenieurwesen

Weight of the mark for the final score

Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

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Further Information

Hydrogen Technologies Hydrogen Technologies					
Module number 138020-139260	Credits 5 CP	Workload 150 h	Semester[s] ab dem 2. Sem.	Duration 2 Semester[s]	Group size no limitation
Courses a) Hydrogen Technologies I: Production and Storage b) Hydrogen Technologies II: Synthetic Fuels and Basic Chemicals			Contact hours a) 2 WLH (30 h) b) 2 WLH (30 h)	Self-study a) 45 h b) 45 h	Frequency a) each summer b) each winter
Module coordinator and lecturer(s) Prof. Thomas Ernst Müller a) Prof. Dr.-Ing. Ralf Peters b) Prof. Dr.-Ing. Ralf Peters					
Admission requirements Recommended previous knowledge: none					
Learning outcome, core skills After successfully completing the module, students can • describe the basic principles and functionality of current technologies and processes for the production and use of hydrogen, • apply the methods presented in the lecture for the design of electrolysis systems. • identify the necessary boundary conditions, possible applications and limits of the technologies and processes under consideration and, within the framework of the energy transition, derive possible scenarios for large-scale implementation, • assess the contribution of water electrolysis to the energy transition from technological, ecological and economic aspects. • describe the basic principles and functionality of current technologies and processes for the production and use of synthetic fuels and chemicals in the Power-to-X process chains, • apply the methods presented in the lecture for the design of Power-to-X systems, • identify the necessary boundary conditions, possible applications and limits of the technologies and processes under consideration and, within the framework of the energy transition, derive possible scenarios for large-scale implementation					
Contents a) The hydrogen technologies course includes the theoretical foundations and technical development for topics such as electrolysis, chemical energy conversion and fuel cells in the field of electrochemical and chemical process engineering, which are crucial for the successful implementation of the energy transition in research and development in the coming decades. The Hydrogen Technologies I course focuses on the topics of hydrogen production, storage, transport and direct use of hydrogen.					

As part of the lecture, the underlying concepts and basic functionality of the technologies and processes under consideration are presented. Building on this, the electrochemical and chemical conversion steps are discussed in detail, relevant material and heat transfer phenomena are considered, initial model equations are derived in order to derive design approaches for technical implementation and to evaluate the technologies in terms of future value chains for hydrogen. The components electrolysis and fuel cells play an important role.

- Motivation, concepts and boundary conditions for the production and use of hydrogen and synthesis gas as well as other electrochemically produced intermediate products as part of the energy transition
- Balancing electrochemical conversion processes and deriving relevant equations for the design of electrolyzers and fuel cells
- Scaling of processes and technical structures from electrocatalyst and component research, process engineering analysis and process development to the technical representation of subsystems and systems on a technical scale up to integration into pilot plants
- Scientific and technical fundamentals of SOC technology for electrolysis and fuel cell operation including design, construction and operation as well as scale-appropriate integration into existing real-world laboratories
- Storage technologies and transport options for hydrogen
- Methodical approaches from modeling and simulation, analytics as well as manufacturing methods and apparatus technology that can be derived from the system technology orientation

b)

The **Hydrogen Technologies II** course focuses on the topics of hydrogen use for power-to-fuel and power-to-chemicals process chains.

As part of the lecture, the basic ideas and functionality of the technologies and processes under consideration are presented. Building on this, the chemical conversion steps are discussed in detail, relevant material and heat transfer phenomena are considered, initial model equations are derived in order to derive design approaches for technical implementation and to evaluate the technologies in terms of future value chains for synthetic fuels and sustainably produced chemicals.

Possible process chains are: the use of hydrogen and CO₂ for dynamic and decentralized methanol production (CH₃OH), the transport of CH₃OH and H₂ from preferred regions to Europe, the refining there using processes such as MtG (methanol-to-gasoline) and MtO (methanol-to-gasoline). to-olefins) to alkenes (chemical industry) and higher alcohols. Methanol-to-kerosene and methanol-to-diesel processes will provide liquid but sustainably produced fuels for various transport applications in the future

- Motivation, concepts and boundary conditions for the production and use of hydrogen, synthetic fuels and sustainably produced chemicals as part of the energy transition
- Process engineering aspects of the use of hydrogen and synthesis gas as well as other electrochemically produced intermediate products and CO₂ to produce synthetic fuels and chemicals. This may be done using CO₂ from biomass, from industrial process gases and, in the long term, by separating it from the air. Keywords: Power-to-X, Power-to-Fuel, Power-to-Chem.
- Balancing chemical conversion processes and deriving relevant equations for the design of synthesis reactors and peripheral components such as pumps, compressors and heat exchangers
- Process conditions and reactor design to achieve relevant throughputs with high thermomechanical integrity of components in thermocatalytic (membrane) reactors with elevated process temperatures and under high pressure. Increased integration of the development of membrane and multiphase reactors for process intensification

- Scaling of processes and technical structures from catalyst and component research, process engineering analysis and process development to the technical representation of subsystems and systems on a pilot scale to integration into pilot plants.
- Methodical approaches from modeling and simulation, analytics as well as manufacturing methods and apparatus technology that can be derived from the system technology orientation.

Educational form / Language

a) Lecture (2 WLH) / English

b) Lecture (2 WLH) / English

Examination methods

- Written exam 'Hydrogen Technologies' (90 min., Part of modul grade 100 %, in case of number of participants lower than 10 the examination may be conducted orally)

Requirements for the award of credit points

Passed final module exam: Written exam or oral exam

Module applicability

M. Sc. Maschinenbau

M. Sc. Umweltingenieurwesen

Weight of the mark for the final scorePercentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

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Further Information

In addition to the classic form of in-person lectures, short practical examples are offered as part of the lecture. In addition, at the end of the lecture, smaller mini-projects will be worked on - possibly as group work - which will then be presented online to the entire lecture course. Consultation by appointment.

The lecture counts as online lecture according to HDVO.

Hydrology Hydrologie					
Module number BI-WP34/UI-WPD2	Credits 6 CP	Workload 180 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Deterministic hydrology/modeling technology b) Hydrometry practical seminar			Contact hours a) 3 WLH (45 h) b) 1 WLH (15 h)	Self-study a) 60 h b) 60 h	Frequency a) each summer b) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Martina Flörke a) Prof. Dr.-Ing. Martina Flörke b) Prof. Dr.-Ing. Martina Flörke					
Admission requirements Recommended previous knowledge: Knowledge of advanced mathematics, fluid mechanics, fundamentals of hydrology, and water management					
Learning outcome, core skills Students • acquire fundamental knowledge of the most important procedures and methods for establishing hydrological statements on a deterministic basis • learn the methodological basics of modelling using exemplary applications and design mathematical models to solve hydrological and water management problems • evaluate independently collected data using measurement methods for hydrological and hydraulic variables in the laboratory and in the field • independently adopt a professional perspective and devise application-oriented problems and solutions.					
Contents a) The course deals with procedures and methods for determining the available water supply and for recording and describing the runoff process in catchment areas and river sections on a causal-deterministic basis. Furthermore, deterministic models from the field of hydrological engineering and water management are discussed. The following topics are covered in detail: • Recording and describing the spatial heterogeneity of climatic factors • Physical principles for describing the groundwater balance • Accounting for the combined effects of soil and vegetation in evaporation calculations • Methods for calculating the regional water budget and groundwater recharge • Description of runoff formation during flooding • Runoff concentration models: translation approaches, storage-translation models, • Flood wave propagation models for river courses: translation-diffusion models, numerical solution with simplified Saint-Venant equations (kinematic wave) • Methodology for flood assessment on a deterministic basis • Scaling problems: measurement scales, process scales and model scales					

- Examples of precipitation-runoff models, water balance models
- Methods for model calibration and validation
- Model and parameter uncertainties.

b)

The practical course focuses on the use of hydrological measuring instruments in the laboratory and in the field. The course takes place in groups that carry out and evaluate measurements several times during the semester under supervision.

Specifically, these include:

- Flow measurements: use of the current meter for flow velocity measurements, salt dilution measurements
- Soil moisture measurements with TDR probes
- Permeability measurements, Darcy experiment
- Measurement of infiltration capacity using the double ring infiltrometer
- Operation and evaluation of rain gauges.

The lecture is divided into two main areas: the description of the water balance, considering the complex interactions of climatic, pedological and vegetation-specific factors, and methods for calculating floods in catchment areas and river sections.

In the practicals, the various methods are studied using practical examples. Computer exercises are necessary to master the modelling techniques. Various models with corresponding data sets are available for this purpose, which can be used by students in the faculty's CIP pool.

Educational form / Language

a) Lecture (2 WLH) / Tutorial (1 WLH) / German

b) Internship / German

Examination methods

- Term paper 'Hydrometry practical seminar' (30 h., Part of modul grade 0 %, submission deadline to be announced at the beginning of the semester)
- Written exam 'Hydrology' (90 min., Part of modul grade 100 %)

Optional Moodle online test to assess learning progress and earn bonus points (5 hours, starting halfway through the semester)

Optional online Moodle quiz to assess learning progress and earn bonus points (5 hours, halfway through the semester)

Requirements for the award of credit points

- Passed module final exam: Written exam
- Passed term paper (hydrometry practical)

Module applicability

- M.Sc. Civil Engineering
- M.Sc. Environmental Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $6 \cdot 100 \cdot \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Hydrological Processes Hydrologische Prozesse					
Module number BI-W38	Credits 3 CP	Workload 90 h	Semester[s] ab dem 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Hydrological Processes			Contact hours a) 1 WLH (15 h)	Self-study a) 75 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Martina Flörke a) Dr. rer. nat. Hans Dürr					
Admission requirements Recommended previous knowledge: Knowledge of deterministic hydrology, mass transport in catchment areas					
Learning outcome, core skills Students • learn how to work with scientific publications in English and develop an in-depth understanding of concepts for describing and analyzing hydrological processes • evaluate knowledge from various subject areas and can critically discuss the methods used • present their findings in summaries and lectures in English (optionally in German) to the other participants and learn scientific discourse.					
Contents a) The seminar deals with hydrological theories and process descriptions in addition to the courses 'Hydrology' and 'Material Transport in Catchment Areas'. The topics change annually. The following content will be covered: • Introduction to internet-based literature research and computer-assisted literature management • Development of fundamental scientific publications on different theories (benchmark papers) • Conducting literature research individually • Leading a scientific discussion, as is customary at conferences, for example.					
Educational form / Language a) Seminar / German / English					
Examination methods • Seminar 'Hydrological Processes' (30 h., Part of modul grade 100 %) • Writing a summary of the topic (max. 2 pages) in English (15 hours, Deadline to be announced at the beginning of the semester) • Presentation on the topic (20 minutes) and Discussion (10 minutes) (15 hours, date to be announced at the beginning of the semester) • Summary of the discussion (Report)					
Requirements for the award of credit points • Passed module final exam (writing a summary of the topic, presentation on the topic, discussion, and summary of the discussion)					

Module applicability

- M.Sc. Civil Engineering
- M.Sc. Environmental Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $3 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

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Further Information

Individual or group work (2 people) depending on the number of participants

Innovations in Urban Water Management and Mathematical Simulation Innovationen in der Siedlungswasserwirtschaft und mathematische Simulation					
Module number BI-WP38/UI-WPD6	Credits 6 CP	Workload 180 h	Semester[s] 2./3. Sem.	Duration 2 Semester[s]	Group size no limitation
Courses a) Innovations in Urban Water Management b) Simulation of Wastewater Treatment Plants c) Computer Lab: Simulation Models			Contact hours a) 2 WLH (30 h) b) 1 WLH (15 h) c) 2 WLH (30 h)	Self-study a) 60 h b) 15 h c) 30 h	Frequency a) each winter b) each summer c) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marc Wichern a) Prof. Dr.-Ing. Marc Wichern b) Dr.-Ing. Manfred Lübken c) Dr.-Ing. Manfred Lübken					
Admission requirements Recommended previous knowledge: Siedlungswasserwirtschaft					
Learning outcome, core skills The students • are familiar with new procedures and methods for planning and optimisation of systems in urban water management. • have the ability to define relevant measures for climate protection, energy issues and sustainability in the context of urban water management, • have the ability to critically assess these systems and to evaluate and reflect on research findings in this area, • are able to transfer findings from urban water management to specific and new problems, • know the basics of dynamic simulation in wastewater treatment and can relate their knowledge to practical applications in wastewater treatment, • know how established mathematical models are used to model key processes and process variables in biochemical wastewater treatment, • have an overview of the possibilities of using simulation and dimensioning models in biochemical wastewater treatment, • are able to create model plants and validate them based on practical case studies.					
Contents a) The course deals with research-relevant topics such as • Energy consumption and greenhouse gases on wastewater treatment plants • Sustainable systems and closed cycles • Energy generation from wastewater and renewable raw materials • new processes of nitrogen elimination (deammonification) • pathways from wastewater to drinking water • Aerobic granules and the use of biofilm processes					

- Elimination of trace substances

b)

The course focuses on

- a detailed understanding of the chemical, physical and microbiological processes of modern wastewater treatment, which are realised by efficient technical engineering systems.
- the presentation of methods required for the development of simulation models.

c)

In the course

- static and dynamic simulation models for wastewater treatment plants are explained.
- the SIMBA# programme is used as simulation software for this purpose.
- the relevant biochemical processes and hydraulic aspects of municipal wastewater treatment are described in the mathematical models.
- the implementation and calibration of models and sample calculations support the understanding of wastewater treatment processes.

Educational form / Language

a) Lecture (2 WLH) / German

b) Lecture (1 WLH) / German

c) Tutorial (2 WLH) / German

Examination methods

- Oral exam 'Innovations in Urban Water Management and Mathematical Simulation' (60 min., Part of modul grade 100 %, Oral exam every semester)
- Term paper 'Computer exercise Simulation models' (15 h., Part of modul grade 0 %, Submission each semester)

Requirements for the award of credit points

- Passed module final exam: oral exam
- Passed report on computer exercise
- Attendance: for c) will be announced at the beginning of the semester

Module applicability

- M.Sc. Civil Engineering
- M.Sc. Environmental Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

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Further Information

This module can be recognized as part of the RUB sustainability certificate.

Integrated High-Pressure Methods Integrierte Hochdruckverfahren					
Module number 137600	Credits 5 CP	Workload 150 h	Semester[s] 3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Integrierte Hochdruckverfahren			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marcus Grünewald a) Dr. rer. nat. Sabine Kareth					
Admission requirements Recommended previous knowledge: keine					
Learning outcome, core skills Nach dem erfolgreichen Abschluss des Moduls • verstehen die Studierenden industrielle Hochdrucksynthesen (z.B. Polyethylensynthese, Ammoniaksynthese) und deren integrierte Prozessführung. • verstehen die Studierenden Verfahren zur Standardisierung von Lebensmittelprodukten (z.B. Hochdruckextraktion) und moderne Hochdruckverfahren zur Herstellung von Mikropartikelsystemen (z.B. PGSS, CPF, RESS, GAS). • sind die Studierenden in der Lage die thermo- und fluiddynamischen Grundlagen zur Planung und Auslegung von Hochdruck-Prozessen zu benutzen. • können die Studierenden die Verfahren zur Erzeugung von Mikropartikeln in ihrer Anwendbarkeit auf neue Produkte bewerten. • können die Studierenden geeignete Verfahren kombinieren und somit mögliche neue integrierte Hochdruckverfahren entwerfen.					
Contents a) In der Vorlesung Integrierte Hochdruckverfahren werden moderne Entwicklungen auf dem Gebiet der Naturstofftechnologie, der Herstellung und Verarbeitung von Polymeren, der Lebensmitteltechnologie und der Pharmazie vorgestellt. Die Vorteile der Anwendung erhöhter Drücke im Rahmen von Gesamtprozessen werden erläutert. Ferner werden spezielle Gesichtspunkte und Randbedingungen der Verfahrensentwicklung vermittelt. Hierzu zählen z.B. die Berücksichtigung der Bedürfnisse des Verbrauchers, der sorgfältige und schonende Umgang mit Ressourcen, betriebliche und volkswirtschaftliche Sicherheitsaspekte und das Verständnis für Entscheidungsabläufe oder Anforderungen hinsichtlich geschlossener Stoffkreisläufe und „life-cycle“ Betrachtungen für die erzeugten Produkte.					
Educational form / Language a) Lecture (3 WLH) / Tutorial (1 WLH) / German					
Examination methods • Oral exam 'Integrierte Hochdruckverfahren' (30 min., Part of modul grade 100 %)					
Requirements for the award of credit points Bestandene Modulabschlussprüfung: mündliche Prüfung					

Module applicability

- MSc. Maschinenbau
- MSc. Sales Engineering and Product Management
- MSc. Umweltingenieurwesen

Weight of the mark for the final score

Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

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Further Information

International Wastewater Treatment, Industrial Wastewater Treatment and River Water Quality Internationale Siedlungswasserwirtschaft, industrielle Abwasserreinigung und Gewässergüte					
Module number BI-WP37/UI-WPD4	Credits 6 CP	Workload 180 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) International Wastewater Treatment b) Industrial wastewater treatment c) River Water Quality			Contact hours a) 2 WLH (30 h) b) 1 WLH (15 h) c) 1 WLH (15 h)	Self-study a) 60 h b) 30 h c) 30 h	Frequency a) each summer b) each summer c) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marc Wichern a) Prof. Dr.-Ing. Marc Wichern b) Prof. Dr.-Ing. Burkhard Teichgräber c) Prof. Dr.-Ing. Marc Wichern					
Admission requirements Recommended previous knowledge: Urban water management					
Learning outcome, core skills The students • have a comprehensive overview of the current state of technology and science in the field of international urban water management, • know adapted technical solutions for drinking water treatment and wastewater treatment in other European countries as well as the basics for calculating and operationally optimising these processes, • are familiar with integrated processes for wastewater treatment and know why cycle-orientated processes play an important role. • are familiar with the special features of industrial wastewater and have a comprehensive overview of the current state of the art in the field of biological wastewater treatment, • are familiar with processes for pre-treatment and chemical treatment of industrial wastewater, • are able to develop solutions and plan holistic concepts. • know the characteristics of the material balance of water bodies and understand the biochemical turnover processes involved, • know what influence selective and diffuse discharges of wastewater have on water quality • are able to assess water quality on the basis of the EU-WRRL • are familiar with models to describe the condition of water bodies and are able to critically assess the results, • are able to recognise water body problems, develop integrative solutions and improve the status of water bodies in accordance with the EU-WRRL					
Contents a) The course addresses the development of solutions for drinking water treatment and wastewater purification in the context of challenges faced in non-European countries. These include:					

- Development of sustainable concepts and utilisation of wastewater as a resource
- Utilisation of methods for the evaluation of sustainable solutions
- In-depth consideration and operational optimisation of various internationally used process technologies such as activated sludge processes, anaerobic technology, soil filters and pond systems.
- Development of solutions for drinking water treatment and resource-conserving waste management

b)

The course provides an overview of processes in industrial wastewater treatment. Topics include:

- Special features of biological treatment including the pre-treatment of industrial wastewater for discharge into the public sewerage system
- Chemical treatment of special industrial wastewater
- Explanation of special aerobic and anaerobic wastewater treatment options using selected examples.

c)

The course provides an insight into the ecological principles of water bodies, water characteristics and the material balance. The following topics are covered in detail:

- Impairment of water bodies through the discharge or impact of pollutants
- Modelling the quality of water bodies and developing solutions to improve water quality
- Methods for the integrative consideration of water bodies, sewers, sewage treatment plants and agriculture and the development of solutions

Educational form / Language

a) Lecture (1 WLH) / Tutorial (1 WLH) / German

b) Lecture (1 WLH) / German

c) Lecture (1 WLH) / German

Examination methods

- Written exam 'International Wastewater Treatment, Industrial Wastewater Treatment and River Water Quality' (150 min., Part of modul grade 100 %)

Requirements for the award of credit points

- Passed module final exam: Written exam

Module applicability

- M.Sc. Civil Engineering
- M.Sc. Environmental Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $6 \cdot 100 \cdot \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Nuclear Power Plants Engineering Kernkraftwerkstechnik					
Module number 137130	Credits 5 CP	Workload 150 h	Semester[s] 3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Kernkraftwerkstechnik			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marco K. Koch a) Prof. Dr.-Ing. Marco K. Koch					
Admission requirements Recommended previous knowledge: Grundlagen der Werkstofftechnik, Grundlagen der Thermo- und Fluidodynamik					
Learning outcome, core skills Die Studierenden verfügen über grundlegende Kenntnisse der Reaktortypen, innovativer Reaktorkonzepte und die geschlossene Darstellung der Reaktorsicherheit. Sie können exemplarisch den Stand moderner ingenieurwissenschaftlichen Forschung sowie die modernsten Methoden und Verfahren der Ingenieurwissenschaften einschätzen und anwenden. Sie können das entsprechende Fachvokabular interpretieren. Nach dem erfolgreichen Abschluss des Moduls • lösen Studierende komplexe mathematische Problemstellungen in physikalischen Systemen fachübergreifend mit geeigneten Methoden, • differenzieren Studierende Erkenntnisse und übertragen diese auf konkrete und neue Problemstellungen, • validieren Studierende die komplexen ingenieurtechnischen modellierten und gelösten Probleme zu eigenen Ansätzen, • wählen Studierende durch die Fähigkeit zu vernetztem und kritischem Denken die etablierten Methoden und Verfahren aus und modifizieren diese, • verifizieren Studierende vertiefte, auch interdisziplinäre Methodenkompetenzen.					
Contents a) • Klassifizierung der Reaktortypen nach ihren Merkmalen und wirtschaftlich-technischen Einsatzfähigkeit als Kraftwerksreaktoren, • Vorstellung der internationalen Entwicklungen sowie evolutionäre und innovative Reaktorkonzepte, • Beschreibung des konstruktiven Aufbaus des Reaktorkerns und der -kühlkreisläufe sowie die wärmetechnischen Aspekte der einzelnen Reaktortypen, • Diskussion über die Anlagenbereiche außerhalb des eigentlichen Reaktors unter Berücksichtigung der radiologischen und anlagentechnischen Gesichtspunkte, • Erläuterungen der Einrichtungen zu Wechsel und Lagerung der Brennelemente im Rahmen des Brennstoffkreislaufs,					

- Erläuterung der geschlossenen Darstellung der Reaktorsicherheit, die Funktion der verschiedenen Strahlungsbarrieren, insbesondere die Funktion des Containments,
- Diskussion der Sicherheitsforderungen und -maßnahmen.

Educational form / Language

a) Lecture (3 WLH) / Tutorial (1 WLH) / German

Examination methods

- Written exam 'Kernkraftwerkstechnik' (90 min., Part of modul grade 100 %)

Requirements for the award of credit points

Bestandene Modulabschlussprüfung: Klausur

Module applicability

- MSc. Maschinenbau
- MSc. Sales Engineering and Product Management
- MSc. Umweltingenieurwesen

Weight of the mark for the final score

Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Climate-Resilient Urban Planning Klimaresilienter Städtebau					
Module number BI-W76	Credits 2 CP	Workload 60 h	Semester[s] ab dem 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Climate-Resilient Urban Planning			Contact hours a) 1 WLH (15 h)	Self-study a) 45 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Justin Geistefeldt a) Dr.-Ing. Sandra Hohmann					
Admission requirements Recommended previous knowledge: Design of transportation facilities					
Learning outcome, core skills Students are able to • develop a qualitative understanding of the impacts of climate change on urban areas and the underlying relationships and processes, • demonstrate in-depth knowledge of the role of urban greening for microclimate regulation and of water-sensitive urban design as an approach to climate adaptation, • understand the challenges of soil sealing and apply techniques for de-sealing urban surfaces, • become familiar with concepts such as Blue-Green Streets as well as sustainable and participatory urban planning approaches, • examine practical case studies to understand different urban planning and mobility concepts and transfer these insights to other contexts.					
Contents a) The course provides strategies for how cities can adapt to the impacts of climate change. It focuses on nature-based solutions such as urban greening, water-sensitive urban design, and the de-sealing of surfaces to improve the urban climate and enhance resilience. In addition, innovative concepts such as Blue-Green Streets and sustainable mobility strategies are addressed. A key aspect of the module is interdisciplinary and participatory urban planning, which promotes active community involvement. International case studies are used to illustrate successful implementations in different cities.					
Educational form / Language a) Lecture (1 WLH) / German					
Examination methods • Term paper 'Climate-Resilient Urban Planning' (30 h., Part of modul grade 100 %, Term paper with presentation and final discussion)					
Requirements for the award of credit points • Passed module final exam: Term paper with presentation and final discussion					
Module applicability • M.Sc. Civil Engineering • M.Sc. Environmental Engineering					

Weight of the mark for the final score

Percentage of total grade [%] = $2 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Literature:

- Richtlinien für die Anlage von Stadtstraßen (RASt). Forschungsgesellschaft für Straßen- und Verkehrswesen (Hrsg.), 2006.
- Ergänzende Handlungsanleitungen zur Anwendung der RAST 06. Forschungsgesellschaft für Straßen- und Verkehrswesen (Hrsg.), 2024.

Contact-Based Sensors for Structural and Environmental Monitoring					
Kontaktierende Sensorik für Bauwerks- und Umweltmonitoring					
Module number BI-W77	Credits 3 CP	Workload 90 h	Semester[s] ab dem 1. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Contact-Based Sensors for Structural and Environmental Monitoring			Contact hours a) 2 WLH (30 h)	Self-study a) 60 h	Frequency a) each winter
Module coordinator and lecturer(s) Dr.-Ing. Christoph Baer a) Dr.-Ing. Christoph Baer					
Admission requirements Recommended previous knowledge: Basic knowledge of mathematics, physics, and engineering fundamentals at bachelor's level is recommended. Prior knowledge of electrical engineering or measurement technology is helpful but not required.					
Learning outcome, core skills Students acquire fundamental knowledge of the design, operating principles, and applications of contact-based sensor systems in civil and environmental engineering. Upon successful completion of the module, students will be able to: • describe and analyse measurement chains from the physical quantity being measured to digital data processing, • understand fundamental principles of signal conditioning and signal digitization, • assess typical error sources, uncertainties, and interference effects in measurement systems, • select appropriate sensors for different monitoring tasks in structural and environmental applications, • critically interpret measurement results with regard to their significance and limitations, • apply contact-based sensors for measuring mechanical, thermal, and environmental parameters in structures and infrastructure systems.					
Contents a) • Fundamentals of measurement chains and instrumentation systems • Electrical fundamentals of sensor systems • Signal conditioning and digitization of measurement signals • Measurement errors, uncertainty analysis, calibration, and long-term stability • Strain gauges for strain and stress measurements • Pressure sensors for monitoring structures, pipelines, and water infrastructure • Flow sensors for applications in water and environmental systems • Temperature and humidity sensors for structural and environmental monitoring • Inductive and capacitive displacement sensors for deformation and settlement measurements • MEMS-based acceleration and inclination sensors for vibration and structural condition monitoring • Selection, design, and evaluation of sensor systems for monitoring applications					
Educational form / Language					

a) Lecture with tutorial / German

Examination methods

- Oral exam 'Contact-Based Sensors for Structural and Environmental Monitoring' (30 min., Part of modul grade 100 %, Participation in the expert-group format may be considered as a bonus component.)

Requirements for the award of credit points

- Successful completion of the oral module examination

Module applicability

- M.Sc. Civil Engineering
- M.Sc. Environmental Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $3 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

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Further Information

- Lectures with integrated problem-solving and conceptual exercises
- Demonstration experiments using selected sensor technologies
- Analysis and interpretation of exemplary measurement data

Optionally, an expert-group format is offered in which student teams work on an advanced sensor topic and present their topic at the end of the semester.

Air Quality Luftqualität					
Module number 139230	Credits 5 CP	Workload 150 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Luftqualität			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marcus Petermann a) Dr.-Ing. Stefan Pollak					
Admission requirements					
Learning outcome, core skills Nach dem erfolgreichen Abschluss des Moduls • sind die Studierenden mit den Fachtermini der Luftqualität und denen der angrenzenden Disziplinen vertraut. • verstehen die Studierenden die technischen Funktionsprinzipien sowohl der Luftreinigung als auch der Messtechnik von Luftschadstoffen und können diese auf Beispiele anwenden. • sind die Studenten in der Lage, eine Messreihe sinnvoll zu planen, vorzubereiten, auszuführen und die Ergebnisse zu bewerten und darzustellen. • beherrschen die Studierenden das Protokollieren und Aufbereiten von Messergebnissen. Sie können eigene experimentelle Ergebnisse präsentieren und wissenschaftlich diskutieren.					
Contents a) Im Kampf gegen die Umweltverschmutzung stehen die Reinhaltung der Luft und Erhaltung einer guten Luftqualität mehr denn je im Fokus des Interesses. Verschmutzte Luft wirkt sich in vielfältiger Weise auf die menschliche Gesundheit, die Ökosysteme und Materialien aus. Das Seminar „Luftqualität“ soll diese Komplexität an Zusammenhängen darstellen und analysieren. Hierfür wird zunächst das Medium Luft betrachtet und dessen Bedeutung für anderen Disziplinen besprochen. Berechnungen von relevanten Parametern, verschiedene Luftschadstoffe und Atemgifte werden ebenfalls behandelt. Anschließend werden sowohl medizinische Grundlagen zum Aufbau und Funktion der Lunge als auch Krankheiten, resultierend aus einer vermehrten Exposition mit Luftschadstoffen, erörtert. Einen Schwerpunkt des Seminars bilden die verschiedenen Arten von Luftfiltern sowie die technischen Aspekte der Luftfilterung an sich. Ergänzt wird das Seminar durch Exkurse z.B. zu Prüfstäuben und Transportprozessen in der Atmosphäre. Die Veranstaltung „Luftqualität“ ist in zwei Teile gegliedert: Teil 1: Die erste Hälfte des Semesters findet im Format einer Vorlesung statt. In diesem Zeitraum wird mit den Studenten ein Thema vereinbart, das in Kleingruppen erarbeitet werden muss. Dieses Thema kann praktische Arbeiten, z.B. das Erfassen von Messwerten, enthalten. Teil 2:					

Die zweite Hälfte der Veranstaltung wird als Seminar gestaltet. Die Studierenden präsentieren ihr Forschungsthema und ihre Ergebnisse ihren Kommilitonen. Die Ergebnisse werden anschließend im Plenum wissenschaftlich diskutiert.

Educational form / Language

a) Lecture (2 WLH) / Tutorial (2 WLH) / German

Examination methods

- Oral exam 'Luftqualität' (45 min., Part of modul grade 100 %, in Form einer Präsentation eines Forschungsthemas im Bereich „Luftqualität“ (Anteil an der Modulnote 100 %))

Requirements for the award of credit points

- Bestandene Modulabschlussprüfung: Mündliche Prüfung

Module applicability

MSc. Umweltingenieurwesen

Weight of the mark for the final score

Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Die Teilnehmerzahl ist begrenzt, die Anmeldung findet in der ersten Vorlesung statt.

Management of Non-Renewable and Renewable Resources					
Management nicht-erneuerbarer und erneuerbarer Ressourcen					
Module number 139513	Credits 3 CP	Workload 90 h	Semester[s] 1./3. Sem.	Duration 1 Semester[s]	Group size 25
Courses a) Management nicht-erneuerbarer und erneuerbarer Ressourcen			Contact hours a) 2 WLH (30 h)	Self-study a) 60 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Manfred Renner a) Dr.-Ing. Hartmut Pflaum					
Admission requirements Recommended previous knowledge: Voraussetzung ist ein Bachelor-Abschluss aus einem naturwissenschaftlich-technischen oder ökonomischen Fachgebiet sein. Systemanalytische Kenntnisse (z. B. Anwendung und Nutzen volkswirtschaftlicher oder verfahrenstechnischer Modelle) sind von Vorteil. Weitere Voraussetzungen sind nicht erforderlich. Die Gruppengröße ist auf 25 begrenzt, da im Rahmen der Vorlesung Gruppenarbeiten durchgeführt werden, die Methoden und Fähigkeiten für die Prüfung vermitteln und einüben.					
Learning outcome, core skills Nach dem erfolgreichen Abschluss des Moduls • kennen und verstehen Studierende globale, nationale und lokale Verfügbarkeiten und Nutzungspfade von nicht-erneuerbaren und erneuerbaren Ressourcen. • können die Studierenden die Bedeutung einer nachhaltigen Ressourcenbewirtschaftung für Wirtschaftssysteme bewerten. • demonstrieren und transferieren Studierende selbständig Grundlagen und Methoden des Stoffstrommanagements auf gegebene Aufgabenstellungen zur industriellen Ressourcenbewirtschaftung. • bewerten und berechnen die Studierenden das Einsatzpotenzial von nicht-erneuerbaren und erneuerbaren Ressourcen für gegebene industrielle Aufgabenstellungen. • konzipieren Studierende erste Konzepte, um Innovationsansätze für bestehende Systeme zur Ressourcenbewirtschaftung zu entwickeln.					
Contents a) Im Rahmen der Vorlesung werden die Grundlagen, Ziele und Methoden des Stoffstrommanagements, der Stoffstromanalyse sowie der Stoffstrombewertung vorgestellt. Dies erfolgt auf der Basis des Konzepts der „nachhaltigen Entwicklung“. Eine Einführung in der Rohstoffbewirtschaftung innerhalb von Wirtschaftssystemen illustriert, wie alle Lebens-/Konsumbereiche von einer intelligenten Rohstoffnutzung profitieren. Im Anschluss werden die Rohstoffpotenziale der nicht-erneuerbaren Ressourcen sowie ihre Bedeutung als stoffliche und/oder energetische Quelle diskutiert. Der nächste Vorlesungsteil widmet sich den Verfügbarkeiten und Bewirtschaftungsgrundsätzen von erneuerbaren Ressourcen. Dabei stehen die Produktion von Biomasse, das nutzbare Ertragspotenzial sowie mögliche Produkte im Vordergrund. Darüber hinaus wird die Rohstoff- und Energiepolitik in					

den internationalen Wirtschaftsbeziehungen verdeutlicht. An konkreten Beispielen wird erläutert, welche Rohstoffinformationen in industriellen Entscheidungsprozessen in welcher Weise verarbeitet werden müssen, um das Ressourcenmanagement unter verschiedenen gegebenen Zielstellungen (z. B. Nachhaltiges Wirtschaften, Reduktion von Treibhausgasen, Reduktion Primärrohstoffeinsatz) optimal zu realisieren. Die Rolle von Innovationen sowie Methoden zur Findung von neuen Ressourcenlösungen in Wertschöpfungsketten wird in diesem Kontext an Beispielen erläutert.

Als Vorlesungsmaterial dienen Präsentationsfolien in elektronischer Form.

Educational form / Language

a) Lecture (2 WLH) / German

Examination methods

- Oral exam 'Management nicht-erneuerbarer und erneuerbarer Ressourcen' (30 min., Part of modul grade 100 %, Selbständig vorbereiteter Vortrag zu einem in der Vorlesung behandelten Fachthema und Fachdiskussion/-fragen)

Anwesenheitspflicht

Requirements for the award of credit points

- Bestandene Modulabschlussprüfung: Mündliche Prüfung
- Präsenz

Module applicability

MSc. Umweltingenieurwesen

Weight of the mark for the final score

Percentage of total grade [%] = $3 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Zwischen dem 1. und 12. Oktober wird eine ca. 45-minütige Vorbesprechung angeboten: Beachten Sie hierzu bitte den Aushang auf der Homepage des Lehrstuhls :<https://rpe.ruhr-uni-bochum.de/>

Im ersten Schritt ist eine Anmeldung beim Dozenten per E-Mail bis spätestens 30. November erforderlich; E-Mail-Adresse: hartmut.pflaum@umsicht.fraunhofer.de

Die Anmeldungen werden in der Reihenfolge ihres Eingangs bearbeitet.

Nach der Teilnahmebestätigung durch den Dozenten per E-Mail kann die Prüfung angemeldet werden.

Eine selbständige Anmeldung bei FlexNow ist nicht möglich.

Master's Thesis Masterarbeit UI					
Module number UI-MA	Credits 30 CP	Workload 900 h	Semester[s] 4. Sem.	Duration 6 Monate	Group size no limitation
Courses a) Masterarbeit UI			Contact hours	Self-study a) 900 h	Frequency a) each sem.
Module coordinator and lecturer(s) Alle Professorinnen und Professoren des Studiengangs a) Alle Professorinnen und Professoren des Studiengangs					
Admission requirements Zur Masterarbeit kann zugelassen werden, wer erfolgreich abgeschlossene Module im Umfang von mindestens 70 LP nachweisen kann.					
Learning outcome, core skills Die Studierenden • sollen unter Anleitung zum selbstständigen wissenschaftlichen Arbeiten in einem Fach aus dem Umweltingenieurwesen befähigt werden, • sind in der Lage internationale Literatur zu recherchieren und diese zu verstehen, • können bei der dazugehörigen Präsentation, fachliche Themen passend aufarbeiten und verständlich präsentieren, • sollen nach der Bearbeitung der Masterarbeit notwendige Fachkenntnisse für den Übergang ins Berufsleben erworben haben, • sind damit in der Lage die Zusammenhänge des Faches zu überblicken und besitzen die Fähigkeit, Probleme des vertieften Fachgebietes mit wissenschaftlichen Methoden zu bearbeiten sowie wissenschaftliche Erkenntnisse anzuwenden.					
Contents a) Die Masterarbeit kann theoretisch, praktisch, konstruktiv oder auch organisatorisch ausgerichtet sein. Das Thema wird vom Prüfenden formuliert, die Kandidatin / der Kandidat hat dabei ein Vorschlagsrecht. Es ist möglich die Masterarbeit in einem externen Unternehmen zu schreiben. In dem Fall übernimmt die fachliche Betreuung und Bewertung das externe Unternehmen. Der betreuende Lehrstuhl steht administrativ zur Seite und übernimmt die Bewertung der wissenschaftlichen Ausfertigung. Die Ergebnisse sind im Detail in schriftlicher und bildlicher Form darzustellen. Dazu gehören insbesondere auch eine Zusammenfassung und ein Ausblick sowie eine Kurzfassung, eine Gliederung und ein Verzeichnis der in der Arbeit verwendeten Literatur.					
Educational form / Language a) Final thesis / German / English					
Examination methods • Final thesis 'Master's Thesis' (900 h., Part of modul grade 100 %, mit abschließender Präsentation)					
Requirements for the award of credit points • Bestandene Abschlussarbeit					

-
- Abgelegte Präsentation

Module applicability

- M.Sc. Umweltingenieurwesen

Weight of the mark for the final score

Percentage of total grade [%] = $30 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Mathematical Statistics Mathematische Statistik					
Module number BI-P02/UI-P1	Credits 5 CP	Workload 150 h	Semester[s] 1. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Mathematical Statistics			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr. Holger Dette a) Prof. Dr. rer. nat. N. Bissantz					
Admission requirements Recommended previous knowledge: Knowledge of advanced mathematics					
Learning outcome, core skills Students acquire in-depth knowledge of essential methods of mathematical statistics closely related to engineering applications.					
Contents a) The lecture begins with a brief review of the fundamentals of probability theory and statistics taught in the Mathematics C lecture. The most important probability distributions and parameter estimation methods are presented. Other topics include goodness-of-fit tests and confidence intervals. From multivariate statistics, multivariate regression and model selection, analysis of variance, principal component analysis, and factor analysis are covered. From the field of extreme value theory, the most important extreme value distributions and the associated parameter estimation methods will be presented. Another chapter covers the fundamentals of time series analysis, including trend and seasonal effect estimation, ARMA models, and spectral analysis. Since the focus is on the practical application of the methods, exercises will be combined with homework assignments, some of which will be completed using the statistical program R.					
Educational form / Language a) Lecture (2 WLH) / Tutorial (2 WLH) / German					
Examination methods - Written exam 'Mathematical Statistics' (90 min., Part of modul grade 100 %, inklusive Multiple Choice Fragen, für die ein Anteil von maximal 50% der Punkte vergeben wird) - Homework (optional): 30 hours of independent study					
Requirements for the award of credit points Passed module final exam: Written exam					
Module applicability - M.Sc. Civil Engineering - M.Sc. Environmental Engineering					
Weight of the mark for the final score Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents.					

DIV: The values can be taken from the table of contents.

Further Information

Mechanical Process Engineering Mechanische Verfahrenstechnik					
Module number 137310	Credits 5 CP	Workload 150 h	Semester[s] 1. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Mechanische Verfahrenstechnik			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marcus Petermann a) Prof. Dr.-Ing. Marcus Petermann					
Admission requirements					
Learning outcome, core skills Nach dem erfolgreichen Abschluss des Moduls • sind die Studierenden mit den Mechanismen und Operationen sowie den vertieften ingenieurwissenschaftlichen Grundlagen der mechanischen Verfahrenstechnik vertraut. • lösen die Studierenden konkrete ingenieurtechnische Problemstellungen mit den Methoden, Erkenntnissen und Fertigkeiten der mechanischen Verfahrenstechnik. • nutzen die Studierenden Prinzipien der mechanischen Verfahrenstechnik, um komplexe mathematische Problemstellungen in Systemen zu bearbeiten. • verfügen die Studierenden über die Fähigkeit zu vernetztem und kritischem Denken und sind in der Lage fachspezifische Grundoperationen kritisch zu hinterfragen.					
Contents a) Die mechanische Verfahrenstechnik beschäftigt sich mit der Erzeugung, der Umwandlung, der Verarbeitung und der Handhabung von feinverteilten („dispersen“) Stoffen. Das Ziel der Vorlesung <i>Mechanische Verfahrenstechnik</i> ist es, einen Einstieg in die verfahrenstechnische Problembehandlung solcher Systeme zu ermöglichen. Aus diesem Grund werden in der Vorlesung die allgemeine Beschreibung von Partikelsystemen und die Funktionsweisen der Partikelmesstechnik behandelt. Ebenso werden das Lager-, Fließ- und Mischverhalten von Schüttgütern erläutert sowie deren Klassifizierung. Die Vorlesungseinheit wird mit einem Praktikum begleitet, in dem die Studierenden anhand eigener experimenteller Arbeiten Grundoperationen der mechanischen Verfahrenstechnik erlernen.					
Educational form / Language a) Lecture (3 WLH) / Tutorial (1 WLH) / German					
Examination methods • Written exam 'Mechanische Verfahrenstechnik' (120 min., Part of modul grade 100 %)					
Requirements for the award of credit points Bestandene Modulabschlussprüfung: Klausur					
Module applicability no information					
Weight of the mark for the final score Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$					

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Stormwater Treatment Misch- und Regenwasserbehandlung					
Module number BI-W36	Credits 3 CP	Workload 90 h	Semester[s] ab dem 1. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Stormwater Treatment			Contact hours a) 2 WLH (30 h)	Self-study a) 60 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marc Wichern a) Dr.-Ing. Klaus Hans Pecher					
Admission requirements Recommended previous knowledge: Urban water management I					
Learning outcome, core skills The students • know the functions and different elements of a sewer network for the discharge of wastewater, • are familiar with analytical and numerical methods for rainfall-runoff-calculations, • are able to name the functions of decentralised and near-natural rainwatertreatment and to dimension the structures, • have a basic understanding of sustainable processes in wastewater treatment.					
Contents a) The course deals with concepts for the planning of sewer networks and stormwater treatment systems. This includes: • Function and structure of individual elements of the sewerage system • Sewer calculation methods • Hydraulic rehabilitation of existing sewer networks • Methods and concepts of decentralised rainwater treatment • Economic efficiency calculations					
Educational form / Language a) Lecture (1 WLH) / Tutorial (1 WLH) / German					
Examination methods • Written exam 'Stormwater Treatment' (60 min., Part of modul grade 100 %)					
Requirements for the award of credit points • Passed module final exam: Written exam					
Module applicability • M.Sc. Civil Engineering • M.Sc. Environmental Engineering					
Weight of the mark for the final score Percentage of total grade [%] = $3 \cdot 100 \cdot \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents.					

DIV: The values can be taken from the table of contents.
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Further Information

Modeling of environmental processes Modellierung umweltrelevanter Prozesse					
Module number UI-P2	Credits 6 CP	Workload 180 h	Semester[s] 1. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Modeling of environmental systems b) Modeling the dispersion of substances in the atmosphere			Contact hours a) 2 WLH (30 h) b) 2 WLH (30 h)	Self-study a) 45 h b) 75 h	Frequency a) each winter b) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marc Wichern a) Dr.-Ing. Manfred Lübken b) Dr.-Ing. Cornelia Kalender					
Admission requirements Recommended previous knowledge: Fluid mechanics					
Learning outcome, core skills Students • will learn the fundamentals and practical applications of dynamic simulation of environmental systems. • have knowledge of how mathematical models are formulated and used and know how essential processes and process variables of various environmental systems are implemented in the models, • are able to understand the mathematical simulation of biochemical processes using examples and to validate and calibrate the models using collected data. • can describe the atmospheric wind near the ground and its influence on the dispersion of substances, and interpret the transport equations necessary for this description. • can characterize various numerical simulation methods for dispersion modeling, apply at least two simulation models in practice, and select a suitable model for environmentally relevant issues, taking various factors into account, • can analyze and evaluate numerical calculation results in the context of current legal regulations on immission control, • organize themselves into small groups and jointly develop and present a subject-related topic					
Contents a) The environment is both a complex and an extremely sensitive system. The perceptible effects of environmental influences often occur with a time lag relative to the external factors that cause them. In order to understand the complex interrelationships and describe the behavior of environmental systems in terms of time and space, mathematical models are formulated and calibrated/validated using collected data. The course covers the following topics: • Dynamic model approaches for describing temporal processes (change of state, growth, decay, inhibition/delay)					

- Model structure and simulation calculations (measurement data collection and analysis, model parameterization, sensitivity analysis, calibration, validation, scenario calculations)
- Mathematical simulation using process examples (adsorption/desorption processes, natural biochemical processes)

b)

- Chain of effects in the air, pollutants (particles, gases), legal background to air pollution control
- Formation of wind, its physical properties, environmental meteorology
- Description of transport processes in wind flow (differential basic equations)
- Various approaches to numerical dispersion modeling using model examples (Gaufte plume models, Gauft puff models, Eulerian grid models, and Lagrangian particle models)
- Practical application of the current Lagrange propagation model AUSTAL2000 from the Technical Guide - Air and application of the multiphysics software ANSYS® CFX in propagation modeling
- Fundamentals of physical dispersion experiments in the boundary layer wind tunnel
- Model theory, sources of error, and uncertainties

Educational form / Language

a) Lecture (1 WLH) / Tutorial (1 WLH) / German

b) Lecture (1 WLH) / Tutorial (1 WLH) / German

Examination methods

- Written exam 'Modeling of environmental processes' (90 min., Part of modul grade 100 %)
- Term paper 'Modeling the dispersion of substances in the atmosphere' (30 h., ungraded, in groups, accompanying the lecture, can be submitted in the winter and summer semesters)

Requirements for the award of credit points

- Passed module final exam: Written exam
- Passed term paper

Module applicability

- M.Sc. Environmental Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $6 \cdot 100 \cdot \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Sustainable Water Resources Management					
Nachhaltige Wasserbewirtschaftung					
Module number BI-WP33/UI-WPD1	Credits 6 CP	Workload 180 h	Semester[s] 3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) River basin management b) Water budget modeling			Contact hours a) 2 WLH (30 h) b) 2 WLH (30 h)	Self-study a) 30 h b) 90 h	Frequency a) each winter b) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Martina Flörke a) Prof. Dr.-Ing. Martina Flörke b) Prof. Dr.-Ing. Martina Flörke					
Admission requirements Recommended previous knowledge: Completed module in Fundamentals of Hydrology and Water Management, Hydrology module					
Learning outcome, core skills Students • apply the fundamentals of water management planning as part of the administration of water resources • demonstrate an interdisciplinary understanding of problems and methodological competence in relation to the application of water budget modelling • independently develop solutions for challenging water management tasks and assess the water balance, considering the complex interactions of climatic, pedological and vegetation-specific factors • can assign and further develop procedures for determining and considering the technical, economic and ecological dimensions of water management measures.					
Contents a) The strain and utilization of water resources and regionally and temporally variable requirements of society for water-dependent conditions require specific procedures and methods for planning, managing and controlling water management facilities. The concept of sustainability, particularly in the context of the UN Sustainable Development Goals, is of growing importance. In detail, the course covers the following topics: • Fundamentals of integrative planning in river basins • Securing water supply (long-term demand planning, assessment of water availability, sustainable water use) • Flood protection planning, structural flood protection, flood prevention, flood damage assessment • Planning fundamentals of low flow management, determination of minimum water flow • Agriculture and water management (agrochemical pollution of water resources, planning of protected areas and reservoirs) • Ecological assessment of water bodies, measures to improve structural quality, ecosystem services • Conflicts of interest, prioritisation of water use • Risk assessment and risk management of extreme events					

- Determination of technical, economic, ecological and social evaluation criteria for water management assessment
- Principles of water law and institutional framework conditions.

b)

The course aims to provide an in-depth understanding of water budget modelling on different scales (from single-reservoir models to 2D approaches). Topics covered include:

- Fundamentals of model development and parameterization
- Fundamentals of model error and uncertainty diagnostics
- Practicals with a hydrological model (e.g., HBV light)
- Preparation and plausibility check of model input data
- Methods for and practical implementation of model calibration and validation
- Quantification of model uncertainty and sensitivity
- Model evaluation.

Computer exercises are required to master the modelling techniques. Various models with corresponding data sets are available for this purpose, which can be used by students in the CIP pool of the faculty. In the practicals, the various methods are explained and applied using real-world examples.

Educational form / Language

a) Lecture (1 WLH) / Tutorial (1 WLH) / German

b) Lecture (1 WLH) / Tutorial (1 WLH) / German

Examination methods

- Term paper 'Sustainable Water Resources Management' (60 h., Part of modul grade 100 %, Presentation of results (20-minute presentation))

Requirements for the award of credit points

- Passed module final exam: Term paper and final presentation of results

Module applicability

- M.Sc. Civil Engineering
- M.Sc. Environmental Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

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Further Information

This module can be recognized as part of the RUB sustainability certificate.

Sustainable operation and resource conservation with urban water management facilities Nachhaltiger Betrieb und Ressourcenschutz bei siedlungswasserwirtschaftl. Anlagen					
Module number BI-WP40/UI-WPB6	Credits 6 CP	Workload 180 h	Semester[s] 3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Sustainable operation of urban water management facilities b) Water reuse			Contact hours a) 2 WLH (30 h) b) 2 WLH (30 h)	Self-study a) 60 h b) 60 h	Frequency a) each winter b) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marc Wichern a) Prof. Dr.-Ing. Marc Wichern b) Dr.-Ing. Manfred Lübken					
Admission requirements Recommended previous knowledge: Urban water management					
Learning outcome, core skills The students • have a comprehensive overview of various technical purification processes in urban water management, • are familiar with various options for operating technical systems for water and wastewater treatment, • know the expected emissions and greenhouse gases that are produced during the operation of urban water management facilities, • know measures to reduce these emissions and GHG in terms of sustainable operation, • are familiar with ways of protecting and reusing recyclable materials, • are able to develop solutions and plan holistic concepts, • know the relevant wastewater treatment strategies in the national and international context of water reuse, • know the hygienic standards and other requirements for irrigation water, • are able to assess possible areas of application for the reuse of treated wastewater, e.g. agricultural, urban or industrial, • can assess risks to the environment and people, taking into account legal requirements, and derive measures to minimise risks.					
Contents a) The course deals with the development of solutions for the sustainable operation of drinking water and wastewater treatment processes. The contents include: • In-depth knowledge and operational optimisation of various process technologies used, such as activated sludge processes, filtration and anaerobic processes, mechanical processes, new technologies • Effect of different operating modes of purification technologies on water-related emissions • Estimation of indirect emissions and GHG depending on the process and mode of operation • Possibilities for sustainable plant operation					

• Solutions for new, holistic process concepts and their operating modes
b) The course deals with the principles and possible applications of water reuse for different users. The contents include: • Relevance of water reuse on a national and international level • In-depth knowledge of the nutrient cycle, resource efficiency and efficient water utilisation • Institutional requirements and risk management • Requirements for proceeding wastewater treatment with the aim of downstream reuse as irrigation water
Educational form / Language a) Lecture (1 WLH) / Tutorial (1 WLH) / German b) Lecture (1 WLH) / Tutorial (1 WLH) / German
Examination methods • Oral exam 'Sustainable operation and resource conservation with urban water management facilities' (40 min., Part of modul grade 100 %)
Requirements for the award of credit points • Passed module final exam: oral exam
Module applicability • M.Sc. Environmental Engineering • M.Sc. Civil Engineering
Weight of the mark for the final score Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.
Further Information This module can be recognized as part of the RUB sustainability certificate.

Sustainable Building Nachhaltiges Bauen					
Module number BI-WP47/UI-WPB3	Credits 6 CP	Workload 180 h	Semester[s] 3. Sem.	Duration 1 Semester[s]	Group size 12
Courses a) Resource-efficient construction b) Sustainability assessment for buildings			Contact hours a) 2 WLH (30 h) b) 2 WLH (30 h)	Self-study a) 60 h b) 60 h	Frequency a) each winter b) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Annette Hafner a) Prof. Dr.-Ing. Annette Hafner b) Prof. Dr.-Ing. Annette Hafner					
Admission requirements Recommended previous knowledge: Knowledge of building construction, knowledge of building physics					
Learning outcome, core skills Students • have basic knowledge in the field of resource-efficient construction and can explain this independently, • have basic knowledge of the environmental considerations of buildings and their demolition options, • can illustrate specific knowledge for engineering and environmental tasks in this field, • independently test and solve common problems related to resource efficiency, taking into account life cycle analysis, • investigate the return of materials to the material cycle and its effects • after successfully completing the module, have basic knowledge of sustainability aspects in construction, • can explain evaluation systems for sustainable buildings • have a basic understanding of the environmental, economic, and socio-functional aspects of buildings, • can establish connections between building structures and sustainability as well as service life • are able to use sustainability assessment systems and apply them to buildings					
Contents a) The course provides a general introduction to the topic of resource-efficient construction and related topics, such as: • Observation and analysis of built examples with regard to resource efficiency criteria • Resource-efficient use of materials • Special consideration of modern timber construction • In-depth investigation of the return of building materials to the material cycle during the demolition phase • Demolition and recycling options in the building sector b)					

A newly constructed building is examined on sustainability aspects. The focus here is on specific evaluation systems

- First, the individual profiles are worked on in small groups
- After a general introduction to the evaluation system and the profiles, they are applied to the specific building (weekly supervision by the chair)
- The aim is to determine the current status quo for a building that was not familiar with the criteria during the planning/construction phase
- At the end of the semester, an overall evaluation of the real building should have been prepared and discussed

Educational form / Language

a) Lecture (1 WLH) / Tutorial (1 WLH) / German / English

b) Lecture (1 WLH) / Tutorial (1 WLH) / German / English

Examination methods

- Oral exam 'Sustainable Building' (30 min., Part of modul grade 100 %)
- Term paper 'Resource efficient building' (45 h., Part of modul grade 0 %)
- Term paper 'Sustainability assessment for buildings' (45 h., Part of modul grade 0 %)

Requirements for the award of credit points

- Passed assignments
- Passed oral module final exam

Module applicability

- MSc Environmental Engineering
- MSc Civil Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $6 \cdot 100 \cdot \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

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Further Information

This module can be recognized as part of the RUB sustainability certificate.

Sustainability and Digitisation in road construction Nachhaltigkeit und Digitalisierung im Straßenbau					
Module number UI-WPC2	Credits 6 CP	Workload 180 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Environmental aspects and sustainability in road construction b) Management systems in road construction c) Digitalisation in the planning processes of road infrastructure			Contact hours a) 2 WLH (30 h) b) 1 WLH (15 h) c) 1 WLH (15 h)	Self-study a) 60 h b) 15 h c) 45 h	Frequency a) each summer b) each summer c) each summer
Module coordinator and lecturer(s) Vertr.-Prof.'in Dr.-Ing. Nina Nytus a) Vertr.-Prof.'in Dr.-Ing. Nina Nytus b) Vertr.-Prof.'in Dr.-Ing. Nina Nytus c) Vertr.-Prof.'in Dr.-Ing. Nina Nytus					
Admission requirements Recommended previous knowledge: Pavement Construction and Maintenance or Environmental Engineering in Pavement Construction					
Learning outcome, core skills After successfully completing the module, students will be able • select and evaluate the criteria necessary for the sustainability of a road, - select and check the engineering aspects necessary for management • supported systematic maintenance, • generate the steps necessary for the digitisation process of road planning using computer software.					
Contents a) In this course, sustainability in road construction is considered against the background of comprehensive resource conservation. The following topics are covered in detail • Legal principles of environmental protection and sustainability • Life cycle assessment • Suitability of recycled construction materials and industrial by-products for road construction • Use of sustainable construction materials • Environmental compatibility of construction materials • Aspects of life cycle assessment • Sustainability assessment criteria b) The course deals with the determination of road conditions and road network management in the context of maintenance planning. In detail, it deals with • Meaning and purpose of management systems • Data bases and collection of road data • Systematic condition survey and assessment of roads					

- Forecast of maintenance and financial requirements
- Planning of maintenance measures on road pavements
- Work site/construction site management
- Current developments in recording and evaluation technology

c)

This course aims to impart practical skills in the field of digital road planning through the targeted implementation of software training. In detail, the following topics are covered

- Application of typical software tools used in road planning
- Building Information Modelling in road construction.

Educational form / Language

a) Seminar / Lecture (1 WLH) / German

b) Lecture (1 WLH) / German

c) Seminar / German

Examination methods

- Written exam 'Sustainability and Digitalisation in road construction' (90 min., Part of modul grade 100 %, written examination on a), b) and c))
- Term paper 'Sustainability in road construction' (45 h., Part of modul grade 0 %, seminar paper "Sustainability in road construction" (submission deadline will be announced at the beginning of the semester))
- Term paper 'Digitalization in the planning processes' (30 h., Part of modul grade 0 %, seminar paper "Digitalisation in planning processes" (submission deadline will be announced at the beginning of the semester))

Requirements for the award of credit points

- Passed final module examination on a), b) and c): Written exam
- Passed seminar paper "Sustainability in Road Construction"
- Passed seminar paper "Digitalisation in Planning Processes"

Module applicability

- M.Sc. Environmental Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

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Further Information

Non-motorized traffic Nichtmotorisierter Verkehr					
Module number BI-W67	Credits 2 CP	Workload 60 h	Semester[s] ab dem 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Non-motorized traffic			Contact hours a) 2 WLH (30 h)	Self-study a) 30 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Justin Geistefeldt a) Dr.-Ing. Sandra Hohmann					
Admission requirements Recommended previous knowledge: Design of transportation systems					
Learning outcome, core skills Students • will be able to independently implement design specifications for pedestrian and bicycle facilities, • have in-depth knowledge of calculation and evaluation methods for pedestrian and bicycle traffic, • recognize the interrelationships between design, cost-effectiveness, and safety of pedestrian and bicycle traffic facilities, • are able to understand various pedestrian and bicycle traffic concepts using practical examples, • are able to reflect on the interaction between the promotion of non-motorized traffic and the intended resource-saving and sustainable handling of traffic.					
Contents a) Non-motorized transport is an effective component of environmentally friendly mobility. Students learn about the design specifications and the calculation and evaluation procedures of the technical regulations for the two most common forms of non-motorized individual transport—walking and cycling. In addition, they learn about tried-and-tested walking and cycling concepts and gain insights into the economic efficiency and safety aspects of walking and cycling facilities.					
Educational form / Language a) Lecture (2 WLH) / German					
Examination methods • Oral exam 'Non-motorized traffic' (30 min.ungraded)					
Requirements for the award of credit points • Passed module final exam: Oral exam					
Module applicability • M.Sc. Civil Engineering • M.Sc. Environmental Engineering					
Weight of the mark for the final score Percentage of total grade [%] = 0, ungraded					
Further Information					

Operations Research for Energy System Applications					
Operations Research for Energy System Applications					
Module number 138120	Credits 5 CP	Workload 150 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Operations Research for Energy System Applications			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr. rer. pol. Valentin Bertsch a) Dr.-Ing. Jonas Finke					
Admission requirements Recommended prior knowledge: Basic knowledge of energy economics, such as that covered in the B.Sc. module Energy Economics is recommended. Any prior knowledge in operations research and programming with Python is advantageous but not necessary. Knowledge from the M.Sc. module Energy Systems Analysis can be helpful, but is also not necessary. Most exercises are organised as computer tutorials. If possible, these take place in the CIP pool(s) on campus. If students want to work on the exercises outside the CIP pool hours, they need a (mobile) computer on which they can install Python and a package for linear optimisation, both of which are open-source. This will also be advantageous for the case study.					
Learning outcome, core skills After successful completion of this module the students are able to • Explain basic concepts of linear programming and solve linear optimisation problems manually and with Python • Explain and interpret the structure and elements of linear energy system optimisation models by referring to concepts of linear programming and techno-economic characteristics of real energy systems • Apply the concepts and methods learnt to a case study to answer a research question about the energy transition by developing, implementing and solving an energy system optimisation model using Python • Analyse and interpret optimisation results and draw conclusions for the energy transition • Work independently in project groups and present results of their group work in an understandable way, both in an oral and written form Moreover, the students will have • developed the ability to think in a networked and critical way and are able to select and apply established methods and procedures, • acquired in-depth and interdisciplinary methodological competence and are able to apply it in a situationally appropriate manner. The students practice scientific learning and thinking and can • develop complex problems in technical systems in a structured way and solve them in an interdisciplinary way using suitable methods, • transfer knowledge/skills to concrete systems engineering problems.					
Contents a)					

- Linear programming • Standard form and graphical solution • Duality • Mixed-integer linear programming - Energy system optimisation models • Typical formulations and key components (Variables, parameters, constraints, objectives) • Selected case studies - Linear programming in Python with Linopy (taught in computer exercises) • Formulating and solving basic linear problems • Formulating and solving small and large energy system models - Students work on a case study in small project groups • Students develop an own energy system model to address a selected research question / problem using real-world data • Students evaluate the corresponding results and draw conclusions from it • Students communicate their model and findings in a presentation and a short written report
Educational form / Language a) Lecture (2 WLH) / Project / Tutorial (2 WLH) / English
Examination methods • Project report 'Operations Research for Energy System Applications' (90 h., Part of modul grade 100 %, group work consisting of a written report, presentation and model code – details will be announced at the beginning of the semester) • Digital learning assessment during the semester – not graded
Requirements for the award of credit points • Successful completion of project work (details will be announced at the beginning of the semester) • Successful completion of digital learning assessment (not graded)
Module applicability M.Sc. Mechanical Engineering M.Sc. Sales Engineering and Product Management M.Sc. Umweltingenieurwesen
Weight of the mark for the final score Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.
Further Information

Operations Research and Databases Operations Research und Datenbanken					
Module number BI-P10/UI-P3	Credits 6 CP	Workload 180 h	Semester[s] 1 Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Operations Research (127020) b) Databases			Contact hours a) 2 WLH (30 h) b) 2 WLH (30 h)	Self-study a) 60 h b) 60 h	Frequency a) each winter b) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Markus König a) Prof. Dr.-Ing. Markus König b) Prof. Dr.-Ing. Markus König					
Admission requirements					
Learning outcome, core skills Upon completion of the course, students will be able to: • mathematical optimization strategies and structured data management concepts to solve practice-oriented problems in civil and environmental engineering, • familiar with current optimization software and employ it purposefully to address engineering problems, • the necessary knowledge to implement data management concepts computationally and to apply them both theoretically and practically to engineering challenges.					
Contents a) • Linear optimization • Queueing theory • Fuzzy-Control • Evolutionary algorithms • Multi-criteria decision-making methods b) • Database models • Database implementation • Database queries					
Educational form / Language a) Lecture (1 WLH) / Tutorial (1 WLH) / German b) Lecture (1 WLH) / Tutorial (1 WLH) / German					
Examination methods • Written exam 'Operations Research and Databases' (150 min., Part of modul grade 100 %)					
Requirements for the award of credit points • Passed final module examination: Written exam					
Module applicability • M.Sc. Civil Engineering • M.Sc. Environmental Engineering					

Weight of the mark for the final score
Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$
FAK: The weighting factors can be taken from the table of contents.
DIV: The values can be taken from the table of contents.
Further Information

Planning, Speaking, Writing : project management and scientific work in engineering Planen, Sprechen, Schreiben: Projektmanagement und wissenschaftliches Arbeiten im Ingenieurwesen					
Module number BI-W28	Credits 3 CP	Workload 90 h	Semester[s] ab dem 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Planning, Speaking, Writing : project management and scientific work in engineering			Contact hours a) 3 WLH (45 h)	Self-study a) 45 h	Frequency a) each sem.
Module coordinator and lecturer(s) Dr.-Ing. Sandra Greassidis a) Dr.-Ing. Sandra Greassidis, Vertr.-Prof.'in Dr.-Ing. Nina Nytus, Dr.-Ing. Christian Jolk					
Admission requirements					
Learning outcome, core skills In addition to their technical training, students who complete this module will have acquired knowledge of project planning and independent project management to prepare them for upcoming projects and final theses. After successfully completing the module • students will plan their final theses according to the rules of efficient time and project management • students will have acquired techniques for scientific work and presentation • students will write scientific texts with the help of learned writing techniques • students will research, manage, and organize literature with the help of current software					
Contents a) In cooperation with the Project Office for Construction and Environment, the course treats the topics of project management and scientific working techniques as a "simulated engineering office" and with the involvement of experts. This includes, among other things: • Time and project management • Structure of an exposé • Structure and characteristics of a scientific paper • Literature research and management • Writing training • Presentation techniques and criteria for a professional oral presentation The content is not only taught "theoretically," but also tested and practiced under realistic conditions.					
Educational form / Language a) Lecture (3 WLH) / German					
Examination methods • Term paper 'Planning, Speaking, Writing : project management and scientific work in engineering' (15 h., ungraded, with final oral exam (30 min.))					
Requirements for the award of credit points • Passed module final exam: Term paper with oral exam					
Module applicability					

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- | |
|---|
| <ul style="list-style-type: none">• M.Sc. Civil Engineering• M.Sc. Environmental Engineering• B.Sc. Civil Engineering• B.Sc. Environmental Engineering |
| Weight of the mark for the final score
Percentage of total grade [%] = 0, ungraded |
| Further Information
Block seminar at the end of the semester |

Project Management in Plant Engineering Project Management in Plant Engineering					
Module number 139200	Credits 5 CP	Workload 150 h	Semester[s] ab dem 1. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Project Management in Plant Engineering			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marcus Grünwald a) Dr.-Ing. Dorothea Schwarz					
Admission requirements Recommended previous knowledge: none					
Learning outcome, core skills After successfully completing the module, students will be able to • Structure a project and place it in its overall context • Recognize methods and tools to deal with typical project situations • Understand projects, recognize role patterns and evaluate boundary conditions					
Contents a) The course is aimed at students who are interested in analyzing tasks/projects that initially appear complex. The following project-specific topics are addressed using numerous examples from the current and historical social environment as well as everyday situations: • Familiarization with typical management theories with their relevance to the current work environment • Organization and structure of large companies • Recognizing and analyzing typical role patterns in projects • Structuring and analyzing projects with the aim of resource-efficient, timely and cost-saving execution • Dealing with employees as well as stakeholders and shareholders in a national and international environment • Getting to know the various sub-management tasks such as deadline, cost and personnel management etc. • Use of tips, tricks and methods to achieve goals As part of the exercise accompanying the lecture, students will work independently in small groups on a process and plant engineering project. In doing so, the various aspects and tasks of project management from the lecture are familiarized with in a practical way and thus an awareness of these is developed.					
Educational form / Language a) Lecture (2 WLH) / Tutorial (2 WLH) / English					
Examination methods • Oral exam 'Project Management in Plant Engineering' (30 min., Part of modul grade 100 %)					
Requirements for the award of credit points Passed final module examination: oral examination					

Module applicability
• M.Sc. Mechanical Engineering • M.Sc. Environmental Engineering
Weight of the mark for the final score Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.
Further Information

Project sustainability in the built environment. Projektarbeit Nachhaltigkeit in der bebauten Umwelt					
Module number UI-PA3	Credits 10 CP	Workload 300 h	Semester[s] 1.-3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Project sustainability in the built environment.			Contact hours	Self-study a) 300 h	Frequency a) each winter
Module coordinator and lecturer(s) N.N. a) Vertr.-Prof.'in Dr.-Ing. Nina Nytus, Prof. Dr.-Ing. Annette Hafner, Prof. Dr. rer. pol. Valentin Bertsch, Prof. Dr.-Ing. Martina Flörke, Prof. Dr.-Ing. Marc Wichern, Prof. Dr.-Ing. habil. Iurie Curosu, Prof. Dr.-Ing. Justin Geistefeldt					
Admission requirements					
Learning outcome, core skills The students • learn under supervision to work independently and scientifically in an environmental engineering subject, • are able to research and understand international literature, • are able to prepare and present technical topics in an appropriate and understandable way in the corresponding presentation, • should be able to gain an overview of the interrelationships of the subject and acquire the ability to work on problems in the specialised field using scientific methods and apply scientific findings					
Contents a) On the content of the compulsory elective modules, students are assigned project work that is carried out collaboratively in project teams with a division of tasks. The project teams organise and coordinate the distribution of tasks independently. The lecturers act as supervisors and advisors during the project work and check the results at regular intervals. At the end of the project work, the students present their results. The content of the project work varies from semester to semester, so that current problems relating to material flow management of different resources (material, energy, emissions, water), sustainable construction in building construction and road construction, environmental modelling as well as environmental planning and GIS can be dealt with. Complex tasks from the practice of infrastructure and building construction and environmental technology are chosen as the subject of the projects. The project work is generally designed to incorporate interdisciplinary aspects into the task processing. This means that at least two chairs are responsible for supervision. The content defined in the assignment is formulated in such a way that the following aspects are taken into account: • Recognising and describing problems • Formulate objectives • Distributing and coordinating tasks • Group dynamic problem solving • Design and optimize time and workload distribution • Interdisciplinary problem solving • Obtaining and analysing literature and interviewing experts					

• Documentation, visualisation and presentation of work results
Educational form / Language a) Project / German / English
Examination methods • Term paper 'Project sustainability in the built environment.' (300 h., Part of modul grade 100 %, including presentation))
Requirements for the award of credit points • Completed project work • Completed presentation
Module applicability • M.Sc. Environmental Engineering
Weight of the mark for the final score Percentage of total grade [%] = $10 * 100 * \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.
Further Information

Project Sustainable Systems and Technologies Projektarbeit Sustainable Systems and Technologies					
Module number UI-PA2	Credits 12 CP	Workload 360 h	Semester[s] 1.-3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Projektarbeit Sustainable Systems and Technologies (129227)			Contact hours	Self-study a) 360 h	Frequency a) each sem.
Module coordinator and lecturer(s) N.N. a) Prof. Dr.-Ing. V. Scherer, Prof. Dr. Francesca di Mare, Prof. Romuald Skoda, Prof. Dr. rer. pol. Valentin Bertsch, Prof. Dr.-Ing. G. Deerberg, Prof. Dr.-Ing. Marcus Grünewald, Prof. Dr.-Ing. Marco K. Koch, Prof. Dr.-Ing. Manfred Renner, Prof. Dr. rer. nat. Rolf Bracke, Prof. Dr.-Ing. Marcus Petermann, Prof. Dr.-Ing. Roland Span, Prof. Thomas Ernst Müller, Prof. Christian Doetsch					
Admission requirements					
Learning outcome, core skills Die Studierenden sind nach erfolgreichem Abschluss des Moduls in der Lage, • deutsch- und englischsprachige Fachliteratur zu spezifischen Fragestellungen aus dem Umweltingenieurwesen (Fachbereich Energie-/ Verfahrenstechnik) zu verstehen und zu bewerten • basierend auf den recherchierten Ergebnissen eine aktuelle Forschungsfrage aus dem Umweltingenieurwesen (Fachbereich Energie-/ Verfahrenstechnik) abzuleiten • fachspezifische wissenschaftliche Methoden anzuwenden, um die die abgeleitete Forschungsfrage zu bearbeiten • die Ergebnisse der Projektarbeit systematisch und verständlich in schriftlicher (Abschlussarbeit) und mündlicher Form (Präsentation) darzustellen, zu erläutern und zu bewerten					
Contents a) Zu den Lehrinhalten der Wahlpflichtmodule werden den Studierenden Fachthemen genannt, zu denen von den Studierenden eine Forschungsfrage abgeleitet und bearbeitet wird. Die Projektarbeit kann in Projektteams bearbeitet werden. Die Projektteams organisieren und koordinieren die Aufgabenverteilung untereinander eigenständig. Die Betreuungsfunktion, die von Seiten des betreuenden Lehrstuhls erbracht wird, umfasst • die Durchführung eines Startgesprächs, in der das zu bearbeitende Fachthema genannt und die organisatorischen Randbedingungen geklärt werden • die Prüfung und Freigabe (ggf. nach einem Überarbeitungsschritt durch die Studierenden) der Forschungsfrage • einen fachlichen Abstimmungstermin zu den Inhalten und Ergebnissen der Projektarbeit vor Anfertigung der schriftlichen Arbeit und der Abschlusspräsentation Die Inhalte der Projektarbeit werden an aktuellen Forschungsfragen und Problemstellungen der Energie- und Verfahrenstechnik und insbesondere an den am betreuenden Lehrstuhl fokussierten Themen ausgerichtet.					
Educational form / Language a) Project / German / English					

Examination methods

- Term paper 'Project Sustainable Systems and Technologies' (360 h., Part of modul grade 100 %, mit Präsentation)

Requirements for the award of credit points

- Bestandene Projektarbeit
- Abgelegte Präsentation

Module applicability

- M.Sc. Umweltingenieurwesen

Weight of the mark for the final score

Percentage of total grade [%] = $12 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Project Road and Traffic Engineering and Infrastructure planning					
Projektarbeit Verkehrswesen und Infrastrukturplanung					
Module number UI-PA4	Credits 10 CP	Workload 300 h	Semester[s] 1.-3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Projektarbeit Verkehrswesen und Infrastrukturplanung (129229)			Contact hours	Self-study a) 300 h	Frequency a) each sem.
Module coordinator and lecturer(s) N.N. a) Vertr.-Prof.'in Dr.-Ing. Nina Nytus, Prof. Dr.-Ing. habil. Iurie Curosu, Prof. Dr.-Ing. Justin Geistefeldt					
Admission requirements					
Learning outcome, core skills Die Studierenden • sollen unter Anleitung zum selbstständigen wissenschaftlichen Arbeiten in einem Fach aus dem Umweltingenieurwesen befähigt werden, • sind in der Lage internationale Literatur zu recherchieren und diese zu verstehen, • können bei der dazugehörigen Präsentation, fachliche Themen passend aufarbeiten und verständlich präsentieren, • sollen in die Lage versetzt werden, die Zusammenhänge des Faches zu überblicken und die Fähigkeit zu erlangen, Probleme des vertieften Fachgebietes mit wissenschaftlichen Methoden zu bearbeiten sowie wissenschaftliche Erkenntnisse anzuwenden.					
Contents a) Zu den Lehrinhalten der Wahlpflichtmodule wird in jedem Jahr ein Themenbereich ausgewählt, der möglichst Aufgaben aus mehreren der angesprochenen Module enthält. Vorzugsweise wird dieses Thema mit Bezug zu einer Aufgabenstellung aus der Praxis verbunden. Der Umfang der Aufgabe richtet sich nach der Anzahl der Teilnehmer. Die Teilnehmer bearbeiten die Problemanalyse und die Aufgaben des Projektes in mehreren Teams. Die Organisation der Teams und die Aufgabenaufteilung nehmen die Studierenden unter Anleitung des Projektleiters selbst vor. Die Dozenten fungieren vorzugsweise als Betreuer und Berater der Projektarbeit und überprüfen das Ergebnis in regelmäßigen Abständen, ggf. unter Vorgabe von Verbesserungsvorschlägen. Während der Projektbearbeitung finden mehrere Sitzungen der Teilnehmer und der Projektleiter zur Koordinierung der Arbeiten statt. Zu diesen Sitzungen werden –sofern sich dies eignet –auch Experten aus der Praxis eingeladen, die mit dem zugrundeliegenden realen Fall befasst sind. Zum Abschluss der Projektarbeit dokumentieren und präsentieren die Studierenden ihre Ergebnisse. Die Inhalte der Projektarbeiten werden individuell von Semester zu Semester unterschiedlich gestaltet, so dass aktuelle Aufgabenstellungen zu verkehrsplanerischen und bautechnischen (Verkehrswegebau) Fragen, bearbeitet werden können. Als Gegenstand der Projekte werden komplexe Aufgabenstellungen aus der Praxis des Verkehrswesens gewählt. Die Projektarbeit wird grundsätzlich so gestaltet, dass fachübergreifende Aspekte in die Aufgabenbearbeitung einfließen. Das heißt, dass mindestens zwei Lehrstühle die Betreuung übernehmen. Die über die Aufgabenstellung definierten Inhalte werden so formuliert, dass folgende Aspekte Berücksichtigung finden:					

- Problemstellungen erkennen und beschreiben,
- Zielvorstellungen formulieren,
- Aufgaben verteilen und koordinieren
- Gruppendynamische Problemlösung
- Zeit- und Arbeitseinteilung gestalten und optimieren
- Interdisziplinäre Problemlösung,
- Literaturbeschaffung und Auswertung sowie Expertenbefragung,
- Dokumentation, Darstellung und Präsentation von Arbeitsergebnissen.

Educational form / Language

a) Project / German / English

Examination methods

- Term paper 'Project Road and Traffic Engineering and Infrastructure planning' (300 h., Part of modul grade 100 %, mit Präsentation)

Requirements for the award of credit points

- Bestandene Projektarbeit
- Abgelegte Präsentation

Module applicability

- M.Sc. Umweltingenieurwesen

Weight of the mark for the final score

Percentage of total grade [%] = $10 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Project Water management and geotechnics Projektarbeit Wasserwesen und Geotechnik					
Module number UI-PA5	Credits 10 CP	Workload 300 h	Semester[s] 1.-3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Project Water management and geotechnics			Contact hours	Self-study a) 300 h	Frequency a) each sem.
Module coordinator and lecturer(s) N.N. a) Prof. Dr.-Ing. Martina Flörke, Prof. Dr.-Ing. Marc Wichern, Prof. Dr.-Ing. Torsten Wichtmann					
Admission requirements					
Learning outcome, core skills The students • learn under supervision to work independently and scientifically in an environmental engineering subject, • are able to research and understand international literature, • are able to prepare and present technical topics in an appropriate and understandable way in the corresponding presentation, • should be able to gain an overview of the interrelationships of the subject and acquire the ability to work on problems in the specialised field using scientific methods and to apply scientific findings.					
Contents a) On the content of the compulsory elective modules, students are assigned project work that is carried out collaboratively in project teams with a division of tasks. The project teams organise and coordinate the distribution of tasks independently. The lecturers act as supervisors and advisors during the project work and check the results at regular intervals. At the end of the project work, the students present their results. The content of the project work varies from semester to semester so that current problems relating to hydrological issues, the dimensioning and control of water management systems, wastewater disposal and water supply as well as environmental planning and ecology can be addressed. Complex tasks from the practice of water management and environmental technology are chosen as the subject of the projects. The project work is generally designed to incorporate interdisciplinary aspects into the task processing. This means that at least two chairs are responsible for supervision. The content defined in the assignment is formulated in such a way that the following aspects are taken into account: • Recognising and describing problems • Formulate objectives • Distributing and coordinating tasks • Group dynamic problem solving • Design and optimize time and workload distribution • Interdisciplinary problem solving • Obtaining and analysing literature and interviewing experts • Documentation, visualisation and presentation of work results					

Educational form / Language
a) Project / German / English
Examination methods
• Term paper 'Project Water management and geotechnics' (300 h., Part of modul grade 100 %, including presentation)
Requirements for the award of credit points
• Completed project work • Completed presentation
Module applicability
• M.Sc. Environmental Engineering
Weight of the mark for the final score
Percentage of total grade [%] = $10 * 100 * \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.
Further Information

Processes in Mechanical Process Engineering					
Prozesse der Mechanischen Verfahrenstechnik					
Module number 138400	Credits 5 CP	Workload 150 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Prozesse der Mechanischen Verfahrenstechnik			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marcus Petermann a) Prof. Dr.-Ing. Marcus Petermann					
Admission requirements					
Learning outcome, core skills Nach dem erfolgreichen Abschluss des Moduls • sind die Studierenden mit den vertieften ingenieurwissenschaftlichen Grundlagen, den Prozessen, Verfahren sowie den Anwendungsfeldern der mechanischen Verfahrenstechnik vertraut. • lösen die Studierenden komplexe mathematische Problemstellungen in Prozessen der mechanischen Verfahrenstechnik mit geeigneten Methoden. • lösen die Studierenden komplexe Problemstellungen in der Anwendung der mechanischen Verfahrenstechnik, entwickeln eigene Ansätze und setzen diese um. • sind die Studierenden in der Lage etablierte Prozesse der Mechanischen Verfahrenstechnik auszuwählen und anzuwenden. • praktizierten die Studierenden wissenschaftliches Lernen und Denken und üben dies an aktuellen Trennprozessen der Mechanischen Verfahrenstechnik ein. • haben die Studierenden vertiefte, auch interdisziplinäre Methodenkompetenz erworben und können diese situativ angepasst anwenden. • übertragen die Studierenden Erkenntnisse und Fertigkeiten aus den vorgestellten Prozessen der mechanischen Verfahrenstechnik auf konkrete, neue Problemstellungen.					
Contents a) Die Vorlesung Prozesse der Mechanischen Verfahrenstechnik vermittelt wichtige Verfahren der Schüttguttechnik. Dazu zählen die Partikelabscheidung aus Gasen und die Abtrennung von Feststoffen aus Flüssigkeiten, etwa mit Filtern oder Zentrifugen. Im Weiteren werden Verfahren zur Änderung der Partikelgröße vorgestellt. Hierzu zählen beispielsweise Mahlvorgänge, wie sie zur Herstellung von Zement notwendig sind. Die Agglomeration von Partikeln führt dagegen zu größeren Partikelkollektiven. Diese Technik wird unter anderem bei Waschmitteln genutzt, um Staubbelastungen zu verhindern. Die Vorlesung schließt ab mit der Beschreibung von durchströmten Partikelschüttungen. Diese Wirbelschichten werden zur Weiterverarbeitung von Partikelsystemen oder zum Transport der Partikel durch die so genannte pneumatische Förderung genutzt.					
Educational form / Language a) Lecture (3 WLH) / Tutorial (1 WLH) / German					

Examination methods

- Written exam 'Prozesse der Mechanischen Verfahrenstechnik' (120 min., Part of modul grade 100 %)

Requirements for the award of credit points

Bestandene Modulabschlussprüfung: Klausur

Module applicability

- MSc. Maschinenbau
- MSc. Sales Engineering and Product Management
- MSc. Umweltingenieurwesen

Weight of the mark for the final score

Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Process Simulation of Energy Plants Prozesssimulation energietechnischer Anlagen					
Module number 139920	Credits 5 CP	Workload 150 h	Semester[s] 1./3. Sem.	Duration 1 Semester[s]	Group size 45
Courses a) Process Simulation of Energy Plants			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Roland Span a) Prof. Dr.-Ing. Roland Span					
Admission requirements Knowledge with regard to the thermodynamic analysis of processes and plants in energy technologies, which can typically be taken for granted after completion of a Bachelor course with an appropriate extent of content relevant for energy technologies. No specific preconditions for participation.					
Learning outcome, core skills After successful completion of the module • Building on fundamental knowledge regarding processes in energy technologies, students are able to model existing and new (discussed in the scientific literature) processes using modern simulation tools, • Students can assess power and efficiency of plants and processes in energy technologies and can identify influential parameters, • Students can analyse and assess the operating behaviour of real and hypothetical processes and plants in energy technologies, • Students can explain and assess the relevance of specific parameters of a process on a high level of abstraction based on parameter studies, • Students know the mathematical and thermodynamic foundations of process-simulation software, • Students can use advanced simulation tools to solve complex tasks, • Students can assess the performance and limits of simulation tools and can critically evaluate their performance (advantages and disadvantages).					
Contents a) Starting from the manual evaluation of processes in energy technology, which has been dealt with in different modules in pertinent Bachelor courses, the essential requirements for software for the simulation of processes in energy technologies are derived. The four main elements of such programs (graphical user interface, nonlinear equation solver, models for specific components, property package) are exemplarily introduced. Advantages and disadvantages of different solutions are discussed. The students set up models for simple processes (gas turbine and steam power-plants, ORC process, electrolysis, heat pump, solar power plant). The influence of the most important operating parameters is explained using the self-developed models as examples. Options for a systematic variation of operating parameters are introduced. As special case the application of process-simulation tools for an assessment of completely new processes (scientific application) and for the validation of measured process parameters (process control in operating plants) is discussed.					
Educational form / Language a) Lecture with tutorial / German / English					

Examination methods

- Written exam 'Process Simulation of Energy Plants' (120 min., Part of modul grade 100 %, In case less than 10 students are enrolled, the written exam can be replaced by an oral exam (30 minutes) with 60 minutes preparation of the questions at a computer (60 minutes))

Requirements for the award of credit points

Passed module examination: written or oral exam, see above

Module applicability

no information

Weight of the mark for the final score

Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Lecture and tutorials integrated (4 SWS); the module is offered in a bilingual mode. Supervision of the enrolled students can be offered in German and English in parallel.

Processthermodynamics Prozessthermodynamik					
Module number 135220	Credits 5 CP	Workload 150 h	Semester[s] 1./3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Prozessthermodynamik			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Roland Span a) Prof. Dr.-Ing. Roland Span, Dr.-Ing. Monika Thol					
Admission requirements Kenntnisse aus dem Modul Grundlagen der Thermodynamik. Vorheriges Bestehen der entsprechenden Modulabschlussprüfung ist nicht erforderlich.					
Learning outcome, core skills Nach dem erfolgreichen Abschluss des Moduls • können Studierende die Besonderheiten der Stoffeigenschaften einfacher Gemische erläutern, diskutieren und interpretieren, • können Studierende technische Prozesse mit reinen Stoffen und Gemischen analysieren, berechnen und bewerten, • können Studierende komplexe energietechnische Prozesse energetisch und exergetisch analysieren und bewerten, • besitzen die Studierenden die Fähigkeit, mit Methoden der Thermodynamik die Energetik von chemischen Stoffumwandlungen (insbesondere von Verbrennungsprozessen) zu beschreiben, entsprechende technische Prozesse zu analysieren, zu simulieren und Ergebnisse kritisch zu überprüfen.					
Contents a) • Vertiefte Behandlung des Exergiekonzepts und seine Anwendung auf rechts- und linksläufige Kreisprozesse • Die Energetik von Prozessen mit feuchter Luft • Betrachtung von Stoffeigenschaften realer Gemische • Berechnung von Phasengleichgewichten • Analyse komplexerer Wärmepumpen und ähnlicher Prozesse • Die Energetik chemischer Reaktionen, Verbrennungsprozesse					
Educational form / Language a) Lecture (2 WLH) / Tutorial (2 WLH) / German					
Examination methods • Written exam 'Prozessthermodynamik' (150 min., Part of modul grade 100 %, Die Modulprüfung kann je nach Teilnehmerzahl auch mündlich durchgeführt werden.)					
Requirements for the award of credit points Bestandene Modulabschlussprüfung: Klausur					
Module applicability					

no information

Weight of the mark for the final score

Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.
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Further Information

Spatial data analysis and environmental modelling Räumliche Datenanalyse und Umweltmodellierung					
Module number BI-WP35/UI-WPB5	Credits 6 CP	Workload 180 h	Semester[s] 1. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Methodological fundamentals of environmental modelling b) Big data in environmental sciences			Contact hours a) 2 WLH (30 h) b) 2 WLH (30 h)	Self-study a) 60 h b) 60 h	Frequency a) each winter b) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Martina Flörke a) Prof. Dr.-Ing. Martina Flörke b) Dr.-Ing. Henning Oppel					
Admission requirements Recommended previous knowledge: Knowledge from bachelor's degree in advanced mathematics and computer science					
Learning outcome, core skills Students - describe the fundamentals of common data sources, data types and data formats, as well as relevant model concepts in the context of environmental modelling - can prepare, analyse and present (large) spatial data sets and time series using geographic information systems (GIS) and scripting languages (Python and R) - can evaluate the model results and uncertainties and thus assess the validity of the methods, - can understand standard tasks and independently develop solution strategies for environmentally relevant issues.					
Contents a) The course covers the basic knowledge of the methodological fundamentals of environmental modelling. This includes: - Sources of spatial information for environmental modelling, importing and processing large data sets - Use of various data formats and model concepts from the fields of hydrology, urban water management, traffic planning, etc. - Working with and developing in GIS, Python and R - Spatial statistics (variogram), geostatistics (spatial interpolation) - Time series analysis (trend tests, autocorrelation). b) The lecture focuses on the use of modern data sources and modelling approaches to solve environmentally relevant issues and the presentation of results. The following topics will be covered in detail: - Machine learning and data mining					

- Model uncertainty and validity criteria
- Ensemble forecasting and ensemble analysis
- Evaluation and processing of remote sensing data
- Presentation of results.

The methodological and technical fundamentals of analyzing, evaluating and presenting environmentally relevant data are covered in the lectures and discussed in terms of their validity, uncertainty and decision support.

Computer exercises are necessary to master the modelling and programming techniques. Various programmes and models with corresponding data sets are available for this purpose, which can be used by students in the CIP pools of the faculty.

The various methods are applied using real-world examples in the practicals.

Educational form / Language

- a) Lecture (1 WLH) / Tutorial (1 WLH) / German
b) Lecture (1 WLH) / Tutorial (1 WLH) / German

Examination methods

- Term paper 'Spatial data analysis and environmental modelling' (60 h., Part of modul grade 100 %, term paper with presentation of results (20 minutes) (deadline to be announced at the beginning of the semester))

Requirements for the award of credit points

- Passed term paper and final presentation of results

Module applicability

- M.Sc. Environmental Engineering
- M.Sc. Civil Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Seminar for transportation and traffic engineering Seminar für Verkehrswesen					
Module number BI-W61	Credits 2 CP	Workload 60 h	Semester[s] ab dem 1. Sem.	Duration 1 Semester[s]	Group size 20
Courses a) Seminar for Transportation and Traffic Engineering			Contact hours a) 1 WLH (15 h)	Self-study a) 45 h	Frequency a) each sem.
Module coordinator and lecturer(s) Prof. Dr.-Ing. Justin Geistefeldt a) Prof. Dr.-Ing. Justin Geistefeldt					
Admission requirements					
Learning outcome, core skills Students • have expanded their knowledge in the field of transport to include a current topic, • have learnt how to work in a team to solve a complex task in the field of transport, • have learnt to present the results of their work in a short presentation.					
Contents a) Sub-areas of a given framework topic are worked on in small groups. Finally, an overall report is compiled. Participants are required to present and discuss the results.					
Educational form / Language a) Lecture (1 WLH) / German					
Examination methods • Term paper 'Seminar for Transportation and Traffic Engineering' (30 h., Part of modul grade 100 %, seminar report with presentation)					
Requirements for the award of credit points • Passed module final exam: written exam					
Module applicability • M.Sc. Civil Engineering • M.Sc. Environmental Engineering					
Weight of the mark for the final score Percentage of total grade [%] = $2 * 100 * \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.					
Further Information					

Model based Design of Reactors and Separation Units Simulationsgestützte Auslegung von Reaktions- und Trennapparaten					
Module number 138060	Credits 5 CP	Workload 150 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Simulationsgestützte Auslegung von Reaktions- und Trennapparaten			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marcus Grünewald a) Prof. Dr.-Ing. Marcus Grünewald					
Admission requirements Recommended previous knowledge: keine					
Learning outcome, core skills Nach dem erfolgreichen Abschluss des Moduls können Studierende • Möglichkeiten und Grenzen dynamischer Simulationstools bewerten • in der Verfahrenstechnik gängige Apparate mathematisch beschreiben • reale Reaktoren und Phänomene in diesen Reaktoren mithilfe von Modellen abbilden und in das verwendete Simulationstool implementieren • die für eine Bilanzierung realer Reaktoren relevanten Parameter zu erfassen und eigenständig Stoff- und Wärmebilanz mithilfe des verwendeten Simulationstools lösen und die Ergebnisse bewerten und darstellen.					
Contents a) In der Lehrveranstaltung werden die Methoden der verfahrenstechnischen Modellierung und Simulation von Apparaten vermittelt. Dazu werden insbesondere nachfolgende Themen adressiert: • In der Vorlesung wird zunächst eine Übersicht über reale Reaktoren und Trennapparate gegeben. Hierzu werden zunächst Beispielprozesse besprochen, die in dem entsprechenden Apparat durchgeführt werden. Anhand der Beispiele werden die unterschiedlichen Betriebszustände, Stofftransport- und Wärmetransportphänomene diskutiert. Anschließend erfolgt die Herleitung einer Modellbeschreibung der "beobachteten" Phänomene. • Das resultierende und in eine verfahrenstechnische Software zur Prozesssimulation (z.Z. Aspen Custom Modeller) implementierte Gleichungssystem wird in den computergestützten Übungen bearbeitet. Mithilfe von Simulationsstudien werden die in der Vorlesung besprochenen Beispielfälle detaillierter analysiert. Als Abschluss einer Übungseinheit wird das Vorgehen bei der Auslegung erarbeitet und die Abhängigkeit der Apparatedimensionen von den Beispielprozessen demonstriert. • Nach dem Erarbeiten der grundlegenden Möglichkeiten des Aspen Custom Modeller werden in 2er bis 3er Gruppen selbstständig Projektthemen bearbeitet und die jeweiligen Fragestellungen mithilfe der zuvor in den Übungen erworbenen Kompetenzen in einer Simulation gelöst.					
Educational form / Language a) Lecture (1 WLH) / Tutorial (3 WLH) / German					

Examination methods

- Oral exam 'Simulationsgestützte Auslegung von Reaktions- und Trennapparaten' (30 min., Part of modul grade 100 %, Gruppenprüfung)

Requirements for the award of credit points

Bestandene Modulabschlussprüfung: mündliche Gruppenprüfung

Module applicability

- MSc. Maschinenbau
- MSc. Sales Engineering and Product Management
- MSc. Umweltingenieurwesen

Weight of the mark for the final score

Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Material Flow Management Stoffstrommanagement					
Module number BI-WP54/UI-WPB2	Credits 6 CP	Workload 180 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Material flow analysis in construction with life cycle assessment tool			Contact hours a) 4 WLH (60 h)	Self-study a) 120 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Annette Hafner a) Prof. Dr.-Ing. Annette Hafner					
Admission requirements Recommended previous knowledge: Knowledge of life cycle assessment, knowledge of building physics, knowledge of building construction					
Learning outcome, core skills Students • After successfully completing the module, students will have a basic understanding of material flows in construction and their interactions, • can explain environmental considerations of building constructions and determine references to sustainability and service life, • acquire the ability to independently perform a building life cycle assessment using the eLCA tool (or possibly another tool), • can compare and evaluate the results of building life cycle assessments.					
Contents a) The lecture provides an overview of life cycle assessment (LCA) methods. The lecture is based on national and international standards. Specific topics covered include: • LCA processes and procedures (system boundaries, functional unit, life cycle inventory, life cycle impact assessment, etc.) • Special requirements of life cycle assessment in construction (manufacturing, construction, use, and demolition) and conclusions regarding national and international assessment methods for sustainable buildings • Basic knowledge for creating an LCA with the eLCA tool (or possibly another tool) for the independent creation of a building LCA • Structural analysis of different building structures and their influence on the LCA					
Educational form / Language a) Lecture (2 WLH) / Tutorial (2 WLH) / German					
Examination methods • Term paper 'Material Flow Management' (30 h., Part of modul grade 100 %, with a final oral exam (15 min). The scope and deadline will be announced at the beginning of the semester.)					
Requirements for the award of credit points					

-
- Passed term paper

Module applicability

- M.Sc. Civil Engineering
- M.Sc. Environmental Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Transport and fate of substances in river basins Stofftransport in Einzugsgebieten					
Module number BI-WP36/UI-WPD3	Credits 6 CP	Workload 180 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Mass transport and mass transport equations b) Modeling and assessment of water quality			Contact hours a) 2 WLH (30 h) b) 2 WLH (30 h)	Self-study a) 60 h b) 60 h	Frequency a) each summer b) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Martina Flörke a) Prof. Dr.-Ing. Martina Flörke b) Prof. Dr.-Ing. Martina Flörke					
Admission requirements Recommended previous knowledge: Completed module in Fundamentals of Hydrology and Water Management, Hydrology module, knowledge of R					
Learning outcome, core skills Students - characterize the fundamentals of sources and sinks as well as the transport of the most important dissolved and particulate, organic and inorganic substances, such as nutrients, BOD, pesticides, fertilizers, heavy metals and nanoparticles from a catchment area perspective - differentiate between pollutant dispersion and substance behaviour in the aquatic environment based on processes such as sorption, volatilisation, transformation and degradation - olve standard tasks with the aid of analytical transport equations with initial and boundary conditions - interpret the quality of calculation methods and model results in the given context - prepare analyses and assessments of substance input in aquatic systems.					
Contents a) The course covers the basics of mass transport in aquatic systems and the theoretical principles for solving mass transport equations. Specifically, the course addresses the following topics: - Water pollution and its consequences - Sources of substances and the determination of substance loads and substance balances - Conservative and reactive transport (processes, flow paths) - Consideration of specific pollutants (BOD, nutrients, pesticides, fertilizers, heavy metals, nanoparticles) - Sediment and heat transport - Tracer experiments and breakthrough curves - Analytical solution of the transport equation for 1D and 2D with different boundary and initial conditions - Presentation of common numerical solution methods for mass and heat transport - Water management measures for water pollution control. b)					

The course covers the collection of water quality data and the introduction and use of water quality models for describing, analyzing and evaluating substance inputs into aquatic systems.

This includes:

- Theoretical introduction to measurement methods for various water quality parameters
- Presentation of environmental pressures and environmental protection measures (DPSIR model):
Driving forces, Pressures, State, Impact, Response
- Interactions between changes in land use and water quality
- Classification of water quality models
- Scale issues in the analysis and description of processes
- Spatio-temporal analysis of water quality, including long-term problems spanning several decades
- Assessment of potential sources of pollution in catchment areas
- Pollutant classes and guidelines for assessing water quality
- Modelling of various water quality parameters
- Model efficiency measures for evaluating model results
- Presentation of specific models and their application.

Educational form / Language

a) Lecture (1 WLH) / Tutorial (1 WLH) / German

b) Lecture (1 WLH) / Tutorial (1 WLH) / German

Examination methods

- Term paper 'Mass transport in catchment areas - Term paper' (40 h., Part of modul grade 0 %, presentation (max. 20 pages) and final presentation of results at the end of the course (deadline to be announced at the beginning of the semester))
- Written exam 'Transport and fate of substances in river basins' (60 min., Part of modul grade 100 %)

Requirements for the award of credit points

- Passed module final exam: Written exam
- Passed presentation with final presentation

Module applicability

- M.Sc. Environmental Engineering
- M.Sc. Civil engineering

Weight of the mark for the final score

Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Technical Combustion Technische Verbrennung					
Module number 136020	Credits 5 CP	Workload 150 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Technische Verbrennung			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. V. Scherer a) Prof. Dr.-Ing. V. Scherer					
Admission requirements Recommended previous knowledge: Strömungsmechanik, Thermodynamik, Wärme- und Stoffübertragung					
Learning outcome, core skills Nach dem erfolgreichen Abschluss des Moduls können Studierende: • Die technisch wichtigsten Brennstoffe benennen und deren Eigenschaften bewerten • Für eine konkrete technische Anwendung das geeignete Verbrennungssystem und die für die Anwendung notwendigen Auslegungsdaten und Berechnungsmethoden auswählen • Technische Verbrennungskonzepte konzipieren und deren Abgasemissionen einschätzen • Die gängigen Berechnungsmethoden zur Auslegung von Verbrennungssystemen sicher anwenden • die Auswirkung von Verbrennungsprozesse auf Mensch und Umwelt beurteilen					
Contents a) In der Lehrveranstaltung „Technische Verbrennung“ werden die Grundlagen für das Verständnis von Verbrennungsprozessen vermittelt sowie für die Auslegung von technischen Verbrennungssystemen. Dazu werden folgende Themen adressiert: • Übersicht über Brennstoffe und deren Eigenschaften • stöchiometrische der Verbrennung • chemische Thermodynamik und Reaktionskinetik • Berechnung der Verbrennungstemperatur • Zündprozesse von Flammen und Zündkriterien • Berechnungsmethoden für vorgemischte Flammen (z.B. Ottomotor, Gasturbine) und Diffusionsflammen (z.B. Dieselmotor, Industriefeuerungen) • Unterschiede von laminaren und turbulenten Flammen • Verbrennungsmethoden für gasförmige, flüssige und feste Brennstoffe • Schadstoffbildungsmechanismen (NO_x, CO, SO₂, unverbrannte Kohlenwasserstoffe) • Primärmaßnahmen zur Minderung dieser Schadstoffe • Übersicht über Beispiele technischer Verbrennungssysteme					
Educational form / Language a) Lecture (3 WLH) / Tutorial (1 WLH) / German					

Examination methods

- Written exam 'Technische Verbrennung' (120 min., Part of modul grade 100 %, Bei einer Teilnehmerzahl < 10 kann die Prüfung auch mündlich durchgeführt werden.)

Requirements for the award of credit points

Bestandene Modulabschlussprüfung: Klausur

Module applicability

no information

Weight of the mark for the final score

Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Thermal Power Plants Thermische Kraftwerke					
Module number 135155	Credits 5 CP	Workload 150 h	Semester[s] 1. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Thermische Kraftwerke			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. V. Scherer a) Prof. Dr.-Ing. V. Scherer					
Admission requirements Recommended previous knowledge: Strömungsmechanik, Thermodynamik, Wärme- und Stoffübertragung					
Learning outcome, core skills Nach dem erfolgreichen Abschluss des Moduls können Studierende: • Thermische Kraftwerksprozesse und Dampferzeuger konzipieren und die Auswirkung einzelner thermodynamischer Parameter auf die Prozessauslegung abschätzen • Unterschiedliche Auslegungsvarianten quantitativ bewerten • Wärmetechnische und strömungstechnische Auslegungsregeln anwenden und deren Genauigkeit beurteilen • Sinnvolle Annahmen über die vorzugebenden Daten und Randbedingungen abschätzen und notwendige Auslegungsinformationen beschaffen • die Auswirkung thermischer Kraftwerke auf die Umwelt bewerten • die Wirtschaftlichkeit unterschiedlicher Anlagenkonzepte grob ermitteln					
Contents a) „Thermische Kraftwerke“ behandelt die wärme- und strömungstechnische Auslegung von thermischen Kraftwerken. Hierzu werden folgende Themen adressiert: • Bedeutung thermischer Kraftwerke für die Stromerzeugung • Thermodynamik von Kraftwerksprozessen • Wirkungsgrad- und Leistungsberechnung für verschiedene Kraftwerkstypen • Kraftwerksprozess mit CO₂-Abscheidung • Auslegung von Dampferzeugern • Wärmeübertragungs- und Strömungsvorgänge in Dampferzeugern • An- und Abfahren sowie das Regelungsverhalten von thermischen Kraftwerken • Werkstoffe und Beanspruchungsmechanismen • Genehmigungsverfahren • Stromgestehungskosten					
Educational form / Language a) Lecture (3 WLH) / Tutorial (1 WLH) / German					
Examination methods					

• Written exam 'Thermische Kraftwerke' (120 min., Part of modul grade 100 %, Bei einer Teilnehmerzahl < 10 kann die Prüfung auch mündlich durchgeführt werden.)
Requirements for the award of credit points • Bestandene Modulabschlussprüfung: Klausur
Module applicability no information
Weight of the mark for the final score Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.
Further Information

Thermodynamics of Mixtures Thermodynamik der Gemische					
Module number 138240	Credits 5 CP	Workload 150 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Thermodynamik der Gemische			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Roland Span a) Prof. Dr.-Ing. Roland Span					
Admission requirements Kenntnisse der Grundlagen der Thermodynamik, wie sie in einschlägigen Bachelorstudiengängen vermittelt werden. Keine spezifischen Voraussetzungen.					
Learning outcome, core skills Nach dem erfolgreichen Abschluss des Moduls • können Studierende die Besonderheiten der Stoffeigenschaften von Gemischen auf einem hohen Abstraktionsgrad erläutern. • können Studierende neue Erkenntnisse im Bereich der Stoffdatenthermodynamik kritisch hinterfragen und bewerten. • können Studierende ihre Kenntnisse im Bereich der Mischphasenthermodynamik einsetzen, um komplexe Aufgabenstellungen in Energie- und Verfahrenstechnik zu lösen. • können Studierende Informationsbedarfe im Bereich der Stoffdaten erkennen, Informationsquellen beschaffen und dort gefundene Daten kritisch bewerten. • können Studierende die Relevanz von Forschungsergebnissen im Bereich der Mischphasenthermodynamik einschätzen.					
Contents a) • Berechnung von Stoffdaten für energietechnische Prozesse (Zustandsgleichungsmodelle, Stoffdaten von Wasser und Dampf als Sonderfall, ideale Mischung realer Gase) • Zustandsgrößen von Gemischen, Darstellung als Exzessgrößen und als partielle molare Größen • Grundlagen von Mischungseffekten auf molekularer Ebene • Modelle für die Exzess-Gibbs-Energie und den Aktivitätskoeffizienten • Phasengleichgewichte mit Flüssigkeiten, Feststoffen und Gasen • Moderne Zustandsgleichungen für Gemische					
Educational form / Language a) Lecture (3 WLH) / Tutorial (1 WLH) / German					
Examination methods • Written exam 'Thermodynamik der Gemische' (150 min., Part of modul grade 100 %)					
Requirements for the award of credit points Bestandene Modulabschlussprüfung: Klausur					
Module applicability • Msc Maschinenbau					

- MSc Sales Engineering and Product Management
- MSc Umweltingenieurwesen

Weight of the mark for the final score

Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Das Modul „Thermodynamics of Mixtures“ vermittelt identische Kompetenzen und Inhalte in englischer Sprache.

Environmental aspects and sustainability in road construction Umweltaspekte und Nachhaltigkeit im Straßenbau					
Module number BI-W42	Credits 1 CP	Workload 30 h	Semester[s] ab dem 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Environmental aspects and sustainability in road construction			Contact hours a) 1 WLH (15 h)	Self-study a) 15 h	Frequency a) each summer
Module coordinator and lecturer(s) Vertr.-Prof.'in Dr.-Ing. Nina Nytus a) Vertr.-Prof.'in Dr.-Ing. Nina Nytus					
Admission requirements The module cannot be selected if BI-WP29 or UI-WPC2 is taken. Recommended prior knowledge: Pavement Construction and Maintenance or Environmental Engineering in Pavement Construction Recommended previous knowledge: Straßenbau und -erhaltung bzw. Umwelttechnik in Straßenplanung und -bau					
Learning outcome, core skills After successfully completing the module, students will be able to select and evaluate the criteria necessary for the sustainability of a road.					
Contents a) In this course, sustainability in road construction is considered against the background of comprehensive resource conservation. The following topics are covered in detail • Legal principles of environmental protection and sustainability • Life cycle assessment • Suitability of recycled construction materials and industrial by-products for road construction • Use of sustainable construction materials • Environmental compatibility of construction materials • Aspects of life cycle assessment • Assessment criteria for sustainability					
Educational form / Language a) Lecture (1 WLH) / German					
Examination methods • Written exam 'Environmental aspects and sustainability in road construction' (30 min., Part of modul grade 100 %, or oral examination (15 minutes). The form of examination is determined at the beginning of each semester depending on the number of participants.)					
Requirements for the award of credit points • Passed module final examination: written exam					
Module applicability • M.Sc. Civil Engineering • M.Sc. Environmental Engineering					

Weight of the mark for the final score
Percentage of total grade [%] = $1 * 100 * \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.
Further Information

Environmental Geotechnics Umweltgeotechnik					
Module number BI-WP43/UI-WPD7	Credits 6 CP	Workload 180 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Landfill technology b) Dealing with contaminated sites c) Abandoned mining d) Seminar Abandoned mining			Contact hours a) 1 WLH (15 h) b) 1 WLH (15 h) c) 1 WLH (15 h) d) 1 WLH (15 h)	Self-study a) 30 h b) 30 h c) 30 h d) 30 h	Frequency a) each summer b) each summer c) each summer d) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Torsten Wichtmann a) Dr.-Ing. Hanna Viefhaus b) Dr.-Ing. D. König c) Dr. rer. nat. Ferdinand Stöckhert d) Dr. rer. nat. Ferdinand Stöckhert					
Admission requirements Recommended previous knowledge: Completed module in soil mechanics and foundation engineering					
Learning outcome, core skills The students - are familiar with the legal framework and the concepts and procedures of environmental geotechnics and related design concepts, - can develop solutions for environmental geotechnical problems and identify risks, - are able to adapt the methods learned to specific problems and to further develop them if necessary.					
Contents a) The course covers landfill technology: - Legal framework - Site selection - Construction of a landfill facility - Sealing systems - Monitoring and aftercare b) The course introduces participants to the handling of contaminated sites: - Legal framework - Contaminants relevant to contaminated sites - Decontamination and safety procedures c) The course deals with issues relating to abandoned mines:					

- Issues relating to abandoned mines depending on the mining techniques used
- Impacts and failure mechanisms on the surface of the terrain
- Legal framework
- Exploration techniques
- Securing and remediation procedures
- Monitoring in abandoned mines

d)

In the seminar on abandoned mining, the methods from c) are applied in practice using examples.

Educational form / Language

- a) Lecture (1 WLH) / German
- b) Lecture (1 WLH) / German
- c) Lecture (1 WLH) / German
- d) Seminar / German

Examination methods

- Written exam 'Environmental Geotechnics' (180 min., Part of modul grade 100 %)
- Term paper 'Seminar of abandoned mines' (25 h., Part of modul grade 0 %, homework with presentation (dates for presentation will be announced at the beginning of the semester))

Requirements for the award of credit points

- Homework with presentation for d)
- Passed final module examination: written examination

Module applicability

- M.Sc. Environmental Engineering
- M.Sc. Civil Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Environmental Engineering II Umweltingenieurwesen II					
Module number UI-P4	Credits 5 CP	Workload 150 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Umweltingenieurwesen II (138100)			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marcus Grünewald a) Prof. Dr.-Ing. Marcus Grünewald					
Admission requirements Keine, aber Einschreibung zu Semesterbeginn zwecks Gruppeneinteilung erforderlich!					
Learning outcome, core skills Nach dem erfolgreichen Abschluss des Moduls können Studierende • Methoden zur effizienten Nutzung von Ressourcen in den Bereichen Verfahrenstechnik/Energietechnik und Bauen erklären, differenzieren und bewerten • den Einsatz, die Verfügbarkeit und die Interdependenzen ingenieurtechnisch relevanter materieller Ressourcen im Kontext konkreter Beispiele bewerten und ingenieurtechnische Maßnahmen zur Optimierung der Ressourceneffizienz ableiten • Einsatzmöglichkeiten stofflicher und energetischer Verwertungsverfahren im Kontext kreislaufwirtschaftlicher Fragestellungen rangordnen und bewerten					
Contents a) Die Lehrveranstaltung führt die Studierenden inhaltlich in den Master-Studiengang ein und wird daher als Seminarveranstaltung durchgeführt, zu der die verschiedenen Vertiefungsrichtungen der beteiligten Fakultäten beitragen. Um den Studierenden eine Orientierung sowohl hinsichtlich der inhaltlichen Ausrichtung des Studiengangs als auch der Struktur (bezogen auf die fakultätsspezifischen Vertiefungsrichtungen) zu geben, werden inhaltlich folgende Themenfelder adressiert: • Menschen und Bevölkerung • Landwirtschaftliche, urbane oder industrielle Wasserwirtschaft • Ressourceneffiziente Materialverwendung beim Bauen • Land für die Nahrungsmittelversorgung • Nachwachsende Rohstoffen für Energie- und Stoffumwandlung • Unerschöpfliche Energieträger • Erze (Metalle & seltene Erden)					
Educational form / Language a) Lecture (1 WLH) / Tutorial (3 WLH) / German					
Examination methods • Seminar 'Environmental Engineering II' (10 wks., Part of modul grade 100 %, - Gruppenarbeit zur Erstellung eines Posters zu einem der o.g. Themenfelder (Bearbeitungszeit 8 Wochen + Recherche 30h + Sprechstunden) - Gruppenarbeit zur Vorstellung und Diskussion der Poster im Format, World Café (Vortragszeit 10 Min, Moderation Diskussionszeit 10 Min.) - Gruppenarbeit zur Erstellung eines					

Gruppenkurzvortrages zur Diskussion der Wechselwirkungen/Abhängigkeiten unter den o.g. Themen-/Handlungsfeldern (Bearbeitungszeit 1 Woche, Gruppenvortrag 10 Min.))
Requirements for the award of credit points • Bestandene Modulabschlussprüfung: Poster (40%), Eigenvortrag & Diskussionleitung (40%), Gruppenvortrag (20%)
Module applicability • M.Sc. Umweltingenieurwesen
Weight of the mark for the final score Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.
Further Information Die Anmeldung zur Prüfung erfolgt über den Lehrstuhl (NICHT über FlexNow!!!) mit der Auswahl eines Themas für die Posterpräsentation

Environmental Planning + GIS Umweltplanung und GIS					
Module number BI-P11/UI-WPB1	Credits 6 CP	Workload 180 h	Semester[s] 1. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Introduction to environmental planning b) Introduction to geoinformation systems (GIS)			Contact hours a) 2 WLH (30 h) b) 2 WLH (30 h)	Self-study a) 60 h b) 60 h	Frequency a) each winter b) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Annette Hafner a) Dr.-Ing. Sandra Greassidis, Prof. Dr.-Ing. Annette Hafner b) Dr.-Ing. Sandra Greassidis, Prof. Dr.-Ing. Annette Hafner					
Admission requirements					
Learning outcome, core skills Students • have an understanding of working methods and methods of spatial and environmental planning with regard to different planning levels (federal, state, city/municipal level) and sectoral planning (e.g. water management planning, nature conservation planning, waste management planning, urban development planning, etc.) • can use the GIS knowledge they have acquired to evaluate various practical issues in environmental planning					
Contents a) Introduction to spatial planning, in particular environmental planning (water, landscape, development, etc.). The students are familiarised with the working methods and procedures of (environmental) planning by means of practical questions, e.g: • Buildings, infrastructure and the environment • Interdependencies between buildings, infrastructure and the environment • Recording the current state and impact prognosis • Planning systems and planning methods • Integrated urban development planning (resilience, climate protection, green spaces, water / flooding, mobility) • Specialised environmental planning (water, nature conservation, waste, etc.) • Environmental impact assessment, strategic environmental impact assessment • Site search for structures and facilities • Line identification for routes • Informal planning processes b) Geoinformation systems (GIS) are modern instruments for processing and utilising spatial data. They are used worldwide for environmental planning, for example, to record and evaluate the diverse effects of buildings on the environment. Different types of information often have to be processed in large quantities					

and visualised spatially.. This can be done effectively and continuously with the help of geographic information systems (GIS). GIS has become an integral part of civil engineering and environmental planning. Students are given an introduction to ArcGIS from ESRI.

The following topics are covered:

- Introduction to ArcMap, Arc Catalog, ArcToolbox
- Factual queries, spatial queries
- Coordinate systems
- Georeferencing
- Digitising
- Attribute tables (field value calculation, field statistics, etc.)
- Geodata processing (spatial join, attribute join, dissolve, summerise)
- Geoprocessing tools (buffer, clip, merge, etc.)
- Layout creation and editing

Educational form / Language

a) Lecture (2 WLH) / German

b) Lecture (1 WLH) / Tutorial (1 WLH) / German

Examination methods

- Written exam 'Environmental Planning + GIS' (90 min., Part of modul grade 100 %)

Optional term paper in the course 'Introduction to Environmental Planning' to achieve a maximum of 10 bonus points for the written exam (30 hours, submission deadline will be announced at the beginning of the semester)

Requirements for the award of credit points

- Passed final module examination: written exam

Module applicability

- M.Sc. Environmental Engineering
- M.Sc. Civil Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Environmental law (excursion) Umweltrecht (Exkursion)					
Module number W10	Credits 1 CP	Workload 30 h	Semester[s] ab dem 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Environmental law (excursion)			Contact hours a) 1 WLH (15 h)	Self-study a) 30 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marc Wichern a) Dr. jur. Till Elgeti					
Admission requirements Recommended previous knowledge: Lecture on environmental law					
Learning outcome, core skills The students • know the main areas of application of general environmental law, • have in-depth knowledge of special environmental law through concrete examples (spatial planning, nature conservation and landscape management, soil protection-, water protection-, pollution control-, water-, mining- and recycling management law).					
Contents a) The course illustrates • the basic requirements for authorisations set out in environmental law. • specific installations which are relevant under environmental law in detail regarding authorisation and monitoring requirements. • these installations under expert lead.					
Educational form / Language a) Excursion / German					
Examination methods • Seminar 'Environmental law (excursion)' (15 h., ungraded, participation in the excursion with prior presentation [ungraded])					
Requirements for the award of credit points • Participation in the excursion and preliminary meeting					
Module applicability • B.Sc. Civil Engineering • B.Sc. Environmental Engineering • M.Sc. Civil Engineering • M.Sc. Environmental Engineering • M.Sc. Geoscience					
Weight of the mark for the final score Percentage of total grade [%] = 0, ungraded					

Further Information

Registration takes place via the Chair of Urban Water Management and Environmental Technology. Students will be informed in good time via the Moodle course "Environmental Law."

Environmental Risks Umweltrisiken					
Module number 138050	Credits 5 CP	Workload 150 h	Semester[s] 1./2. Sem.	Duration 2 Semester[s]	Group size no limitation
Courses a) Umweltrisiken 1 – Risiken der industriellen Produktion b) Umweltrisiken 2 – Chemikalien in der Umwelt			Contact hours a) 2 WLH (30 h) b) 2 WLH (30 h)	Self-study a) 45 h b) 45 h	Frequency a) each summer b) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marcus Grünewald a) Prof. Dr.-Ing. G. Deerberg b) Prof. Dr.-Ing. G. Deerberg					
Admission requirements Recommended previous knowledge: keine					
Learning outcome, core skills Die Studierenden kennen vertiefte ingenieurwissenschaftliche Grundlagen im Bereich der „Umweltrisiken“. Sie haben die Fähigkeit zu vernetztem und kritischem Denken dabei ausgebaut und sind in der Lage etablierte Methoden und Verfahren zur Minderung der Risiken auszuwählen und entsprechend anzuwenden bzw. Gegenmaßnahmen einzuleiten. Die Studierenden können diese Erkenntnisse auf dem Feld der Risiken auch auf konkrete und neue bzw. analoge Problemstellungen übertragen und bewerten. Die Studierenden sollen nach der Veranstaltung „Umweltrisiken 1“ Kenntnisse über das relevante Regelwerk und den Ablauf von Genehmigungsverfahren für umweltrelevante Maßnahmen haben und in der Lage sein, Maßnahmen und Technologien der industriellen Produktion und der Ressourcenbereitstellung hinsichtlich der Umweltrisiken zu analysieren und zu bewerten sowie bei der Systemplanung und Rohstoffbeschaffung risikoarme Alternativen abzuleiten und zu entwickeln. Die Studierenden sollen nach der Veranstaltung „Umweltrisiken 2“ in der Lage sein, Umweltrisiken aufgrund von Chemikalien, die aus Produkten, nutzungs- oder prozessbedingt freigesetzt werden, zu identifizieren, Möglichkeiten der Risikobeurteilung und -einordnung haben sowie Alternativen entwickeln können.					
Contents a) Umweltrisiken 1: Risiken der industriellen Produktion Einhergehend mit der ansteigenden Technisierung rücken zunehmend die Fragen des Ressourcenverbrauchs in den Mittelpunkt. Dies wird deutlich daran, dass eine Verdoppelung des weltweiten Energiebedarfes bis zum Jahr 2050 prognostiziert wird, der allein auf den Anstieg der Weltbevölkerung unter der Annahme eines nur geringen Wohlstandszugewinnes zurückgeführt wird. Der Klimawandel bedingt zum Teil dramatische Änderungen der Ökosysteme mit Konsequenzen z.B. für die Landwirtschaft aber auch Extremwetterereignisse mit gravierenden Folgen. Durch den Anstieg des Meeresspiegels werden Lebensräume bedroht und die Verknappung von Trinkwasser beschleunigt.					

Im Mittelpunkt der Vorlesung stehen systemische Zusammenhänge der Ressourcenversorgung und des Klimawandels sowie Strategien, mit denen dem Klimawandel zu begegnen ist. Dabei wird auf die Risiken, die mit der Ressourcenbereitstellung und der Nutzung einhergehen, fokussiert. Es wird auf die Risiken, die durch konventionelle, nichtkonventionelle und alternative Ressourcen entstehen, eingegangen. Ein Schwerpunkt ist hier im Bereich der nachwachsenden Rohstoffe gesetzt. In Europa existieren seit vielen Jahrzehnten nationale und internationale Initiativen, mit denen die Basis für Regelungen zur Minderung von Umweltrisiken geschaffen werden sollen. Es wird daher das rechtliche und technische Regelwerk im Umweltbereich behandelt. Neben der Struktur des Regelwerkes wird exemplarisch auf das Chemikalienrecht (REACH), den Emissionshandel und umweltrelevante Genehmigungsverfahren eingegangen, die heute oft in partizipative Prozesse münden. Gliederung:

Einführung

- Hintergründe und Inhalte der Vorlesung
- Einführung in die Thematik
- Einleitende Begriffe und Definitionen
- Lernziele

Ressourcen und Klimawandel

- Risiken der Produktion fossiler Energieträger
- Risiken nachwachsender Rohstoffe

Angewandter Umweltschutz

- Technisches und rechtliches Regelwerk
- Genehmigungsverfahren

b)

Umweltrisiken 2: Chemikalien in der Umwelt

Der heutige Lebensstandard westlicher Nationen ist zum Vorbild und Ziel für die Schwellen- und Entwicklungsländer geworden. Viele Produkte, die in diesem Umfeld entstehen und genutzt werden, sind von Chemikalien geprägt, die während der Herstellung, störungsbedingt, während der Nutzung oder bei der Entsorgung in die Umwelt gelangen. Verunreinigungen der Umwelt mit Chemikalien haben zum Teil sehr langfristige, heute oftmals noch nicht absehbare Folgen. So wird durch die Emission von Arzneimittelresten wie z.B. Antibiotika der medizinische Fortschritt aufgrund wachsender Resistenzen von Keimen in Frage gestellt. Hormonähnlich, kanzerogen oder mutagen wirkende Substanzen können in schon kaum messbar geringen Konzentrationen langfristige Auswirkungen auf Ökosysteme und den Menschen aufweisen. Umso bedeutsamer ist die frühzeitige Analyse und Bewertung von Chemikalien, um möglichst vor der Verbreitung in der Umwelt Klarheit über die Risiken zu schaffen. In der Veranstaltung werden Wirkmechanismen, Bewertungsmethoden und -kriterien sowie Gegenmaßnahmen in Bezug auf die genannten Umweltrisiken diskutiert. Es werden Methoden zur Ermittlung und zur vergleichenden Bewertung sowie Hinweise zur Einordnung von Umweltrisiken gegeben. Gliederung:

Einführung

- Hintergründe und Inhalte der Vorlesung
- Einführung in die Thematik
- Einleitende Begriffe und Definitionen
- Lernziele

Stoff- und prozessbezogene Risiken

- Chemikalien in der Umwelt/ Umweltrelevanz von Chemikalien
- Störungsbedingte Risiken
- Prozessrisiken: Anatomie von Störfällen
- Ausbreitung von Stoffen im Boden

Risiko und Risikobewertung

- Methoden zur Risikoeinschätzung und -quantifizierung
- Risikowahrnehmung

Educational form / Language

a) Lecture (2 WLH) / German

b) Lecture (2 WLH) / German

Examination methods

- Oral exam 'Umweltrisiken' (45 min., Part of modul grade 100 %)

Requirements for the award of credit points

Bestandene Modulabschlussprüfung: mündliche Prüfung

Module applicability

MSc. Umweltingenieurwesen

Weight of the mark for the final score

Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Environmental Protection in Chemical Industry Umweltschutz in der chemischen Industrie					
Module number 137430	Credits 3 CP	Workload 90 h	Semester[s] 1./3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Umweltschutz in der chemischen Industrie			Contact hours a) 2 WLH (30 h)	Self-study a) 60 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marcus Grünewald a) Dr. D. Förtsch					
Admission requirements Recommended previous knowledge: keine					
Learning outcome, core skills Nach dem erfolgreichen Abschluss des Moduls können Studierende - wesentliche Zusammenhänge und Konzepte des Umweltschutzes in der chemischen Industrie benennen und beschreiben - das Konzept der "Besten Verfügbaren Technologien (BVT)" verstehen und anwenden - Zudem produktionsintegrierte Verfahren sowie derzeit angewandte technische End-of-Pipe-Verfahren zur Abluft-, Abwasser- und Abfallbehandlung benennen, beschreiben und gegen andere Verfahren bewerte. - die Wirkprinzipien der einzelnen Verfahren beschreiben und deren Einsatzbereich und -grenzen aufzeigen. - den Einsatz der verschiedenen Verfahren für konkrete Anwendungsfälle zu bewerten.					
Contents a) Umweltschutz-Vorschriften, Mess- und Abscheidetechnik für Staub, Gase und Dämpfe aus Abgas, Mess- und Abscheidetechnik für Abwasserinhaltsstoffe, Abfallbeseitigungstechnik, Bodensanierung, Lärmschutz					
Educational form / Language a) Lecture (2 WLH) / German					
Examination methods Oral exam 'Umweltschutz in der chemischen Industrie' (30 min., Part of modul grade 100 %)					
Requirements for the award of credit points Bestandene Modulabschlussprüfung: mündliche Prüfung					
Module applicability Msc. Umweltingenieurwesen					
Weight of the mark for the final score Percentage of total grade [%] = $3 \cdot 100 \cdot \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.					
Further Information					

Environmental Sustainability and Recycling of Construction Materials Umweltverträglichkeit von Baustoffen und Bauen im Bereich Umweltschutz					
Module number BI-WP25/UI-WPB4	Credits 6 CP	Workload 180 h	Semester[s] 2./3. Sem.	Duration 2 Semester[s]	Group size no limitation
Courses a) Environmental Sustainability and Recycling of Construction Materials b) Concrete structures for environmental protection			Contact hours a) 2 WLH (30 h) b) 2 WLH (30 h)	Self-study a) 60 h b) 60 h	Frequency a) each winter b) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. habil. Iurie Curosu a) Prof. Dr.-Ing. Christoph Müller b) Dr.-Ing. Dieter Lehnen					
Admission requirements Recommended previous knowledge: Knowledge in the design of reinforced concrete structures under serviceability limit states as well as in construction materials and building physics					
Learning outcome, core skills The students • can apply advanced knowledge of the structural design and calculation of sealing and barrier structures. • can evaluate the significant effects of construction materials on the environment and their environmentally friendly recycling and reintegration into the material cycle. • are able to develop concrete designs and assess constructive measures for both new buildings and the repair of existing structures.					
Contents a) Principles of sustainable building • Environmentally relevant aspects in the production of construction materials • Influence of construction materials on the environment • Environmentally friendly recycling of construction materials and their reintegration into the material cycle b) Fundamentals (facets of environmental protection, regulations, laws) • Constructive design (relevant regulations and construction methods) • Selected concrete structures of fossil power plants • Nuclear engineering • Special aspects (including offshore)					
Educational form / Language					

- a) Lecture (2 WLH) / German
b) Lecture (2 WLH) / German

Examination methods

- Written exam 'Environmental Sustainability and Recycling of Building Materials' (90 min., Part of modul grade 100 %)

Requirements for the award of credit points

- Passed written examination of the module

Module applicability

- M.Sc. Civil Engineering
- M.Sc. Environmental Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Literature:

- a) Course related transcripts
b) Slide and link collections

Handling Systems for Supply and Disposal Streams of Power Plants					
Ver- und Entsorgungstechnik von Kraftwerken					
Module number 139060	Credits 5 CP	Workload 150 h	Semester[s] 3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Ver- und Entsorgungstechnik von Kraftwerken			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. V. Scherer a) Priv.-Doz. Dr.-Ing. Martin Schiemann					
Admission requirements Empfohlene Vorkenntnisse: Strömungsmechanik, Thermodynamik, Wärme- und Stoffübertragung					
Learning outcome, core skills Die Studierenden kennen: • die unterschiedlichen Techniken zur Versorgung von Kraftwerken mit den Arbeitsmedien Wasser, Luft und Brennstoff sowie die Entsorgung der anfallenden Reststoffe, • exemplarisch den Stand moderner Forschung, • modernste Methoden, Anwendungsbeispiele und das entsprechende Fachvokabular. Ferner können die Studierenden • komplexe mathematische Problemstellungen in physikalischen Systemen fachübergreifend mit geeigneten Methoden lösen, • Erkenntnisse auf konkrete und neue Problemstellungen übertragen, • komplexe ingenieurtechnische Probleme fachübergreifend modellieren und lösen sowie eigene Ansätze entwickeln und umsetzen. Die Studierenden haben • die Fähigkeit zu vernetztem und kritischem Denken ausgebaut und sind in der Lage etablierte Methoden und Verfahren auszuwählen und anzuwenden, • vertiefte, auch interdisziplinäre Methodenkompetenz erworben und können diese situativ angepasst anwenden. Die Studierenden praktizieren wissenschaftliches Lernen und Denken. Nach dem erfolgreichen Abschluss des Moduls können Studierende • Sinnvolle Annahmen über Anlagenparameter abschätzen und zur Auslegung notwendige Informationen beschaffen. • die Dimensionen von zu- und abzuführenden Stoffströmen energietechnischer Anlagen abschätzen und grundlegende Konzepte zur Behandlung einzelner Ströme entwerfen. • Einzelne Auslegungsvarianten quantitativ bewerten. • Umweltwechselwirkungen prüfen. • Kosten-Nutzen-Zusammenhänge untersuchen.					
Contents					

a)

Die Vorlesung „Ver- und Entsorgungstechnik von Kraftwerken“ behandelt die unterschiedlichen Techniken zur Versorgung von Kraftwerken mit den Arbeitsmedien Wasser, Luft und Brennstoff sowie die Entsorgung der anfallenden Reststoffe. Ausgangspunkt der Vorlesung ist die Wasseraufbereitung und Konditionierung mit ihren chemischen Grundlagen. Die Kühlung solcher Anlagen incl. der Kühlturmauslegung und die Brennstoffversorgung werden besprochen. Die Entsorgung von Kraftwerken beinhaltet die Rauchgasbehandlung durch chemische und physikalische Verfahren sowie die Ausbreitung von Schadstoffen in der Atmosphäre. Eine Übersicht über die Schadstoffbildungsmechanismen schließt die Veranstaltung ab.

Educational form / Language

a) Lecture (3 WLH) / Tutorial (1 WLH) / German

Examination methods

- Written exam 'Ver- und Entsorgungstechnik von Kraftwerken' (120 min., Part of modul grade 100 %, Bei einer Teilnehmerzahl <= 10 Teilnehmer*innen kann die Prüfung mündlich durchgeführt werden.)

Requirements for the award of credit points

Bestandene Modulabschlussprüfung: Klausur

Module applicability

- MSc. Maschinenbau
- MSc. Sales Engineering and Product Management
- MSc. Umweltingenieurwesen

Weight of the mark for the final scorePercentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Medienformen: Vorlesungsfolien (pdf/Powerpoint)

- 1. Skript Ver- und Entsorgungstechnik von thermischen Kraftwerken
- 2. Adrain, F., Quittek, C., Wittoch, E., Fossil beheizte Dampfkraftwerke, Handbuch
- Energie (Hrsg. T. Bohn), Technischer Verlag Resch, 1986.
- 3. Baumbach, G., Luftreinhaltung, 2. Auflage, Springer-Verlag, Berlin, 1992.
- 4. Fritz, W., Kern, H., Reinigung von Abgasen, 3. Auflage, Vogelverlag, Würzburg, 1992.
- 5. Strauß, K., Kraftwerkstechnik, Springer-Verlag, 5. Aufl., 2006.
- 6. Wieland, G., Wasserchemie, 12. Auflage, Vulkan-Verlag, Essen, 1998.

Process Development & Plant Design Verfahrensentwicklung und Anlagenplanung					
Module number 139350	Credits 5 CP	Workload 150 h	Semester[s] 1. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Verfahrensentwicklung und Anlagenplanung			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marcus Grünewald a) Prof. Dr.-Ing. Marcus Grünewald					
Admission requirements Recommended previous knowledge: abgeschlossenes Modul „Grundlagen der Verfahrenstechnik“					
Learning outcome, core skills Nach dem erfolgreichen Abschluss des Moduls können Studierende • Prozesse zur Herstellung chemischer Produkte entwickeln und deren Auswirkungen auf Umwelt und Gesellschaft einschätzen • charakteristische Merkmale von Syntheserouten bewerten und prozesstechnische Auslegungsregeln anwenden sowie den notwendigen Informationsbedarf für diese Aufgaben erkennen und diese Informationen beschaffen • in gängigen Simulationsumgebungen (Aspen Plus®) Prozesse implementieren, Simulationen durchführen und deren Ergebnisse anhand von Parameter- und Sensitivitätsanalysen kritisch bewerten sowie aus den Ergebnissen weiteren Handlungsbedarf ableiten. • die Phasen und Probleme der Anlagenplanung erklären und einzelne Problemstellungen in den Planungsphasen einordnen					
Contents a) In der Lehrveranstaltung werden die Methoden der Verfahrensentwicklung und der Anlagenplanung vermittelt. Dazu werden insbesondere nachfolgende Themen adressiert: • wissenschaftliche Methoden der Prozessentwicklung und Anlagenplanung • Methoden und Kriterien der Reaktorauswahl und Reaktionsführung • Thermodynamische Voraussetzungen zur Auswahl und Synthese von Trennsequenzen • Patente als Informationsquelle für die Prozessentwicklung • Prozesstechnische Möglichkeiten der Wärme- und Ressourcenintegration • Simulation verfahrenstechnischer Prozesse mittels Aspen Plus® • Methoden und Dokumente der Anlagenplanung (Erstellung der Mengen- und Enthalpiebilanzen, Prozessdarstellung im Grund-, Verfahrens- und R&I-Fließbild, Aufstellungs- und Rohrleitungsplanung, apparate- und maschinentechnische Auslegung, Einbindung des prozessintegrierten Umweltschutzes, wärmetechnische Optimierung) in den verschiedenen Planungsphasen • Für die Planung notwendige Investitions- und Produktionskostenbetrachtungen					
Educational form / Language a) Lecture (2 WLH) / Tutorial (2 WLH) / German					

Examination methods

- Oral exam 'Verfahrensentwicklung und Anlagenplanung' (30 min., Part of modul grade 100 %)

Requirements for the award of credit points

- Bestandene Modulabschlussprüfung: mündliche Prüfung

Module applicability

- MSc. Maschinenbau
- MSc. Sales Engineering and Product Management
- MSc. Umweltingeniuerwesen

Weight of the mark for the final score

Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

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Further Information

Transportation Planning Verkehrsplanung					
Module number BI-WP32/UI-WPC5	Credits 6 CP	Workload 180 h	Semester[s] 3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Transport Planning Models b) Evaluation Procedures in Transport			Contact hours a) 2 WLH (30 h) b) 2 WLH (30 h)	Self-study a) 60 h b) 60 h	Frequency a) each winter b) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Justin Geistefeldt a) Prof. Dr.-Ing. Justin Geistefeldt b) Dr.-Ing. Sandra Hohmann					
Admission requirements Recommended previous knowledge: Fundamentals of transportation and traffic engineering					
Learning outcome, core skills Students • have differentiated knowledge of the basic features of handling modern traffic models, • are able to develop simple logit or probit models independently, • are able to subject modelling approaches to critical evaluation and can understand new developments, • have the necessary knowledge and skills to apply transport planning software in their area of responsibility, • are able to assess the effect of the selection of different parameters on the calculation results • have differentiated knowledge of the effects of traffic measures on accidents and noise and pollution levels, • have the ability to independently apply the economic efficiency calculation methods used in practice for transport infrastructure investments and to understand the theoretical background of the methods, • are able to quantify and monetise the traffic effects of various measures and thus evaluate them in economic terms, • are able to judge the quality of the calculation methods and results and to assess the limits of the methods					
Contents a) Traffic modelling comprises four steps: traffic generation, traffic distribution, traffic distribution and traffic reallocation. This process and its variants are presented using examples. In addition to the classic modelling approaches, behaviour-oriented planning models are also considered. These include Route chain models, logit models, nested logit models, probit models, gravity and entropy models as well as reallocation models. The calculation methods of traffic modelling are applied in the exercises. In addition, standard programmes for traffic generation, traffic assignment and simulation are briefly introduced. The background and application of the VISEM and VISUM software is explained in detail as an example of traffic planning software. Concrete planning cases deepen the theory by working on the computer in small groups.					

b)

The economic viability of investments in transport infrastructure is usually examined and economically assessed on the basis of benefit-cost analyses (BCA). To compare the benefits and costs of a measure, the effects on traffic are quantified and monetarised. The effects of traffic on accidents and the environment are analysed in more detail.

In the lectures, the theoretical background of the procedures for quantifying traffic effects and the individual procedural steps of cost-effectiveness analyses are presented. Accident analyses and safety concepts as well as methods for calculating noise and pollution levels are also dealt with in depth. In the exercises, investment measures are examined and evaluated on the basis of specific planning tasks.

Educational form / Language

a) Lecture (1,5 WLH) / Tutorial (0,5 WLH) / German

b) Lecture (1,5 WLH) / Tutorial (0,5 WLH) / German

Examination methods

- Written exam 'Transportation Planning' (120 min., Part of modul grade 100 %)

Requirements for the award of credit points

- Passed module final exam: written exam

Module applicability

- M.Sc. Civil Engineering
- M.Sc. Environmental Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Transportation Systems Verkehrssysteme					
Module number BI-WP31/UI-WPC4	Credits 6 CP	Workload 180 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Public Transport b) Traffic Management c) Air Transport			Contact hours a) 2 WLH (30 h) b) 2 WLH (30 h) c) 1 WLH (15 h)	Self-study a) 60 h b) 30 h c) 15 h	Frequency a) each summer b) each summer c) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Justin Geistefeldt a) Prof. Dr.-Ing. Justin Geistefeldt b) Prof. Dr.-Ing. Justin Geistefeldt c) Prof. Dr. Edmund Krieger					
Admission requirements Recommended previous knowledge: Fundamentals of transportation and traffic engineering					
Learning outcome, core skills Students • have advanced knowledge of planning and operational tasks in the field of public transport, • are able to reflect on the interaction of the individual components of public transport (infrastructure, vehicles, legal framework, economic efficiency, form of operation), • have differentiated knowledge of the methods and systems of transport management and are able to develop and professionally assess transport management measures, • have advanced knowledge of the classic and current technical, legal and economic developments in air traffic. • are able to apply the special planning procedures for air traffic facilities to the various practical and professional fields.					
Contents a) The basics of planning, building and operating local public transport systems are covered. Topics of the lecture are: Legal conditions, tasks and areas of application of transport systems in public transport, requirements for public transport systems, network planning in public transport, stop design, connection points and transfer facilities, operational preparation (operational concepts, timetable design, vehicle and personnel scheduling), operational management (control, security, monitoring), economic efficiency. b) The course covers methods and systems of traffic management in road transport, including new developments in the field of intelligent transport systems. Topics of the lecture are: Fundamentals of road traffic law, signposting, traffic control on motorways, network control, traffic management centres, organisation of traffic management, road works management, traffic safety management, mobility management.					

c)

The lecture primarily deals with the planning and operation of airports. It covers the following topics: Flight operation areas, air traffic control, passenger receiving facilities, cargo terminals and other operational facilities. Environmental aspects are also covered.

Educational form / Language

- a) Lecture (1,5 WLH) / Tutorial (0,5 WLH) / German
- b) Lecture (2 WLH) / German
- c) Lecture (1 WLH) / German

Examination methods

- Written exam 'Transportation Systems' (120 min., Part of modul grade 100 %)

Requirements for the award of credit points

- Passed module final exam: written exam

Module applicability

- M.Sc. Civil Engineering
- M.Sc. Environmental Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Traffic Engineering Verkehrstechnik					
Module number BI-WP30/UI-WPC3	Credits 6 CP	Workload 180 h	Semester[s] 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Transportation Engineering			Contact hours a) 4 WLH (60 h)	Self-study a) 120 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Justin Geistefeldt a) Prof. Dr.-Ing. Justin Geistefeldt					
Admission requirements Recommended previous knowledge: Advanced mathematics, fundamentals of transportation engineering					
Learning outcome, core skills Students • have a differentiated understanding of the laws governing traffic flow on roads and are able to reflect on scientific methods of describing these laws and recognize their practical applicability. • are able to independently develop extensions or adaptations of traffic flow models, • have an in-depth understanding of the theoretical background and the possible applications and limitations of traffic simulation models, • have up-to-date technical knowledge and advanced knowledge of methods for traffic analysis and intersection control, • are able to understand the planning techniques used in practice for traffic light systems and to design complex systems, including coordination, in a practical manner.					
Contents a) The theoretical principles for describing traffic flow on roads and at intersections are developed using mathematical methods. The underlying laws are derived. The basic methods, control systems, and equipment required for their operation are covered for the traffic analysis and design of road intersections. The methods commonly used in practice are illustrated with examples in the exercises. The following topics are covered in detail: • Parameters of traffic flow and their interrelationships • Fundamental diagram • Capacity • Traffic engineering design • Free traffic flow • Continuum theory • Distance models • Vehicle following theory • Microscopic traffic flow simulation • Waiting time determination at intersections					

- Fixed-time control of traffic signal systems
- Coordination of traffic signal systems
- Traffic-dependent control including signal program formation
- Signal technology
- Right-of-way controlled intersections

Educational form / Language

a) Lecture (3 WLH) / Tutorial (1 WLH) / German

Examination methods

- Written exam 'Traffic Engineering' (120 min., Part of modul grade 100 %)

Requirements for the award of credit points

- Passed module final exam: written exam

Module applicability

- M.Sc. Civil Engineering
- M.Sc. Environmental Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Water Chemistry and Laboratory Course					
Wasserchemie und Laborpraktikum					
Module number BI-WP39/UI-WPD5	Credits 6 CP	Workload 180 h	Semester[s] 3. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Water Chemistry b) Research exercise in urban water management			Contact hours a) 2 WLH (30 h) b) 2 WLH (30 h)	Self-study a) 60 h b) 60 h	Frequency a) each winter b) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Marc Wichern a) Prof. Dr.-Ing. Marc Wichern, Dr. rer. nat. Eva Heinz b) Prof. Dr.-Ing. Marc Wichern, Dr. rer. nat. Eva Heinz					
Admission requirements Recommended previous knowledge: Urban water management I + II					
Learning outcome, core skills The students • have a comprehensive overview of the current state of technology and science in the field of water chemistry. • are able to understand the chemical processes in water and have the ability to combine and apply these in the treatment of water and the purification of wastewater. • are familiar with the determination of relevant test parameters in water and wastewater analysis. • are able to carry out physico-chemical determinations independently. • are able to critically assess the informative value of analytical results and practise scientific learning and thinking by preparing test protocols.					
Contents a) • Chemical basics • the importance of the water cycle in chemistry • Introduction to chemical water treatment b) The research exercise introduces students to • analytics • sampling • conservation of analytical methods relevant to water management and the implementation of special analysis methods regarding wastewater technics, such as the photometric determination of nitrogen parameters.					
Educational form / Language a) Lecture (1 WLH) / Tutorial (1 WLH) / German b) Tutorial (2 WLH) / German					

Examination methods

- Oral exam 'Water Chemistry and Laboratory Course' (60 min., Part of modul grade 100 %, 20 minutes, oral questions: 40 minutes)
- Term paper 'Report on research exercise in urban water management' (15 h., Part of modul grade 0 %)

Requirements for the award of credit points

- Passed module final exam: Written exam
- Passed research exercise report
- Attendance at research exercise

Module applicability

- M.Sc. Civil Engineering
- M.Sc. Environmental Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Materials for Energy Technology Werkstoffe der Energietechnik					
Module number 137150	Credits 5 CP	Workload 150 h	Semester[s] 1./3. Sem.	Duration 1 Semester[s]	Group size 60
Courses a) Werkstoffe der Energietechnik			Contact hours a) 4 WLH (60 h)	Self-study a) 90 h	Frequency a) each winter
Module coordinator and lecturer(s) Prof. Dr.-Ing. Alexander Kauffmann a) Dr. rer. nat. Christoph Somsen, Prof. Dr.-Ing. Alexander Kauffmann					
Admission requirements Recommended previous knowledge: keine					
Learning outcome, core skills Die Studierenden sind nach dem erfolgreichen Abschluss des Moduls in der Lage, • die Eigenschaften von Hochtemperaturwerkstoffklassen, wie angelassene martensitische Chromstähle und Ni-Basissuperlegierungen zu beurteilen. • Lebensdauerkonzepte zu beurteilen und zu prüfen. • kritische Komponenten in Energieanlagen und deren Anforderungen an die Werkstoffeigenschaften zu bewerten. • eine Werkstoffauswahl anforderungsgerecht durchzuführen.					
Contents a) In dieser Vorlesung werden Werkstoffe und deren Eigenschaften besprochen, die in Systemen eingesetzt werden, die unsere Energieversorgung sicherstellen. Die Vorlesung soll an einigen Beispielen aufzeigen, dass unabhängig von der Art der Energieumwandlung, strukturelle und funktionelle Werkstoffeigenschaften von entscheidender Bedeutung sind. Unter anderem werden folgende Themenbereiche beleuchtet: • Kriechen, die Spannungsrelaxation, Ermüdung und Hochtemperaturoxidation von Werkstoffen • Beispielhaft werden einige Schlüsselkomponenten von Energieanlagen, wie z. B. (i) das Sammlerrohr im Dampfkraftwerk, (ii) der Rohrbogen im Dampfkraftwerk und (iii) die Turbinenschaufel in Gasturbinen behandelt • Verfestigungskonzepte im Bereich von Hochtemperaturwerkstoffen, wie Mischkristallverfestigung, Ausscheidungsverfestigung und Verbundverstärkung werden behandelt • Einige ausgewählte Werkstoffprobleme aus den Bereichen Windenergie, Solarenergie und Energiespeicherung werden angesprochen, insbesondere hier lebensdauerbegrenzende Schädigungsmechanismen					
Educational form / Language a) Lecture with tutorial / German					
Examination methods • Written exam 'Werkstoffe der Energietechnik' (180 min., Part of modul grade 100 %)					
Requirements for the award of credit points Bestandene Modulabschlussprüfung: Klausur					

Module applicability

- MSc. Maschinenbau
- MSc. Sales Engineering and Product Management
- MSc. Materials Science and Simulation
- MSc. Umweltingenieurwesen

Weight of the mark for the final score

Percentage of total grade [%] = $5 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

Ein Skriptum zur Vorlesung ist vorhanden

Wind effects – Engineering Structures and Wind Turbines					
Windwirkungen – Ingenieurbauwerke und Windenergieanlagen					
Module number BI-WP45	Credits 6 CP	Workload 180 h	Semester[s] ab dem 2. Sem.	Duration 1 Semester[s]	Group size 30
Courses a) Wind effects – Engineering Structures and Wind Turbines			Contact hours a) 4 WLH (60 h)	Self-study a) 120 h	Frequency a) each summer
Module coordinator and lecturer(s) Prof. Dr.-Ing. Rüdiger Höffer a) Prof. Dr.-Ing. Rüdiger Höffer					
Admission requirements Recommended previous knowledge: Knowledge of fluid mechanics, statics and structural engineering, effects on structures and safety theory, building and industrial construction, bridge construction, structural health monitoring					
Learning outcome, core skills Students will be able to • Use and evaluate statistical analyses of wind data (extreme values and basic ensemble) • Interpret wind effects and impacts on civil engineering structures and wind turbines and apply them in a differentiated manner in structural design • Use and evaluate other relevant regulations for civil engineering structures in addition to technical building regulations introduced by building authorities • Interpret and use results from related wind tunnel tests • Compare, select, and combine wind loads on structures using various methods • Determine aerodynamic forces on a rotor blade of a wind turbine • Use the FE analysis computer program "ASHES" to visualize wind effects on wind turbines • Explain and use the identification of structural dynamic parameters from monitoring data • Demonstrate load cycle counts and fatigue analyses based on monitoring data					
Contents a) • Statistical description of wind fields: - Design wind - Wind as a resource • Wind action models for linear and surface building structures • Static equivalent methods for determining stress for static calculation • Experiments in the boundary layer wind tunnel (partly digital as a "remote access laboratory"): - Physical boundary layer generation in wind tunnel model - Measurement methods and sensor technology - Measurement data evaluation and wind load determination • Applications for linear and flat structures: - Chimneys and masts - Wide-span roofs (e.g., stadium roofs) - Cooling tower shells (structural regulations in cooling tower construction BTR)					

- Container shells (including silos) • Wind turbines: - Structure and design - Wind effects and wave action • Offshore wind energy: - Project development - Current and future situation with example projects • Small wind turbines: - Wind energy in urban areas - Savonius and Darrieus rotors • Solar updraft power plants: - Construction of tower and collector - Wind effects • Simulation of wind effects on wind turbines (onshore and offshore) using the FE program "ASHES" - Model construction, load generation, and visualization of results • Strategies for damage and service life estimation of structural components (including application of structural health monitoring for life cycle management)
Educational form / Language a) Seminar / Lecture (4 WLH) / German / English
Examination methods • Seminar 'Wind effects – Engineering Structures and Wind Turbines' (60 h., Part of modul grade 100 %, poster creation with presentation (30 min))
Requirements for the award of credit points • Creation of a poster and presentation
Module applicability • M.Sc. Civil Engineering • M.Sc. Environmental Engineering (optional module)
Weight of the mark for the final score Percentage of total grade [%] = $6 * 100 * \text{FAK} / \text{DIV}$ FAK: The weighting factors can be taken from the table of contents. DIV: The values can be taken from the table of contents.
Further Information Lectures, exercises, and seminars (designed by students), German (and English)

Non-Destructive Testing and Diagnostics of Structures and Environmental Systems Zerstörungsfreie Diagnostik von Bauwerken und Umweltsystemen					
Module number BI-W78	Credits 3 CP	Workload 90 h	Semester[s] ab dem 2. Sem.	Duration 1 Semester[s]	Group size no limitation
Courses a) Non-Destructive Testing and Diagnostics of Structures and Environmental Systems			Contact hours a) 2 WLH (30 h)	Self-study a) 60 h	Frequency a) each summer
Module coordinator and lecturer(s) Dr.-Ing. Christoph Baer a) Dr.-Ing. Christoph Baer					
Admission requirements Recommended previous knowledge: Basic knowledge of mathematics, physics, and engineering fundamentals at bachelor's level is recommended. Prior knowledge of electrical engineering or measurement technology is helpful but not required.					
Learning outcome, core skills Students acquire knowledge of modern non-destructive and non-contact measurement techniques for assessing the condition of structures, infrastructure systems, and environmental systems. Upon successful completion of the module, students will be able to: • explain the physical principles of wave- and radiation-based measurement techniques, • understand the operating principles of non-contact sensors and diagnostic systems, • select suitable methods for different inspection, assessment, and monitoring tasks, • interpret and critically evaluate measurement data obtained from non-destructive testing methods, • identify limitations, uncertainties, and environmental influences affecting non-contact measurements, compare different diagnostic techniques with respect to effort, information content, and practical applicability.					
Contents a) • Fundamentals of electromagnetic, acoustic, and optical measurement techniques • Wave propagation, reflection, and time-of-flight measurements • Radar systems for distance, motion, and subsurface sensing • Ground-Penetrating Radar (GPR) for the investigation of structures, soils, and infrastructure systems • Doppler radar for displacement, vibration, and motion monitoring • Ultrasonic testing methods for material characterization and condition assessment • Infrared thermometry for non-contact temperature measurements • Infrared thermography for the detection of thermal bridges, moisture intrusion, and structural defects • Fibre-optic monitoring systems for strain and temperature measurements • Integration and evaluation of non-destructive testing and monitoring techniques • Case studies in structural health monitoring, infrastructure diagnostics, and environmental monitoring					
Educational form / Language					

a) Lecture with tutorial / German

Examination methods

- Oral exam 'Non-Destructive Testing and Diagnostics of Structures and Environmental Systems' (30 min., Part of modul grade 100 %, Presentations given within the expert-group format may be considered as a bonus component.)

Requirements for the award of credit points

- Successful completion of the oral module examination

Module applicability

- M.Sc. Civil Engineering
- M.Sc. Environmental Engineering

Weight of the mark for the final score

Percentage of total grade [%] = $3 * 100 * \text{FAK} / \text{DIV}$

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information

- Lectures with integrated exercises
- Demonstrations of selected non-contact measurement techniques
- Discussion of practical case studies

Optionally, an expert-group format is offered in which student teams independently investigate an advanced sensing topic and present their findings at the end of the semester.

Master's degree program "Environmental Engineering"
Curriculum

Status 17.03.26

							Specialization					
		Module code	Module title	SWS	CP	Semester	Sustainable Systems and Technologies	Sustainability in the Built Environment	Road and Traffic Engineering and Infrastructure Planning	Water Management and Geotechnics		
Compulsory module												
1. / 2. Semester	Compulsory modules 22 CP	UI-P1	Mathematical Statistics	4	5	WiSe	X	X	X	X		
		UI-P2	Modeling of environmental processes	4	6	WiSe	X	X	X	X		
		UI-P3	Operations Research and Databases	4	6	WiSe	X	X	X	X		
		UI-P4	Environmental Engineering II	4	5	SuSe	X	X	X	X		
Compulsory optional modules												
1. - 3. Semester	Compulsory optional modules 52 CP of which one project (PA) and at least three modules from category 1	Sustainable Systems and Technologies										
		UI-WPA1	Process Development & Plant Design	4	5	WiSe	1					
		UI-WPA2	Circular Process Engineering	4	5	SuSe	2					
		UI-WPA3	Computer Aided Process Design	4	5	SuSe	2					
		UI-WPA4	Mechanical Process Engineering	4	5	WiSe	1					
		UI-WPA5	Processes in Mechanical Process Engineering	4	5	SuSe	2					
		UI-WPA8	High Pressure Process Technology	4	5	SuSe	2					
		UI-WPA9	Integrated High-Pressure Methods	4	5	WiSe	2					
		UI-WPA10	Processthermodynamics	4	5	WiSe	2					
		UI-WPA11	Thermodynamics of Mixtures	4	5	SuSe	1					
		UI-WPA12	Model based Design of Reactors and Separation Units	4	5	SuSe	2					
		UI-WPA13	Waste, Gas and Wastewater Treatment	4	5	WiSe/SuSe	2					
		UI-WPA14	Occupational and Plant Safety	2	3	WiSe	2					
		UI-WPA15	Air Quality	4	5	SuSe	2	2	2			
		UI-WPA16	Environmental Risks	4	5	SuSe/WiSe	2					
		UI-WPA17	Thermal Power Plants	4	5	WiSe	2					
		UI-WPA18	Handling Systems for Supply and Disposal Streams of Power Plants	4	5	WiSe	2					
		UI-WPA20	Nuclear Power Plants Engineering	4	5	WiSe	2					
		UI-WPA21	Demand and Supply Energy Markets	4	5	SuSe	2					
		UI-WPA22	Computer Simulation of Fluid Flow	4	5	SuSe	2			2		
		UI-WPA23	Technical Combustion	4	5	SuSe	2					
		UI-WPA24	Energy Storage Technologies and Applications	4	5	WiSe	2					
		UI-WPA26	Materials for Energy Technology	4	5	WiSe	2					
		UI-WPA27	Chemical Processes for Closed Carbon Cycles	4	5	SuSe	1	2		2		
		UI-WPA28	Chemical Energy Storage and Carbon-Based Feedstocks	4	5	WiSe	2					
		UI-WPA29	Process Simulation of Energy Plants	4	5	WiSe	2					
		UI-WPA30	Energy Systems Analysis	4	5	WiSe	1					
		UI-WPA32	Management of Non-Renewable and Renewable Resources	2	3	WiSe	2					
		UI-WPA33	Environmental Protection in Chemical Industry	2	3	WiSe	2					
		UI-WPA34	Carbon Dioxide Capture from Industrial Processes	4	5	SuSe	2					
		UI-WPA35	Operations Research for Energy System Applications	4	5	SoSe	1	2				
		Sustainability in the Built Environment										
			UI-WPB1	Environmental Planning + GIS	4	6	WiSe		1	2	2	
			UI-WPB2	Material Flow Management	4	6	SuSe	2	1			
			UI-WPB3	Sustainable Building	4	6	WiSe		2			
			UI-WPB4	Environmental Sustainability and Recycling of Construction Materials	4	6	WiSe/SuSe	2	2			
			UI-WPB5	Spatial data analysis and environmental modelling	4	6	WiSe		1	2	2	
			UI-WPB6	Sustainable operation and resource conservation with urban water management facilities	4	6	WiSe		2		2	
		Road and Traffic Engineering and Infrastructure Planning										
			UI-WPC1	Design of roads, material models and practical aspects in road construction technology	5	6	WiSe		2	1		
			UI-WPC2	Sustainability and Digitisation in road construction	5	6	SuSe		1	1	2	
			UI-WPC3	Traffic Engineering	4	6	SuSe			1		
			UI-WPC4	Transportation Systems	5	6	SuSe			2		
			UI-WPC5	Transportation Planning	4	6	WiSe			1		
			UI-WPC6	Durability and Repair of Concrete Structures	4	6	SuSe			2		
		Water Management and Geotechnics										
			UI-WPD1	Sustainable Water Resources Management	4	6	WiSe		2	2	1	
			UI-WPD2	Hydrology	4	6	SuSe			2	1	
			UI-WPD3	Transport and fate of substances in river basins	4	6	SuSe				2	
			UI-WPD4	Intern. Wastewater Treatment, Industrial Wastewater Treatment and River Water Quality	4	6	SuSe	2		2	1	
			UI-WPD5	Water Chemistry and Laboratory Course	4	6	WiSe				1	
			UI-WPD6	Innovations in Urban Water Management and Mathematical Simulation	5	6	WiSe/SuSe				2	
			UI-WPD7	Environmental Geotechnics	4	6	SuSe	2			1	
			UI-WPD8	Earthworks – Soil mechanical background and practice	4	6	WiSe			2	1	
			UI-WPD9	Physical Geology and Laboratory Training Soil Mechanics	4	6	WiSe				2	

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Continuation of the Master's degree program "Environmental Engineering" Curriculum

		Module code	Module title	CP	Semester	Specialization			
						Sustainable Systems and Technologies	Sustainability in the Built Environment	Road and Traffic Engineering and Infrastructure	Water Management and Geotechnics
1. - 3. Semester	Continuation of compulsory optional modules	Projects							
		UI-PA1	Interdisciplinary Project	6	WiSe or SuSe	X	X	X	X
		UI-PA2	Project Sustainable Systems and Technologies	12		X			
		UI-PA3	Project Sustainability in the built environment	10			X		
		UI-PA4	Project Road and Traffic Engineering and Infrastructure planning	10				X	
		UI-PA5	Project Water management and geotechnics	10					X
Master's Thesis									
4. Semester	Master's Thesis 30 CP	UI-MA	Master's Thesis	30					
Wahlmodule									
	Optional modules 16 CP		Further modules from the above list and according to the module handbook	16					
		Foreign languages ¹⁾							
		Modules from other Bachelor's or Master's degree programs ¹⁾							
Total credit points				120					

¹⁾ If similar or equivalent module content was not already part of the Bachelor's examination relevant for admission