HOCHSCHULE
RHEIN-WAAL
Rhine-Waal University
of Applied Sciences

Handbook of Modules for the Degree Programme

# Environment and Energy, B.Sc.

*Faculty of Communication and Environment*

Version 1.2

15.06.2017

## Dokumentenhistorie

| Version | Datum | Verantw. | Bemerkung |
|---|---|---|---|
| 1.0 | | | Version für die Akkreditierung |
| 1.1 | 19.01.2015 | AR | Überschrift geändert (Degree Programm) |
| 1.2 | 24.02.2016 | DL, UHA, IB | Überarbeitung: Aktualisierung Inhalt , Modulverantwortliche/r und Literaturliste:<br>EE_1.01 Introduction to Environmental Sciences<br>EE_1.02 Introduction to Energy Man. And Tech.<br>EE_2.02 (alt 4.02) Evaluation of Ecosystems<br>EE_3.01 Organic and Analytical Chemistry<br>EE_3.06 Microbiology<br>EE_4.01 Resource Management Environmental Health<br>EE_4.02 (alt 2.02) Project Management<br>EE_4.04 Legal Fundamentals<br>EE_5.01 Remediation and Redevelopment<br>EE_5.02 Process Engineering<br>EE_W.02 Environmental and Energy Economics<br>EE_W.03 Innovative Solutions<br>EE_W.04 Advanced Analytical Chemistry<br>EE_W.05 Electromobility<br>Überarbeitung Übersicht Curriculum S. 3 (EE_2.02/4.02 getauscht) |
| 1.21 | 15.06.2017 | SLA, IB | EE_W.02 Environmental and Energy Economics wird geteilt, neu EE_W.08 und EE_W.09<br>EE_W.07 Environmental Monitoring, neues Wahlpflichtmodul<br>EE_W.08 Environmental Economics, neues Wahlpflichtmodul<br>EE_W.09 Energy Economics, neues Wahlpflichtmodul |

HOCHSCHULE RHEIN-WAAL
Rhine-Waal University of Applied Sciences

## Index

# Curriculum of the Bachelor Degree Programme Environment and Energy, B.Sc.

Curriculum Environment and Energy, BSc

| Code No (Kennnr.) | Module | CH (SWS) | Type (Veranstaltungsart) | | | | | | Te (Prü) | CP | WS1 | SS2 | WS3 | SS4 | WS5 | SS6 | WS7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L (V) | SL (SL) | S (S) | Ex (Ü) | PT (Pra) | Pro (Pro) | | | | | | | | | |
| EE_1.01 | Introduction to Environmental Sciences<br>Einführung in die Umweltwissenschaften | 9 | 6 | | | | 3 | | E (P) | 10 | 9 | | | | | EE_6.01 Internship or semester abroad (Praxis- oder Auslandstudiensemester (30 CP; TE: C (T)) | EE_7.10 Workshop 1: Research Methods (Forschungsmethoden) (4 SW; 5 CP; type: S; TE: C (T))<br>EE_7.02 Workshop 2: Scientific Writing (Wissenschaftliches Schreiben) (4 SW; 5 CP; type: S; TE: C (T))<br>EE_7.03 Workshop 3: Advanced Seminar (Hauptseminar) (4 SW; 5 CP; type: S; TE: C (T))<br>EE_7.04 Bachelor Thesis (Bachelorarbeit) (12 CP) and Colloquium (Kolloquium) (3 CP) |
| EE_1.02 | Fundamentals of Energy Management and Technology<br>Grundlagen des Energiemanagements und der Energietechnik | 5 | 4 | | | 1 | | | E (P) | 5 | 5 | | | | | | |
| EE_1.03 | Physics: Mechanics and Optics<br>Physik: Mechanik und Optik | 4 | 2 | | | 2 | | | E (P) | 5 | 4 | | | | | | |
| EE_1.04 | Mathematics: Analysis and Discrete Mathematics<br>Mathematik: Analysis und diskrete Mathematik | 4 | 2 | | | 2 | | | E (P) | 5 | 4 | | | | | | |
| EE_1.05 | Fundamentals of Computer Sciences and Networks<br>Grundlagen der Computerwissenschaften und Netzwerke | 4 | 4 | | | 1 | | | E (P) | 5 | 4 | | | | | | |
| EE_2.01 | General and Inorganic Chemistry<br>Allgemeine und anorganische Chemie | 5 | 2 | | | 1 | 2 | | E/C (P/T) | 5 | | 5 | | | | | |
| EE_2.02 | Evaluation of Ecosystems and Environmental Assessment<br>Ökosystem- und Umweltbewertung | 5 | 2 | | | | 3 | | E/C (P/T) | 5 | | 5 | | | | | |
| EE_2.03 | Physics: Thermodynamics, Radiation and Heat Transfer<br>Physik: Thermodynamik, Strahlung und Wärmeübertragung | 4 | 2 | | | 2 | | | E (P) | 5 | | 4 | | | | | |
| EE_2.04 | Fundamentals of Engineering<br>Grundlagen der Ingenieurwissenschaften | 8 | 4 | | | 4 | | | E (P) | 10 | | 8 | | | | | |
| EE_2.05 | Linear Algebra and Graph Theory<br>Lineare Algebra und Grafentheorie | 4 | 2 | | | 2 | | | E (P) | 5 | | 4 | | | | | |
| EE_3.01 | Organic Chemistry and Analytical Chemistry<br>Organische Chemie und analytische Chemie | 5 | 2 | | | | 3 | | E/C (P/T) | 5 | | | 5 | | | | |
| EE_3.02 | Energy Technology<br>Energietechnik | 4 | 4 | | | | | | E (P) | 5 | | | 4 | | | | |
| EE_3.03 | Statistics and Data Processing<br>Statistik und Datenverarbeitung | 5 | 2 | | | 2 | 1 | | E (P) | 5 | | | 5 | | | | |
| EE_3.04 | Fundamentals of Business Administration<br>Grundlagen der Betriebswirtschaftslehre | 4 | 2 | | | 2 | | | E (P) | 5 | | | 4 | | | | |
| EE_3.05 | Entrepreneurship<br>Unternehmensgründung | 4 | 2 | | | 2 | | | E (P) | 5 | | | 4 | | | | |
| EE_3.05 | Microbiology<br>Mikrobiologie | 4 | 2 | | | | 2 | | E/C (P/T) | 5 | | | 4 | | | | |
| EE_4.01 | Resource Management and Environmental Health<br>Ressourcenmanagement und Umwelthygiene | 6 | 5 | | | 1 | | | E (P) | 5 | | | | 6 | | | |
| EE_4.02 | Project Management and Intercultural Competence<br>Projektmanagement und interkulturelle Kompetenz | 4 | 2 | | | | 2 | | C (T) | 5 | | | | 4 | | | |
| EE_4.03 | Applied Measurement and Control<br>Angewandte Verfahren der Mess- und Regelungstechnik | 4 | 2 | | | 2 | | | E (P) | 5 | | | | 4 | | | |
| EE_4.04 | Legal Fundamentals<br>Rechtliche Grundlagen | 4 | 4 | | | | | | E (P) | 5 | | | | 4 | | | |
| EE_5.01 | Remediation and Redevelopment<br>Sanierung und Standortentwicklung | 5 | 4 | | | 1 | | | E (P) | 5 | | | | | 5 | | |
| EE_5.02 | Process Engineering<br>Verfahrenstechnik | 5 | 4 | | | 1 | | | E (P) | 5 | | | | | 5 | | |
| EE_5.03 | Interdisciplinary Project<br>Interdisziplinäres Projekt | 6 | | | | | | 6 | E (P) | 10 | | | | | 6 | | |
| | Elective courses *<br>Wahlpflichtkurse * | 16 | | | | | | | | 20 | | | | | 8 | 8 | |
| | Total weekly semester hours<br>Gesamt-Semesterwochenstunden | 128 | | | | | | | | | 26 | 26 | 26 | 26 | 24 | 30 | 30 |

128 CH (SWS) 12 CH (SWS)

150 CP 60 CP

**210 CP**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Allocation | CH (SWS) | total | 140 | 26 | 26 | 26 | 26 | 24 | - | 12 |
| | CP | total | 210 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |

| Code No (Kennnr.) | Elective Courses (Wahlpflichtkurse) | CH (SWS) | CP | Te (Prü) |
|---|---|---|---|---|
| EE_W.01 | Simulation and modelling<br>Simulation und Modellierung | 4 | 5 | E (P) |
| EE_W.02 | Environmental and energy economics<br>Umweltökonomie und Energiewirtschaft | 4 | 5 | E (P) |
| EE_W.03 | Innovative Solutions in Environment and Energy<br>Innovative Lösungen in Umwelt- und Energietechnik | 4 | 5 | E (P) |
| EE_W.04 | Environmental analytical chemistry<br>Chemische Umweltanalytik | 4 | 5 | E (P) |
| EE_W.05 | Electromobility<br>Elektromobilität | 4 | 5 | E (P) |
| EE_W.06 | Advanced auditing and certification procedures<br>Auditierungs- und Zertifizierungsprozesse für Fortgeschrittene | 4 | 5 | E (P) |

## EE_1.01 Introduction to Environmental Sciences

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_1.01 | 270 h | 10 CP | 1st semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture „Introduction to Environment and Ecology": 30 h / 2 semester hours per week (SWS)<br>Exercises with excursion "Introduction to Environment and Ecology": 15 h / 1 SWS<br>Lecture "Fundamentals of Biology": 30 h / 2 SWS<br>Exercises with excursion "Fundamentals of Biology": 15 h / 1 SWS)<br>Lecture "Geology and Natural Cycles of Matter": 30 h / 2 SWS<br>Exercises with excursion "Geology and Natural Cycles of Matter": 15 h / 1 SWS | 135 h / 9 SWS | 135 h / 9 SWS | 50 students |

**Learning outcomes / Competences and qualifications profile**

Upon completion of this module, the student will:

- be able to understand the Biology, Geology and Ecology behind topics related to applied Environmental Sciences, Food- and Biotechnology and Environmental Technology;
- be prepared to get involved in the process of scientific investigation and the acquisition of knowledge in these fields;
- have created an attitude of curiosity and self-discovery through advancements in (i) individual studies and personal initiative, (ii) practical lab training, and (iii) excursions;
- have developed an understanding of biological and geological facts and principles, of relationships between mankind and its natural environment, and of technical solutions developed to reduce the human impact on the environment;
- be able to understand the basics of environmental engineering;
- be aware of both the advantages and problems for the modern society related to the use of biological processes in industry, agriculture, waste management, energy technology and medical applications;
- be able to peform literature reviews and evaluations of contemporary issues related to Ecology, Biology, Geology and Environmental Engineering.

**Content**

"Introduction to Environmental Sciences" is composed of introductory courses in general Biology, Geology, and Ecology in the context of Environmental Sciences. The Biology course initiates the approach to environmental sciences by addressing some of its most elemental questions: what is life, of what is a living cell consisting? Key concepts of cell biology and basics of energy processing are presented. The form meets function concept is taught and also genetics, biotechnology and molecular biology. The concepts are presented with special regard to aspects that are of relevance for the composition of biomass and food, for the evaluation and remediation of ecosystems and for the understanding of biological processes in environmental and industrial engineering.
The course "Principals of Geology and the Cycle of Matter" provides an overview and basic understanding of the (structural) elements building up planet earth, and the functions involved leading to these geological structures. Important geologic processes such as sedimentation, residence times of geologic materials in their specific environments, rock weathering and erosion, and transport of geologic material are illustrated and discussed within the contexts of the geologic rock cycle and plate tectonics/continental drift. The concepts are presented to the students to develop an awareness that environmental processes are intimately linked to geology leaving a footprint in the geologic record over time. Special emphasis is laid on the concept of time sequences of events as a method to follow and reconstruct environmental processes and change.
The course "Introduction to Environment and Ecology" gives an overview and fundamental knowledge about ecology, ecosystem functioning and environmental issues and technologies. Fundamental concepts of ecology such as biodiversity, species interactions, biogeography, succession, population growth and natural cycles of matter are put in perspective with current issues related to climate change, land use and the human impact on ecosystems, especially the (un)sustainable use of resources. Human impact is highlighted in selected fields e.g. agriculture, global warming, stratospheric ozone depletion, air pollution and waste management.

**Teaching methods**

Lectures and practical training, excursions

**Entry requirements**

None

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better, successful participation in practical training

**Use of module ( in other study programs )**

**Weight towards final grade**

6,25 %

**Person in charge of module**

PD Dr. Ute Hansen/Prof. Dr. Kai J. Tiedemann

**Additional information**

Literature:

Reece, J.B. et al. (2011) Campbell Biology, 9th ed., Pearson
Botkin, D.B., Keller, E.A. (2012) Environmental Science, 8th ed., John Wiley & Sons Inc.
Schlesinger, Biogeochemistry, Elsevier.
Boeker, E.; vanGrondelle, R. (2001): Environmental science physical principles and applications. Chichester: Wiley.
Eby, G. N. (2004): Principles of environmental geochemistry. Pacific Grove: Thomson-Brooks/Cole.
McKinney, M. L.; Schoch, R. M.; Yonavjak, L. (2007): Environmental Science: Systems and Solutions. London: Jones and Bartlett.
Townsend, C. R.; Begon, M.; Harper, J. L. (2008): Essentials of Ecology. Oxford: Wiley-Blackwell Publishing.
Grotzinger, J.; Jordan, T. (2010): Understanding Earth; Sixth Edition, W.H. Freeman and Company.
Todd, D.K. (1980): Groundwater Hydrology, 2nd Edition, John Wiley & Sons.

Frisch, W.; Meschede, M. (2009): Plattentektonik; 3rd Edition, Primus-Verlag.
Murawski, H.; Meyer, W. (2004): Geologisches Wörterbuch; 11th Edition; Spektrum Verlag.

## EE_1.02 Fundamentals of Energy Management and Technology

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_1.02 | 150 h | 5 CP | 1st semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture: 45 h/ 3 SWS<br>Exercises with excursion:<br>30 h/ 2 SWS | 75 h / 5 SWS | 75 h / 5 SWS | 50 students |

**Learning outcomes / Competences and qualifications profile**

Upon completion of this course, the student will be able to:

- relate renewable and non-renewable energy carriers to their corresponding range of coverage, environmental impact, and their characteristics in the energy chain;
- understand and analyse abstract concepts (e.g. sustainability or the ecological footprint) and contemporary delevopments in global change (e.g. UNFCCC policies or $CO_2$-market);
- explain basic concepts in thermodynamics;
- describe the technology of energy conversion for renewable and non-renewable energy carriers;
- develop an awareness for remaining conventional energy and new, emerging unconventional resources such as shale gas and shale oil in comparison/competition with renewable energies

**Content**

This module intends to increase students´ awareness and interest in the field of energy management and technology.

Based on the introduction of key concepts in the energy chain and thermodynamics, the course analyses trends and drivers in energy supply, and derives the need for renewable energies as a consequence of limited fossil resources and the climate change due to emission of carbon dioxide and other greenhouse gases. An overview is provided on the origin and genesis of conventional energy resources, the search for them and their use and application in society as well as the most important technologies for renewable energy conversion: wind, solar, and hydro.

The vast impact on the environment from conventional and renewable energy resource is illustrated and discussed using different concepts as “sustainability”, “carbon footprint” and others.

National, European and international policy approaches to secure energy provision and to reduce emissions of climate gases are presented and discussed

**Teaching methods**

Lectures and practical trainings with workgroup exercises, excursions

**Entry requirements**

None

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better, successful participation in practical training

**Use of module ( in other study programs )**

**Weight towards final grade**

3,125%

**Person in charge of module**

Prof. Dr. Irmgard Buder

**Additional information**

Literature:

Cengel, Y. A.; Boles, M. A. (2010): Thermodynamics - An Engineering Approach. Boston: McGraw-Hill.

Boeker, E.; Grondelle, R. (2011): Environmental Physics - Sustainable Energy and Climate Change. Chichester: Wiley.

Heinloth, K. (2003): Die Energiefrage - Bedarf und Potentiale, Nutzung, Risiken und Kosten. Braunschweig: Vieweg.
Sorensen, B. (2004): Renewable Energy - its physics, engineering, use, environmental impacts, economy, and planning aspects. Amsterdam: Elsevier.
Gevorkian, P. (2007): Sustainable Energy Systems Engineering. New York: McGraw-Hill.
Quaschning, V. (2005): Understanding Renewable Energy Systems. London: Earthscan.
Quaschning, V. (2010) Renewable Energy and Climate Change John Wiley Sons LTD
Nelson, V. (2011): Introduction to Renewable Energy. Boca Raton: CRC Press.
Link, P.K. (1987): Basic Petroleum Geology. Tulsa, USA: OGCI Publications.
Grotzinger, J.; Jordon, T. (2010): Understanding Earth. 6th Edition; W.H. Freeman and Company

## EE_1.03 Physics: Mechanics and Optics

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_1.03 | 150 h | 5 CP | 1st semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture: 30 h / 2 semester hours per week (SWS)<br>Excercise: 30 h / 2 SWS | 60 h / 4 SWS | 90 h / 6 SWS | 50 students |

**Learning outcomes / Competences and qualifications profile**

This module has introduced students to key principles of Physics. The successful student is able to apply and use the physical concepts, laws and equations he has learned in advanced modules and in his or her professional life. The student is able to describe simple motion mathematically, can decompose forces, and has a sound understanding of the physical concepts work, energy and power. The student has understood the principal of energy conservation and is able to solve given tasks concerning the topics mentioned above. The student is also able to describe simple harmonic oscillation/waves, calculate the natural frequency of simple oscillating systems, has a sound understanding of period and wave length and is able to solve basic tasks including superpositioning of waves. Furthermore the student has understood the behavior and properties of light, including its interactions with matter, geometric optics and physical optics (like diffraction and interference).

**Content**

- Physical quantities and units
- 1D and 3D motion
- Forces and Newton's laws
- Friction and drag forces
- Work, energy, power
- Linear momentum and impulse
- Angular momentum, moment of inertia and torque
- Oscillations, waves and superposition
- Geometric optics and physical optics

**Teaching methods**

Lectures and practical classes

**Entry requirements**

None

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better

**Use of module ( in other study programs )**

Same module in "Environment and Energy" and "Industrial Engineering - Specialization Communication and Information Engineering"

**Weight towards final grade**

3,125%

**Person in charge of module**

Prof. Dr. Christian Ressel

**Additional information**

Reading:

Tipler P.A.; Mosca G. (2007): Physics for Scientists and Engineers. Enlarged 6th Edition; W.H. Freeman.
Halliday D.; Resnick R.; Walker J. (2010): Fundamentals of Physics. 9th Edition; Wiley, John & Sons.

## EE_1.04 Mathematics: Analysis and Discrete Mathematics

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_1.04 | 150 h | 5 CP | 1st semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture: 30 h / 2 semester hours per week (SWS)<br>Excercise: 30 h / 2 SWS | 60 h / 4 SWS | 90 h / 6 SWS | 50 students |

**Learning outcomes / Competences and qualifications profile**

This lecture has introduced students to the basics of Discrete Mathematics and fundamental topics of Analysis and has therefore enabled them to solve technical and operational problems.
With the knowledge of these mathematical methods and formulas students can solve analytical problems based on discrete or continuous functions and are able to apply their knowledge to their professional context as analysts, planners or engineers.
Additionally students are able to develop advanced solutions to describe and optimize technological functionalities in a mathematical way by using basic trigonometric functions as well as main formulas and procedures of differential and integral calculus.

**Content**

- Fundamentals of logic, sets and numerative systems
- Fundamentals of relations and functions
- Elementary functions like rational-, potential-, exponential- and logarithm-functions
- Trigonometric functions like sinus, cosinus, tangens, cotangens
- Fundamentals of differential calculus: functional limits, continuity, derivations and rules of derivations
- Fundamentals of integral calculus: anti derivations, integration and rules of integration

**Teaching methods**

Tuition in lectures and practical classes

**Entry requirements**

None

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better

**Use of module ( in other study programs )**

Same module in "Environment and Energy", "Industrial Engineering - Specialization Communication and Information Engineering", and "Mobility and Logistics"

**Weight towards final grade**

3,125 %

**Person in charge of module**

Prof. Dr.-Ing. Rolf Becker

**Additional information**

Literature:
Stewart J. (2008): Calculus, Early Transcendentals, International Metric Edition, 6th Edition, BrooksCole, ISBN-13: 9780495382737.

## EE_1.05 Fundamentals of Computer Science and Networks

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_1.05 | 150 h | 5 CP | 1st semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture: 45 h / 3 semester hours per week (SWS)<br>Excercise: 15 h / 1 SWS | 60 h / 4 SWS | 90 h / 6 SWS | 45 students |

**Learning outcomes / Competences and qualifications profile**

This module introduces students to the key principles of computers and networks. Successful students have gained the ability to identify the major hardware and software components of a computer system, to understand their relationship to one another and the importance of these components within the system. They are also able to convert numbers from different numeral systems, which are frequently used by computer systems, and can express conditions and causality using binary logic.

Furthermore students gain an understanding of how computer networks work. They are able to explain the ISO/OSI reference model and IP traffic and can set up small networks independently.

**Content**

- Example for today's use of computers in different environments
- Basic principles: numeral systems, representation of text, combinational logic
- Hardware of a computer system, incl. CPU, motherboard, storage devices, RAID and backup systems
- Introduction to operating systems, incl. common operating systems
- Computer networks: network classifications, ISO/OSI reference model, layers of IP networks, network devices, basic security

**Teaching methods**

Tuition in seminars, lectures and practical classes

**Entry requirements**

None

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better

**Use of module ( in other study programs )**

Same module in "Environment and Energy" and "Mobility and Logistics"

**Weight towards final grade**

3,125 %

**Person in charge of module**

Prof. Dr. Christian Ressel

**Additional information**

Literature:

Mafield,C. (2008): Bebop - to the boolean boogie,ISBN 1856175073, Newnes, 3rd. edition.
Tannenbaum,A. (2002): Computer Networks, ISBN 0130661023, Prentice Hall, 4th. edition.
Muller, J.-M. et al. (2009): Handbook of Floting Point Arithmetic, ISBN 081764704X, Springer.
Brent, R. P.; Zimmermann, P. (2010): Arithmetic (Cambridge Monograph on Applied and Computational Mathematics), ISBN 0521194695, Cambridge University Press.

## EE_2.01 General and Inorganic Chemistry

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_2.01 | 150 h | 5 CP | 2nd semester | Summer semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture "Fundamentals of Chemistry": 30 h / 2 semester hours per week (SWS)<br>Exercises "Fundamentals of Chemistry": 15 h / 1 SWS<br>Practical Training "Introduction to Chemical Practice": 30 h / 2 SWS | 75 h / 5 SWS | 75 h / 5 SWS | Lecture: open<br>practical training: 2 x 25 students |

**Learning outcomes / Competences and qualifications profile**

Upon completion of this course, the student will be able to:

- describe an atom and atomic bonds according to contemporary models;
- predict the characteristics of a chemical reaction from the reactants' positions in the periodic table of elements;
- identify fundamental chemistry concepts (e.g. redox reactions, acid-base reactions) as driving forces in chemical reactions;
- master basic laboratory tools and procedures.

**Content**

Natural science and engineering cannot be fully understood without some proficiency in fundamental chemistry. The lecture explains the most relevant concepts for applications in environmental science, based on the introduction of the atomic theory and the contemporary understanding of atomic bonds. The complementary training in laboratory practice is an intensive introduction to the techniques of experimental chemistry and gives first year students an opportunity to learn and master the basic chemistry lab techniques for carrying out experiments.

**Teaching methods**

Lecture with exercises in workgroups and practical lab trainings

**Entry requirements**

None

**Types of assessment**

Graded examination, lab protocols

**Requirements for the award of credit points**

Module exam grade 4.0 or better, successful participation in practical training

**Use of module ( in other study programs )**

**Weight towards final grade**

3,125 %

**Person in charge of module**

Prof. Dr. Irmgard Buder

**Additional information**

Literature:

Housecroft, C. E.; Constable, E. C. (2009): Chemistry - an introduction to organic, inorganic and physical chemistry. Harlow: Pearson Prentice Hall.

Corwin, C. H. (2010): Introductory Chemistry: Concepts and Critical Thinking. Boston: Mass., Prentice Hall.

Mortimer, C. E.; Müller, U. (2010): Chemie - das Basiswissen der Chemie. Stuttgart: Thieme.

Corwin, C. H. (2009): Introductory Chemistry Laboratory Manual: Concepts & Connections. Upper Saddle River,

NJ: Pearson Education.

## EE_2.02 Evaluation of Ecosystems and Environmental Assessment

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_2.02 | 150 h | 5 CP | 4th semester | Summer semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture: 30 h / 2 semester hours per week (SWS)<br>Practicals: 45 h / 3 SWS | 75 h / 5 SWS | 75 h | Lecture: open<br>Field- and laboratory practicals: 2 x 25 students |

**Learning outcomes / Competences and qualifications profile**

The students have been introduced to fundamental methods of ecosystem evaluation and environmental assessment. They know methods to determine selected groups of species and relations between species composition of an ecosystem and abiotic factors including contaminants. The students are familiar with common assessment methods e.g. for terrestrial and/or aquatic ecosystems. Based on ecological field data the students can categorize the status of ecosystems and are able to make decisions taking site-specific or ecosystem-specific parameters into account. The students have practised sampling and analytical techniques, the writing of scientific protocols, the interpretation of ecological field data and the use of assessment criteria.

**Content**

The lecture will provide an introduction to fundamentals of evaluation of ecosystems:

- Components of ecosystems, value of ecosystem services e.g. in soil, assessment of biodiversity
- Concepts evaluation of ecosystems and environmental assessment, assessment criteria and indicators
- Case examples of evaluation of ecosystems and environmental assessment
- Decision making based on both scientific data and consensus-driven assessment criteria

Field- and laboratory practicals will impart practical knowledge on taxonomical and analytical methods as well as methods of data interpretation like:

- Methods of ecological assessment and assessment of anthropogenic impact
- Indicator species in assessing ecosystem status
- Tools for environmental assessment (such as diversity-based indices, Asterics, ETX)

**Teaching methods**

Lectures, field- and laboratory practicals

**Entry requirements**

Completion of the following modules is recommended:

- "Introduction to Environmental Sciences"

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Group protocols of practicals, poster presentation of field practical results, Module examination grade 4.0 or better

**Use of module ( in other study programs )**

**Weight towards final grade**

3,125 %

**Person in charge of module**

Prof. Dr. Daniela Lud

**Additional information**

Literature:

Chapin F.S.III, Matson P.A., Vitousek P.M. (2011) Principles of Terrestrial Ecosystem Ecology. Springer

Reid W.V.; Berkes F.; Wilbanks T., Capistrano D. eds. (2006): Bridging scales and knowledge systems. Concepts and applications in ecosystem assessment. Island Press.

Rutgers M.& Jensen J. (2011) Site specific ecological risk assessment in F.A. Swartjes (ed.), Dealing with Contaminated Sites From Theory towards Practical Application. Springer

Suter, G.W. (2006): Ecological risk assessment. CRC Press

## EE_2.03 Physics: Thermodynamics, Radiation and Heat Transfer

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_2.03 | 150 h | 5 CP | 2nd semester | Summer semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture: 30 h / 2 semester hours per week (SWS)<br>Exercise: 30 h / 2 SWS | 60 h / 4 SWS | 90 h / 6 SWS | 50 students |

**Learning outcomes / Competences and qualifications profile**

After having passed this module, students understand the potential of solar irradiance as a source of renewable energy systems. They know about heat transfer in various forms and are able to quantify heat conductance through construction elements of buildings. They are familiar with basic thermodynamic principles and their applications in thermal machines related to energy generation and conversion.

**Content**

- Solar spectral irradiance and radiation laws
- Atmospheric window and absorption, introduction to molecular spectra (vs. atomic spectra)
- Radiation budget and greenhouse effects
- Heat transfer by radiation, conduction and convection
- Thermal condutance in composit construction elements such as walls
- Thermodynamics of ideal gas
- Phase changes and latent heat with real gas and vapour
- Fundamental laws of thermodynamics
- Thermodynamic cycles: Carnot, Stirling, Rankine, Otto
- Thermodynamics and efficiency of tech. systems: heat pump, refrigerator, steam turbine, combustion engine

**Teaching methods**

Dialog oriented, seminaristic lectures with exercises
Students´ presentations

**Entry requirements**

Completion of the module "Mathematics" is recommended

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better

**Use of module ( in other study programs )**

**Weight towards final grade**

3,125 %

**Person in charge of module**

Prof. Dr.-Ing. Rolf Becker

**Additional information**

Literature:
Çengel, Y. A.; Boles, M.A.: Thermodynamics - an engineering approach

## EE_2.04 Fundamentals of Engineering

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_2.04 | 300 h | 10 CP | 2nd semester | Summer semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture "Electrical Engineering": 30 h / 2 semester hours per week (SWS)<br>Exercise "Electrical Engineering": 30 h / 2 SWS<br>Lecture "Mechanical Engineering": 30 h / 2 SWS<br>Exercise "Mechanical Engineering": 30 h / 2 SWS | 120 h / 8 SWS | 180 h / 12 SWS | 50 students |

**Learning outcomes / Competences and qualifications profile**

Having passed the module students know fundamental principles in electrical and mechanical engineering which serve as a basis for the understanding of advanced concepts of subsequent courses. In particular, students are capable of analysing simple electric circuits with passive components such as resistors, capacitors and inductors. The students are familiar with three-phase alternating current and have understood the principles of induction.

Concerning mechanical engineering the students are able to characterize different engineering materials with emphasis on material strength and can assess their usability in different applications. They know basic processing methods and tools.

**Content**

- Electrical charges & electric fields, electrostatic potential & electric energy
- Current and its cause
- Simple electrical circuits and the nodal analysis
- Magnetic field & electromagnetic induction
- Inductors and capacitors
- Alternating current & alternating voltage
- Complex nodal analysis
- Multiphase systems
- Mechanics in engineering
- Strength of materials (stress-strain-relationship, bending beams, torque in turbine shaft)
- Engineering materials
- Machine elements
- Material processing

**Teaching methods**

Dialog oriented, seminaristic lectures with exercises

Students´ presentations

**Entry requirements**

None

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better

**Use of module ( in other study programs )**

**Weight towards final grade**

| |
|---|
| 6,25 % |
| **Person in charge of module**<br>Prof. Dr.-Ing. Rolf Becker. |
| **Additional information**<br>Literature:<br>Gross, D.; Hauger, W. et al.: Engineering Mechanics 1-3, Springer.<br>Jayendran, A.: Mechanical Engineering, Grundlagen des Maschinenbaus in engl. Sprache, Teubner.<br>Tipler P.A.; Mosca G.: Physics for Scientists and Engineers. enlarged 6th edition; W.H. Freeman.<br>Halliday D.; Resnick R.; Walker J.: Fundamentals of Physics. 9th Edition; Wiley, John & Sons.<br>Hambley, A.R.;Electrical Engineering: Principles and Applications; 5th Edition,Pearson Prentice Hall |

## EE_2.05 Linear Algebra und Graph Theory

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_2.05 | 150 h | 5 CP | 2nd semester | Summer semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture: 30 h / 2 semester hours per week (SWS)<br>Excercise: 30 h / 2 SWS | 60 h / 4 SWS | 90 h / 6 SWS | 50 students |

**Learning outcomes / Competences and qualifications profile**

This lecture has introduced students to mathematical methods of linear algebra and the basics of graph theory which are needed to solve technical and operational problems.
With these mathematical methods and procedures at hand, the students are able to solve linear problems and can therefore apply their knowledge to their professional context as analysts, planners or engineers.
Additionally the students are able to develop advanced solutions to describe and optimize networks by applying the basic rules and procedures of graph theory.

**Content**

- Introduction of vectors, matrices, vector- and matrix operations
- Vector-spaces and sub-spaces
- Linear transformations
- Linear equation systems
- Procedures to solve linear equation systems (Gauss algorithm, determinants)
- Basic definitions of graphs
- Euler rows, Hamilton circles
- Basic problems ("Bridges of Königsberg", "Travelling Salesman") and possible solutions

**Teaching methods**

Tuition in seminars, lectures and practical classes

**Entry requirements**

None

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better

**Use of module ( in other study programs )**

Same module in "Environment and Energy", "Industrial Engineering - Specialization Communication and Information Engineering" and "Mobility and Logistics"

**Weight towards final grade**

3,125 %

**Person in charge of module**

Prof. Dr. Andreas Schürholz.

**Additional information**

## EE_3.01 Organic Chemistry and Analytical Chemistry

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_3.01 | 150 h | 5 CP | 3rd semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture "Fundamentals of Organic Chemistry": 30 h / 2 semester hours per week (SWS)<br><br>Practicals "Applied Organic Chemistry" and "Environmental Analytical Chemistry": 45 h / 3 SWS | 75 h / 5 SWS | 75 h | Lecture: open<br>Practicals:<br>2 x 25 students |

**Learning outcomes / Competences and qualifications profile**

The students have acquired a basic understanding of the structure of organic molecules and the relation between structural properties and physical-chemical properties. The students know and can apply basic equations of environmental partitioning and transport. The students know and can apply basic rules on how physical-chemical properties influence the environmental fate of organic chemicals. The students know and can describe the most important groups of organic contaminants.

The students know symbols and applicable safety rules for the hazardous sustances which are used during the experiments. The students have learned to work safely in a laboratory. They have developed skills to set up and conduct simple chemical experiments and are skilled in applying analytical techniques such as chromatography and photometry. They have also practised scientific documentation, evaluation of analytical results and the interpretation of experiments and analytical results.

**Content**

Lecture " Fundamentals of Organic Chemistry":

- General properties of organic chemicals (structure, formula, bonding, functional groups, nomenclature)
- Fundamentals of environmental fate of organic chemicals (partitioning, transport, transformation)
- Environmental fate of selected organic chemicals (petroleum hydrocarbons, benzene & related compounds, polycyclic aromatic hydrocarbons, organohalogens, persistent organic pollutants)

Practicals "Applied Organic Chemistry" and "Environmental Analytical Chemistry":

- Physical chemical properties of organic chemicals e.g. flashpoint of petroleum hydrocarbons, reactions and properties of polymers
- Basic sampling techniques of environmental samples (e.g. air)
- Extraction of chemicals from environmental samples and analysis
- Fundamentals of analytical methods applied (e.g. chromatography, photometry)

**Teaching methods**

Lectures, laboratory practicals

**Entry requirements**

Completion of the module "General and Inorganic Chemistry" is recommended

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Group protocols and posters of practical experiments; Module examination grade 4.0 or better

**Use of module ( in other study programs )**

**Weight towards final grade**

3,125 %

**Person in charge of module**

| Prof. Dr. Daniela Lud |
| --- |
| **Additional information**<br>Literature<br>Manahan, S. E. (2010): Environmental Chemistry. Boca Raton: CRC Press.<br>Mortimer, C. E. (1986): Chemistry. Belmont, California: Wadsworth Publishing.<br>Mortimer, C. E.; Müller, U. (2010): Das Basiswissen der Chemie. Stuttgart: Thieme.<br>Schwarzenbach, R. P.; Gschwend, P. M.; ImbodenD. M. (2003): Environmental Organic Chemistry. Hoboken, New Jersey: Wiley. |

## EE_3.02 Energy Technology

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_3.02 | 150 h | 5 CP | 3rd semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture: 30 h/ 2SWS<br>Exercises: 30 h/2SWS | 60 h / 4 SWS | 90 h / 6 SWS | 50 students |

**Learning outcomes / Competences and qualifications profile**

Having passed this module, students have gained a sound technical knowledge and critical thinking about energy technology with emphasis on renewable energy systems. They are able to assess the environmental and economic impact of different approaches. They understand the basic physical principles and overall technical design of energy systems. This encompasses electrical energy generation and distribution as well. The students are able to discuss the assets and drawbacks of alternative technologies and consider scalability and transferability to other use cases and regional conditions.

**Content**

- Energy sources for Germany and worldwide
- Photovoltaic (PV) energy systems
- Electrical characteristics of PV systems and inverters
- Heating and warm water with PV
- Solar thermal collectors
- Heat storage tank, mathematical model
- Concentrated solar power plants
- Wind turbines, physical fundamentals and electrical system design
- Hybrid wind power plants
- Heat pumps
- Combined heat and power plants (CHP)
- Alternating and direct current
- Power grids, high voltage DC transmission
- Electrical generators
- Effects of the German Renewable Energy Sources Act (EEG)

**Teaching methods**

Dialog oriented, seminaristic lectures with exercises

Students´ presentations

**Entry requirements**

None

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better

**Use of module ( in other study programs )**

**Weight towards final grade**

3,125 %

**Person in charge of module**

Prof. Dr. Irmgard Buder, Prof. Dr. Rolf Becker

**Additional information**

Literature:

Volker Quaschning (2010) Understanding renewable energy systems. Earthscan

J. Twidell, T. Weir (2006) Renewable Energy Resources, Second Ed. Taylor & Francis London and New York

Robert Gasch, Jochen Twele (Eds.), (2012) Wind Power Plants - Fundamentals, Design, Construction and

Operation, Springer Heidelberg, London, Dordrecht and New York

## EE_3.03 Statistics and Data Processing

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_3.03 | 150 h | 5 CP | 3rd semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture "Statistics": 30 h / 2 semester hours per week (SWS)<br>Exercises "Statistics": 30 h / 2 SWS<br>Practical training "Data Analysis, Processing and Mapping": 15 h / 1 SWS | 75 h / 5 SWS | 75 h / 5 SWS | Lecture and exercises: open<br>Practical training: 2 x 25 students |

**Learning outcomes / Competences and qualifications profile**

Students who have completed this module successfully are able to make informed decisions based on environmental and technical data. Students can select appropriate statistical techniques for collecting, summarizing and displaying data. They are able to analyse and draw inferences from data using appropriate statistical methods and computer software including spatial statistics in geographic information systems for the processing of geographically referenced data. Students have developed the skills to interpret and communicate the results of a statistical analysis in the context of an environmental or technical problem.

**Content**

Probability:

- Random phenomena (Probability experiments and events)
- Probability rules
- Conditional probabilities (Bayes-Theorem)
- Combinatorics (Counting techniques)
- Random variables (Discrete und continuous)
- Expected value and variance
- Discrete and continuous probability distributions

Statistics :

- Descriptive statistics and correlation analysis:
  - Basic concepts (Levels of measurement, univariate data, bivariate data)
  - Sampling and data collection
  - Graphical and numerical summaries
  - Frequency distributions
  - Measures of central tendency, measures of position, measures of dispersion
  - Grouped data
  - Covariance, correlation, regression
- Inferential statistics:
  - Sampling distribution of a sample mean
  - Sampling distribution of a sample proportion
  - Point estimates, interval estimates, confidence intervals
  - Hypothesentests
- Statistical software skills:
  - Using Excel, SPSS/R
- Spatial statistics:
  - Analysis, processing and visualisation of spatial statistical data

**Teaching methods**

Lecture and Exercises. The course will be carried out in a seminar-like, interactive manner. The impartation of the statistical concepts will be supported by the integration of relevant applied examples and the deployment of statistical software (e.g. R, SPSS and/or Excel). One part of the exercises will thereby focus on the particular aspects of the analysis, processing and visualization of geographically referenced statistical data by means of a geographic information system.

| |
|---|
| **Entry requirements**<br>Completion of the following modules is recommended:<br>• "Mathematics: Analysis and Discrete Mathematics"<br>• "Linear Algebra and Graph Theory" |
| **Types of assessment**<br>Graded examination |
| **Requirements for the award of credit points**<br>Module examination grade 4.0 or better |
| **Use of module ( in other study programs )** |
| **Weight towards final grade**<br>3,125 % |
| **Person in charge of module**<br>Dipl.-Biol. Ralf Darius |
| **Additional information**<br>Literature:<br>Johnson R.; Kuby P. (2008): Elementary Statistics. Tenth Edition, Brooks/Cole.<br>Michael S. (2005): Fundamentals of Statistics. 3rd Edition, San Francisco: Pearson Education |

## EE_3.04 Fundamentals of Business Administration

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_3.04 | 150 h | 5 CP | 3rd semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture: 30 h / 2 semester hours per week (SWS)<br>Exercise: 30 h / 2 SWS | 60 h / 4 SWS | 90 h / 6 SWS | Lecture: open<br>Exercise: 40 students |

**Learning outcomes / Competences and qualifications profile**

Students have gained an understanding of fundamental concepts of business administration and the basic functions of organizations. They have a good grasp of important terms, concepts, and methods and are able to apply them to real-life problems. They have discussed the impacts of globalization and can describe its influence on business processes.

**Content**

- An organization and its goals
- Corporate organization and organizational structure
- Principles of strategic management and planning
- The operations function: the process of production, costs and planning, production logistics
- Fundamentals of marketing: the marketing mix
- Principles of finance
- The controlling function
- Fundamentals of human resource management and leadership

**Teaching methods**

Lectures, accompanied by exercises in which case studies and problems in practice are presented

**Entry requirements**

None

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better

**Use of module ( in other study programs )**

Same module in "Environment and Energy", "Industrial Engineering - Specialization Communication and Information Engineering", "International Business and Social Sciences" and "Mobility and Logistics"

**Weight towards final grade**

3,125 %

**Person in charge of module**

Prof. Dr. Kai J. Tiedemann

**Additional information**

Reading:

Gamble, J.E.; Thompson, A. A. (2011): Essentials of Strategic Management. The Quest for Competitive Advantage. 2nd edition. New York: McGraw-Hill.

Hill, C. W. L. (2009): International Business. Competing in the Global Marketplace. 7th edition. New York: McGraw-Hill.

Kotler, P.; Armstrong, G. (2010): Principles of Marketing. 13th edition. Upper Saddle River: Pearson Prentice Hall.

Luthans, F.; Doh, J. P. (2009): International Management. Culture, Strategy, and Behavior. 7th edition. New York: McGraw-Hill.

Robbins, S. P.; DeCenzo, D. A.; Coulter, M. (2011): Fundamentals of Management. Essential Concepts and

Applications. 7th edition. Upper Saddle River: Pearson Prentice Hall.
Slack, N.; Chambers, S.; Johnston, R. (2010): Operations Management. 6th edition. Harlow: Pearson Prentice Hall.

## EE_3.05 Entrepreneurship

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_3.05 | 150 h | 5 CP | 3rd semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture: 60 h / 4 semester hours per week (SWS) | 60 h / 4 SWS | 90 h / 6 SWS | 75 students |

**Learning outcomes / Competences and qualifications profile**

This is a very applied course aiming to teach students relevant aspects before becoming self employed or starting a business. Successful students are able to convincingly present a business idea, explain the company's vision and point out in which way it differs from competitors. Students are able to choose the most appropriate corporate form of business and write a business plan in excel. They can also list public incentives for start-ups in Germany and name typical characteristics of successful start-ups.
They can handle basic double-entry bookkeeping and set up an income statement as well as a balance sheet. They can perform product costing using different methods, can explain methods for customer acquisition and are aware of the importance human resource management and leadership have for startups with employees. Students can explain some pitfalls of starting up a business and know about the economic and administrative consequences of insolvency.

**Content**

- Idea generation, basic market research to validate business idea
- Corporate strategy: Vision, mission, differentiation from competitors/unique selling proposition
- Presenting the own business idea in a short and convincing manner
- Choosing the most suitable corporate form of business for the start-up; economic consequences of corporate form of business
- Business planning: Including all relevant sources of revenue and cost and taking realistic assumptions, efficient excel modelling
- Public programs for start-up incentives / promotion of start-ups in Germany
- Sources of start-up financing end evaluation of those; sources of financing for the growing start-up
- Basics of bookkeeping: Double entry bookkeeping, basics of accrual accounting, setting up an income statement and a balance sheet
- Basics of product costing and pricing strategies
- Basics of taxation for start-ups and small business
- Basics of controlling for entrepreneurs
- Customer acquisition, marketing
- Basics of human resource management and leadership for start-ups and small business
- Case studies of successful start-ups / characteristics of successful start-ups
- Company succession
- Insolvency / Common reasons for failure

**Teaching methods**

The course is mainly tought in lectures. These will be accompanied by smaller group works, student presentations and if possible also PC sessions to demonstrate business planning in excel.

**Entry requirements**

None

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better

**Use of module ( in other study programs )**

Same module in "Environment and Energy" and "Information and Communication Design"

**Weight towards final grade**

3,125 %

| **Person in charge of module** |
| --- |
| Prof. Dr. Irmgard Buder |
| **Additional information** |
| Literature:<br>Bragg, S. M. (2011): Bookkeeping Essentials. Hoboken: Wiley & Sons.<br>Drury, C. (2009): Management Accounting for Business. 4th edition, Andover: Cengage Learning EMEA.<br>Harvard Business School Press: Creating a Business Plan: Expert Solutions to Everyday Challenges. New York: McGrawHill.<br>Kelly, J.; Barrow, P.; Epstein, L. (2011): Bookkeeping. 2nd edition. Chichester: Wiley & Sons.<br>Livingstone, J. (2008): Founders at Work: Stories of Startups' Early Days (Recipes: a Problem-Solution Ap). New York: Apress.<br>Morris, M. (2008): Starting a Successful Business: Start Up and Grow Your Own Company (Starting a Successful Business: Start Up & Grow Your Own Company). London: Kogan Page.<br>Powers, M.; Needles, B. E.; Crosson, S. V. (2010): Financial and Managerial Accounting Principles. 9th edition Andover: Cengage Learning EMEA.<br>Weber, J.; Weißenberger, B. E. (2010): Einführung in das Rechnungswesen. Bilanzierung und Kostenrechnung. 8th edition. Stuttgart: Schäffer-Poeschel. |

## EE_3.06 Microbiology

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_3.06 | 150 h | 5 CP | 3rd semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture "Introduction to Microbiology": 30 h / 2 semester hours per week (SWS)<br>Practical training "Applied Environmental Microbiology": 30 h / 2 SWS | 60 h / 4 SWS | 90 h / 6 SWS | 50 students<br>Practicals:<br>2 x 25 students |

**Learning outcomes / Competences and qualifications profile**

**Learning outcomes / Competences and qualifications profile**

Upon completion of this module the student will have gained basic knowledge on

- the anatomy, the metabolism and the physiology of various types of microorganisms;
- microbial growth and the control of microbial growth;
- methods used to classify and identify microorganisms using microscopy and differential staining;
- the qualitative and quantitative determination of various microorganisms in fresh water samples;
- and they will have applied their knowledge on all these topics in practical lab work.

Students will have gained knowledge on scientific basics and techniques in biotechnology and microbial genetics. They will be able to understand the important roles microorganisms play in ecosystems where they act as destruents, symbionts and pathogens, and their important role in environmental remediation. Students will have performed lab work, learning basic laboratory methods, the writing of scientific protocols and the interpretation of experimental results.

**Content**

Lecture:

- Prokaryotic and Eukaryotic Cells
- Microbial Metabolism, Growth and Control of Microbial Growth
- The Classification of Microorganisms
- Environmental Microbiology
- Applied and Industrial Microbiology
- Biotechnology and recombinant DNA
- Microbial Mechanism of Pathogenicity and host defence

Practical lab training:

- Laboratory Safety and Basic Laboratory Techniques
- Isolation and Cultivation of Microorganisms
- Nutritional Requirements, Physical Factors and Chemical Control Agents
- Methods to determine the amount of bacteria in a culture, bacterial growth
- Microscopy and Bacterial Staining
- Microbiology of soil and water
- Introduction to molecular genetics

**Teaching methods**

Lecture; Laboratory practicals

**Entry requirements**

None

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

| |
|---|
| Group protocols of laboratory practicals; Module examination grade 4.0 or better |
| **Use of module ( in other study programs )** |
| **Weight towards final grade**<br>3,125 % |
| **Person in charge of module**<br>PD Dr. Ute Hansen, |
| **Additional information**<br>Literature:<br>Tortora G.J., Funke B.R., Case C.L. (2010): Microbiology An Introduction. 10th Edition. San Francisco: Pearson Education, INC., publishing as Pearson Benjamin Cummings.<br>Campell, N.A. et al. (2008): Biology. 8th Edition. San Francisco: Pearson Education, INC., publishing as Pearson Benjamin Cummings.<br>Cappuccino, J.G., Sherman N. (2011): Microbiology A Laboratory Manual. 9th Edition. San Francisco: Pearson Education, INC., publishing as Pearson Benjamin Cummings.<br>Fuchs G. (2007): Allgemeine Mikrobiologie. 8. Auflage.Stuttgart: Thieme. |

## EE_4.01 Resource Management and Environmental Health

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_4.01 | 150 h | 5 CP | 4th semester | Summer semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture "Water Cycle and Water Management": 30 h / 2 semester hours per week (SWS)<br>Exercises with field practical "Water Cycle and Water Management": 15 h / 1 SWS<br>Lecture "Toxicology and Environmental Health": 30 h / 2 SWS<br>Exercise "Resource and Risk Management": 15 h / 1 SWS | 90 h / 6 SWS | 60 h / 4 SWS | Lectures: open<br>Exercises: 2 x 25 students |

**Learning outcomes / Competences and qualifications profile**

Upon completion of this course, the student will be able to:

- explain the elements of the water cycle and water catchment management;
- value water as a scarce resource and improve community understanding of the importance of conserving water resources;
- master fundamental laws and equations in hydrology and their application in typical water management situations;
- outline and compute the key elements of irrigation and drainage systems;
- identify the most important procedures of water treatment and purification and appreciate their importance with regard to possible toxicological impacts on human population;
- know and understand basic concepts of toxicology, environmental health and risk management;
- describe anthropogenic impacts on natural resources and environmental health;
- describe and apply selected risk assessment methods;
- use conceptional site models as a tool in risk management to evaluate and manage potential environmental hazards from the exposure to toxic substances;
- understand the interactions of chemical, biological, technical and socioeconomic factors of environmental health;
- evaluate and manage potential environmental hazards from the exposure to toxic substances.

**Content**

This module explains relevant background information for the management of environmental resources and the implications for environmental health. Based on the fundamental knowledge about the properties of water and hydrological concepts, the lecture introduces key technologies for water production, purification and treatment as well as the use of water for irrigation and integrated management concepts for river basins. The scope of water management cannot be fully appreciated without further insights into the complexity of other resources' management and the potential risks that arise for water quality.

For the evaluation of risks for environmental resources, the module outlines processes and methods in toxicology and environmental health. Major global and regional environmental health issues will be introduced covering biological, chemical and physical agents and their effects on health. Based on fundamental concepts of toxicology and dose-response mechanisms current methods of risk assessment will be introduced. The use of conceptual models based on the source-receptor-pathway concept will be explained. The lecture will highlight the use of conceptual models for stakeholder participation in risk assessment and risk management processes with a special focus on the consequences of climate change.

**Teaching methods**

Lectures and practical trainings with workgroup exercises, field practical

| |
|---|
| **Entry requirements**<br>None |
| **Types of assessment**<br>Graded examination |
| **Requirements for the award of credit points**<br>Module examination grade 4.0 or better, successful participation in exercises |
| **Use of module ( in other study programs )** |
| **Weight towards final grade**<br>3,125 % |
| **Person in charge of module**<br>Prof. Dr. Daniela Lud, PD Dr. Ute Hansen, Prof. Dr. Kai J. Tiedemann |
| **Additional information**<br>Literature:<br>Asano, T. (2007): Water Reuse: Issues, Technologies, and Applications. New York: McGraw-Hill.<br>Brutsaert, W. (2005): Hydrology - an Introduction. Cambridge: Cambridge University Press.<br>Davis, M. L.; Cornwell, D. A. (2008): Introduction to Environmental Engineering. Boston: McGraw-Hill.<br>Hornberger, G. M. (1998): Elements of Physical Hydrology. Baltimore, Md.: Johns Hopkins Univ. Press.<br>Friis, R.H. (2012): Essentials of Environmental Health. London: Jones and Bartlett Publishers.<br>Frumkin, H. (2010): Environmental Health: From Global to Local. San Francisco: Jossey-Bass.<br>Hauptmanns, U. (2015): Process and Plant Safety. Dordrecht: Springer<br>Gray, N. F. (2010): Water Technology - an Introduction for Environmental Scientists and Engineers. Oxford: Elsevier Butterworth-Heinemann.<br>Selinus, O. (2013): Essentials of Medical Geology: Revised Edition. Dordrecht: Springer<br>Smith, S. W. (1997): Landscape Irrigation - Design and Management. New York: Wiley.<br>Reece, J.B. et al. (2011) Campbell Biology, 9th ed., Pearson<br>Botkin, D.B., Keller, E.A. (2012) Environmental Science, 8th ed., John Wiley & Sons Inc.<br>Schlesinger, Biogeochemistry, Elsevier.<br>Umweltbundesamt (1999): Berechnung von Prüfwerten zur Bewertung von Altlasten. Ableitung und Berechnung von Prüfwerten der Bundes-Bodenschutz- und Altlastenverordnung für den Wirkungspfad Boden-Mensch aufgrund der Bekanntmachung der Ableitungsmethoden und -maßstäbe im Bundesanzeiger Nr. 161a vom 28. August 1999, Stand 2007. Berlin: Erich Schmidt Verlag. |

## EE_4.02 Project Management and Intercultural Competence

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_2.02 | 150 h | 5 CP | 4th semester | Summer semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture: 30 h / 2 semester hours per week (SWS)<br>Exercise: 30 h / 2 SWS | 60 h / 4 SWS | 90 h / 6 SWS | Lecture: 50<br>Exercise: 2x25 students |

**Learning outcomes / Competences and qualifications profile**

Students know about the importance of project management in today´s world. They have developed the skills to plan and conduct projects. In addition to this they have acquired knowledge and skills on how to develop a professional presentation. Students experienced dynamics and pitfalls of team work in projects and gained some routine in presenting and communicating results.

**Content**

Upon completion of this module the student will

- be familiar with the relevant terminology, terms such as the "mission", the "objective" and the "strategy" of an organization, the "SWOT analysis" related to the management of the organization's strategy, and the "objectives", "milestones", "deliverables", "goals" and "work packages" of projects;
- have defined a project plan and the scope according to the most common project management methodology;
- have developed a project flow chart and a network plan;
- have scheduled a project;
- will have gained experience with creating, leading, and managing a project team, with managing resources, monitoring the project performance, controlling the project and managing risk;
- have got insight into alternative methodologies of project management and specifics of international projects;
- have presented their project to the audience (developing the presentation, structuring the material, use of presentation software, gaining experience with organizing the work within the project team)
- have discussed the challenge of working in a different culture.

**Teaching methods**

Lectures, accompanied by exercises in which students develop their own projects (case studies) and present their results

**Entry requirements**

None

**Types of assessment**

Certificate (Testat)

**Requirements for the award of credit points**

Participation in a project (case study), final presentation and report

**Use of module ( in other study programs )**

Same module in "Environment and Energy", "Industrial Engineering - Specialization Communication and Information Engineering", "Information and Communication Design", "International Business and Social Sciences" and "Mobility and Logistics"

**Weight towards final grade**

None (ungraded)

**Person in charge of module**

PD Dr. Ute Hansen, Prof. Dr. Kai J. Tiedemann

**Additional information**

Reading:

Larson, E.W., Gray, C.F. (2011) Project Management. The Managerial Process. 5th edition. New York: McGraw-Hill.

Hillson, D. (2009): Managing Risk in Projects. Farnham; Burlington: Gower.

Raynolds, G. (2008): Presentation Zen. Simple Ideas on Presentation Design and Delivery. Berkeley: New Riders.

Stanton, N. (2009): Mastering Communication. 5th edition. Basingstoke; New York: Palgrave Macmillian.

## EE_4.03 Applied Measurement and Control

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_4.03 | 150 h | 5 CP | 4th semester | Summer semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture: 30 h / 2 semester hours per week (SWS)<br>Exercise: 30 h /2 SWS | 60 h / 4 SWS | 90 h / 6 SWS | 50 students |

**Learning outcomes / Competences and qualifications profile**

This course follows an application based approach for measurement and control systems in the field of environment and energy. Having completed this course, students are able to:

- consider spatiotemporal scales and variabilities of environmental processes
- design appropriate field sampling procedures
- understand fundamental physical measuring principles of different sensors
- compute sampling and instrumentation error
- develop field sampling systems to collect environmental data
- discuss basic principles and issues of closed loop control systems for automisation

**Content**

- Overview of environmental variables and the spatiotemporal characteristics of the underlying processes
- Sampling and instrumentation error
- Basic principles of sensors and transducers and their application
- Analog signals and interfaces: voltage, current, frequency, pulses
- Digital signals and interfaces
- Fundamentals of signal conditioning and processing
- Sampling, transmission and storage of data
- Connecting sensors and dataloggers
- Control systems basics

**Teaching methods**

Dialog oriented, seminaristic lectures with exercises
Students´ presentations

**Entry requirements**

None

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better

**Use of module ( in other study programs )**

**Weight towards final grade**

3,125 %

**Person in charge of module**

Prof. Dr.-Ing. Rolf Becker

**Additional information**

## EE_4.04 Legal Fundamentals

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_4.04 | 150 h | 5 CP | 4th semester | Summer semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture with exercises "Civil Law": 30 h / 2 semester hours per week (SWS)<br>Lecture "Environmental Law and Regulations": 15 h / 1 SWS<br>Lecture "Audits and Certification": 15 h / 1 SWS | 60 h / 4 SWS | 90 h / 6 SWS | 50 students |

**Learning outcomes / Competences and qualifications profile**

Upon completion of this course, the student will be able to:

- demonstrate comprehensive, current and integrated knowledge and understanding of key concepts in civil and environmental law (with a strong focus on environmental law) and its development in Germany and the EU, the nature of the legal controls over environmental pollution, the operation of environmental regulation and various enforcement mechanisms;
- recognise the issues involved in the implementation and enforcement of environmental law;
- analyse & apply such knowledge to identify and critically evaluate appropriate regulatory and enforcement strategies;
- identify, research (from a variety of sources) and analyse issues in environmental law, producing a persuasive, coherent and critical evaluation;
- understand the application of the principles, procedures and techniques of auditing.

**Content**

Companies in European countries such as Germany are faced with numerous environmental laws and regulations, which can affect the company's core activities, materials flows, planning processes and environmental policy. Compliance and auditing procedures for the certification of environmental and quality standards continuously grow in importance even for small and medium-sized companies and can be a tool to enhance the sustainability of the company's processes. This development not only invites our graduates to understand the meaning of these certifications but may also provide employment opportunities. In an ambience of strong dynamics such as environmental and energy engineering, however, it does not suffice to merely receive a list of relevant procedures and regulations to consider. This module therefore intends to give students a general understanding of the process of legislation and its corresponding implications with particular focus on environmental law in Germany and the European Union.

**Teaching methods**

Lecture with exercises in workgroups

**Entry requirements**

None

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better

**Use of module ( in other study programs )**

**Weight towards final grade**

| |
|---|
| 3,125 % |
| **Person in charge of module**<br>Prof. Dr. Daniela Lud; PD Dr. Ute Hansen |
| **Additional information**<br>Center for Chemical Process Safety (2011): Guidelines for Auditing Process Safety Management Systems. Hoboken, NJ: Wiley.<br>Förtsch G.; Meinholz H. (2014) Handbuch Betriebliches Umweltmanagement. Springer<br>Makuch K. Pereira R. (2012) Environmental and Energy Law. Wiley-Blackwell<br>Nelson, D. D.; Nelson, J. R. (1998): International Environmental Auditing. Government Inst. Press.<br>Prammer H.K. (2010) Corporate Sustainability. Springer<br>Thumann, A.; Younger, W. J.; Niehus, T. (2010): Handbook of Energy Audits. Lilburn, GA: Fairmont Press.<br>Selected legal texts, selected texts of standards related to environment and energy |

## EE_5.01 Remediation and Redevelopment

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_5.01 | 150 h | 5 CP | 5th semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture "Remediation Procedures and Techniques": 30 h / 2 semester hours per week (SWS)<br>Exercises "Remediation Procedures and Techniques": 15 h / 1 SWS<br>Lecture "Sustainable Architecture and Redevelopment": 30 h / 2 SWS | 75 h / 5 SWS | 75 h / 5 SWS | Lecture: open<br>Exercises:<br>2 x 25 students |

**Learning outcomes / Competences and qualifications profile**

Upon completion of the course the students will be able to:

- explain typical combinations of anthropogenic activities and soil and groundwater contaminations;
- apply fundamental equations concerning contaminant transport in soil and groundwater to typical groundwater contamination situations;
- conceptualize and calculate the basic elements of simple groundwater remediation systems;
- describe and categorize the basic approaches of groundwater remediation and know basic advantages and disadvantages with regard to cost, risk-reduction and environmental footprint of these basic approaches;
- know and understand the role of remediation in redevelopment processes of contaminated land;
- know and understand current global and European developments with regard to urbanization and sustainable cities;
- know and understand current municipal climate adaptation processes (urban form, community design, economic viability, energy, mobility);
- know and understand concepts of green buildings and built environments of the future.

**Content**

This module provides relevant background information for a basic understanding of remediation and mitigation of human impact on the environment, a special focus will be given to soil and groundwater remediation and the design of sustainable solutions for redevelopment of contaminated sites. Based on knowledge about the fundamental processes of contaminant behavior and transport in soil and groundwater, the lecture provides insight in basic remediation concepts. The lecture introduces key technologies for containment or in-situ or ex-situ treatment. The lecture will provide insight into advantages and disadvantages of the technical approaches. Methods for the valuation of different approaches will be introduced. The lecture on sustainable architecture and redevelopment provides relevant background information on sustainable built environments (design of healthy and sustainable communities, urban concepts for energy, viability and mobility, municipal climate change adaptation).

**Teaching methods**

Lectures and practical training with practical cases and workgroup exercises

**Entry requirements**

None

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better, successful participation in exercises

**Use of module ( in other study programs )**

**Weight towards final grade**

3,125 %

| |
|---|
| **Person in charge of module**<br>Prof. Dr. Daniela Lud |
| **Additional information**<br>Literature:<br>Dannenberg, A.L.; Frumkin, H.; Jackson R. J. (2011) Making Healthy Places Designing and Building for Health, Well-being, and Sustainability. Island Press<br>Dixon, T.; Raco, M.; Catney, P.; Lerner, D.N. (2007): Sustainable Brownfield Regeneration: Liveable Places from Problem Spaces. Blackwell Publishing.<br>Heilmann, A.; Pundt H. (2016) Kommunale Anpassung an die Folgen des Klimawandels als Komponente einer Nachhaltigen Entwicklung. In Walter Leal Filho (ed.) Forschung für Nachhaltigkeit an deutschen Hochschulen pp 223-244. Springer<br>Keijzer, Th. J. S.; Pijls, C.; Marnette, E.; Sumann, M.; Volkering, F.; van Zutphen, M. (2006): In-situ soil and groundwater remediation: theory and practice. Deventer: Tauw bv.<br>Kitanidis, P.K. and McCarty P.L. (2012) Delivery and Mixing in the Subsurface Processes and Design Principles for In Situ Remediation. Springer<br>Swartjes, F.A. (2011): Dealing with Contaminated Sites: From Theory Towards Practical Application. Springer.<br>Wilke F. (2012) Planning. In: Kresse, W. and Dank D. M. (eds.) Springer Handbook of Geographic Information. Springer |

## EE_5.02 Process Engineering

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_5.02 | 150 h | 5 CP | 5th semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture with exercises "Biotechnology, Biogas and Biofuels": 30 h / 2 semester hours per week (SWS)<br>Lecture with exercises "Mechanical and Thermal Process Engineering": 45 h / 3 SWS | 75 h / 5 SWS | 75 h / 5 SWS | 50 students |

**Learning outcomes / Competences and qualifications profile**

Having passed the module, students are familiar with applications of process engineering in the field of renewable energy systems and environmental protection. They are introduced to main basic methods originating from the different technical branches of process engineering. The students have a sound knowledge of fuels from biogenic sources together with the corresponding generation and energy conversion technologies. The students are able to critically assess the environmental impact, importance, economic effectiveness, sustainability and transferability of most important bioenergy production schemes.

**Content**

- Overview of relevant fields of application
- Introduction to process engineering (mechanical, thermal, chemical, electrochemical, biological)
- Material cycles
- Discussion of basic methods (fermentation, combustion, incineration, pyrolysis, gasification, desalination, separation techniques, etc.)
- Technical and environmental issues of bioenergy production and consumption

**Teaching methods**

Dialog oriented, seminaristic lectures with exercises
Students´ presentations

**Entry requirements**

None

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better

**Use of module ( in other study programs )**

**Weight towards final grade**

3,125 %

**Person in charge of module**

Prof. Dr. Irmgard Buder

**Additional information**

Literature:
Dieter Deublein, Angelika Steinhauser „Biogas from Waste and Renewable Resources“ Wiley VCH 2011 Weinheim
Nazir El Bassam“Handbook of Bioenergy Crops: A Complete Reference to Species, Development and Applications” Routledge 2010
Rafael Luque, Juan Campelo, James Clark „Handbook of biofuel production Processes and technologies“ Woodhead Publishing Limited 2011 Oxford Cambridge Philadelphia New Delhi

Martin Kaltschmitt, Hans Hartmann, Hermann Hofbauer “Energie aus Biomasse Grundlagen Techniken und Verfahren” Springer 2009 Heidelberg Dordrecht London New York
A. A. Vertès et al. „Biomass to Biofuels“ Wiley & Sons LTD 2010,
West Sussex PO19 8SQ UK

## EE_5.03 Interdisciplinary Project

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_5.03 | 300 h | 10 CP | 5th semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Project | 90 h / 6 semester hours per week (SWS) | 210 h / 14 SWS | open |

**Learning outcomes / Competences and qualifications profile**

In this module students have expanded and deepened the knowledge and skills they have acquired in previous project and modules. The interdisciplinary character of the project encourages students to discover new topics and gather practical experiences in different fields. Having completed this module, students are able to work on questions of theory or praxis in an international and interdisciplinary team. They are able to work scientifically and produce convincing results in their teams.

**Content**

The content differs between projects, depending on the study programs which are involved and the teaching staff's background. Depending on students' knowledge, lectures and workshops concerning different topics will be included so that students can attend different lectures of other study programms.

**Teaching methods**

Sessions for basic information about the project options; project coordination; project counseling provided by teaching staff or project partner from a company; accompanying lectures depending on projects' topics and demand; presentation of results to an interested audience consisting of university staff and students as well as external project partners.

**Entry requirements**

None

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better

**Use of module ( in other study programs )**

Same module for all Bachelor study programs of the faculty

**Weight towards final grade**

6,25%

**Person in charge of module**

All professors of the faculty

**Additional information**

## EE_6.01 Internship / Semester Abroad

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_6.01 | 900 h | 30 CP | 6th semester | Summer or winter semester | 1 semester |
| **Courses** | | **Teaching time** | **Self-study** 900 h | | **Planned group size** Open |

**Learning outcomes / Competences and qualifications profile**

The internship module has enabled students to apply their knowledge in a practical setting. Students have gained insights into a company and into specific practical fields. During their stays as interns they have worked on different tasks in the companies and have taken on responsibility for certain topics.

Students having opted for a semester abroad have gained intercultural competences. They have improved their foreign lanuage skills or have even studied a new foreign language, have learned how to get along in a foreign educational system and have worked with other students and teaching staff of different nationalities.

**Content**

Depending on internship company or university abroad. Topics will be discussed beforehand with teaching staff of Rhine-Waal University of Applied Sciences.

**Teaching methods**

**Entry requirements**

89 credit points achieved

**Types of assessment**

Certificate (Testat)

**Requirements for the award of credit points**

20 weeks of internship have to be completed. Splitting these 20 weeks into parts is not possible. An internship report and and a presentation which have to meet quality criteria have to be delivered.

In case of a semester abroad at least 10 ECTS have to be earned at the foreign university which is based in a non-German speaking country. Exceptions can be made in cases in which the success of the semester abroad is defined in a different way.

**Use of module ( in other study programs )**

Same module in "International Business and Social Sciences", "Industrial Engineering - Specialization Communication and Information Engineering", "Information and Communication Design", "Environment and Energy", and "Mobility and Logistics"

**Weight towards final grade**

None (ungraded)

**Person in charge of module**

All professors of the faculty

**Additional information**

## EE_7.01 Bachelor Workshop I: Research Methods

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_7.01 | 150 h | 5 CP | 7th semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Seminaristic lectures: 60 h / 4 semester hours per week (SWS) | 60 h / 4 SWS | 90 h / 6 SWS | 50 students |

**Learning outcomes / Competences and qualifications profile**

This is a very applied course aiming to provide students with the skills and knowledge about research methods they need to write their bachelor thesis. Having completed this course, students are able to decide which research method is suited best to explore their chosen bachelor theses topics. The can research available data sets or collect their own data using questionnaires. They can evaluate the data either with SPSS or estimate simple econometric models with EViews.

With regard to qualitative research methods students are able to apply the case study methodology and write convincing case studies. They can also apply interviewing techniques when conducting expert interviews. Students are aware of quality criteria for both quantitative and qualitative research. They have deepened this understanding through analyzing and criticizing examples of qualitative as well as quantitative research.

**Content**

Quantitative reasearch methods:

- Own data collection vs. working with available data sets
- Where to find available data sets
- Data quality, dealing with missing observations
- How to design a questionnaire
- How to evaluate a questionnaire
- Statistical analysis using SPSS
- Introduction to econometric methods
- Basic estimations using EViews
- Introduction to event study methodology
- Analysis of examples of quantitative research

Qualitative research methods:

- Quality of qualitative data
- Process of qualitative research
- Case study analysis
- Interview techniques
- Content analysis
- Discourse analysis
- Analysis of examples of qualitative research

**Teaching methods**

Seminaristic lectures which will include discussions as well as student tasks performed individually, in pairs or in groups. Some PC sessions to practice SPSS as well as EViews software.

**Entry requirements**

175 credits points achieved (including internship or semester abroad)

**Types of assessment**

Certificate (Testat)

**Requirements for the award of credit points**

Passed assessment

**Use of module ( in other study programs )**

Same module in "International Business and Social Sciences", "Industrial Engineering - Specialization Communication and Information Engineering", "E-Government", "Environment and Energy", "Media

| |
|---|
| Communication and Computer Sciences" and "Mobility and Logistics" |
| **Weight towards final grade**<br>None (ungraded) |
| **Person in charge of module**<br>All professors of the faculty |
| **Additional information**<br>Reading:<br>Pallant, J. (2010): SPSS Survival Manual: A Step by Step Guide to Data Analysis Using SPSS. 4th edition. New York: McGraw-Hill.<br>Saunders, M. / Lewis, P./ Thornhill, A. (2009): Research Methods for Business Students. 5th edition. London: Financial Times.<br>Studenmund, A. H. (2010): Using Econometrics: A Practical Guide with Eviews.Upper Saddle River: Pearson Prentice Hall.<br>Yin, R. K. (2009): Case study research: Design and methods. 4th edition. Thousand Oaks: Sage. |

## EE_7.02 Bachelor Workshop II: Scientific Writing

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_7.02 | 150 h | 5 CP | 7th semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Seminaristic lectures: 60 h / 4 semester hours per week (SWS) | 60 h / 4 SWS | 90 h / 6 SWS | 50 students |

**Learning outcomes / Competences and qualifications profile**

Students are able to communicate their results of scientific working in an appropriate written form. They have learned how to write effectively, concisely, and clearly. By practicing the discussed writing techniques they have gained an understanding of and experience in creating a scientific manuscript.

**Content**

- Writing style
- Writing techniques
- Structure, outline, and first draft
- Organizing the writing process
- How to present methods and results effectively
- Discussing the results
- Putting the fragements together
- Abstract and Introduction
- Rewriting the manuscript
- Editing and publishing the text

**Teaching methods**

Workshop including seminaristic lectures and many writing exercises. Students discuss their results and support each other.

**Entry requirements**

175 credits points achieved (including internship or semester abroad)

**Types of assessment**

Certificate (Testat)

**Requirements for the award of credit points**

Passed assessment

**Use of module ( in other study programs )**

Same module in "International Business and Social Sciences", "Industrial Engineering - Specialization Communication and Information Engineering", "E-Government", "Environment and Energy", "Media Communication and Computer Sciences" and "Mobility and Logistics"

**Weight towards final grade**

None (ungraded)

**Person in charge of module**

All professors of the faculty

**Additional information**

Reading:

Cargill, M.; O'Connor, P. (2009): Writing Scientific Research Articles. Strategy and Steps. Chichester: Wiley-Blackwell.

Glasman-Deal, H. (2010): Science Research Writing for Non-Native Speakers of English. A Guide for Non-Native Speakers of English. London: Imperial College Press.

Hofmann, A. H. (2010): Scientific Writing and Communication: Papers, Proposals, and Presentations. Oxford: Oxford University Press.

Russey, W. E.; Ebel, H. F.; Bliefert, C. (2006): How to Write a Successful Science Thesis. The Concise Guide for Students. Weinheim: Wiley-VCH.

## EE_7.03 Bachelor Workshop III: Advanced Seminar

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_7.03 | 150 h | 5 CP | 7th semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Seminaristic lectures: 60 h / 4 semester hours per week (SWS) | 60 h / 4 SWS | 90 h | 50 students |

**Learning outcomes / Competences and qualifications profile**

Students have received feedback, advice and guidance for their bachelor thesis. Each student has presented his or her own research findings in a short presentation (20-30 minutes). Together with two other students, who had received the respective presentation earlier, he/she has discussed the current state of research findings, methodology etc. In that way students have learned to present their research in a convincing way, to professionally defend their research and to accept feedback or criticism from their peers. At the same time students have learned to give feedback, provide ideas and advice for the work of others and formulate criticism in a fair way.

**Content**

- How to present research findings in a professional way
- How to comment and criticize the research of others
- How to moderate a group discussion
- Students´ presentations of their own findings followed by two discussant contributions and an open group discussion

**Teaching methods**

Students present their own research. Group discussions about the findings and methods applied.

**Entry requirements**

175 credits points achieved (including internship or semester abroad)

**Types of assessment**

Certificate (Testat)

**Requirements for the award of credit points**

Individual student´s presentation of his/her own research findings. Contribution to the discussion of two other students' researches.

**Use of module ( in other study programs )**

Same module in "International Business and Social Sciences", "Industrial Engineering - Specialization Communication and Information Engineering", "Environment and Energy", and "Mobility and Logistics"

**Weight towards final grade**

None (ungraded)

**Person in charge of module**

All professors of the faculty

**Additional information**

## EE_7.04 Bachelor Thesis and Disputation

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_7.04 | 450 h | 15 CP | 7th semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Bachelor Thesis: 12 CP<br>Disputation: 3 CP | Depends on need and demand | | |

**Learning outcomes / Competences and qualifications profile**

Students have conducted their own studies examining a research question from their scientific discipline, developing an appropriate methodological approach, and reflecting their research design and findings critically.

During the disputation students have proven their competencies in evaluating the topic and reflecting on its impact on real-life problems.

**Content**

- Depends on the topic; inter alia:
- Researching and evaluating literature
- Developing a research question and deriving hypotheses
- Operationalizing constructs
- Analyzing methodological strengths and weaknesses of different research approaches
- Developing research designs
- Conducting the studies
- Evaluating the results
- Writing the thesis
- Presenting and defending the findings

**Teaching methods**

Individual supervision and support

**Entry requirements**

175 credits points achieved (including internship or semester abroad)

**Types of assessment**

Graded Bachelor thesis and oral disputation

**Requirements for the award of credit points**

Passed Bachelor thesis and disputation as well as successful completion of all other modules of the curriculum

**Use of module ( in other study programs )**

**Weight towards final grade**

9,375 %

**Person in charge of module**

All professors of the faculty

**Additional information**

## EE_W.01 Advanced Simulation and Modelling

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_W.01 | 150 | 5 CP | 4th semester | Summer semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture (seminaristic style):<br>30 h / 2 semester hours per week (SWS)<br>Excercises:<br>30 h / 2 SWS | 60 h / 4 SWS | 90 h / 6 SWS | 20 students |

**Learning outcomes / Competences and qualifications profile**

Students are able to model systems of the real world and analyze them via simulations, particularly in the context of environmental studies. In detail, the students can model problems of the real world, describe them mathematically and find solutions. They know the appropriate use of models and simulations and their limits and understand the steps of the simulation process. The students are familiar with modern modelling and simulation techniques as well as common tools. They understand the modelling and simulation technology as a useful tool to understand real world systems and they can apply them in different contexts.

**Content**

- Introduction: Meaning of modelling and simulation in the context of environmental studies, the simulation chain
- Continuous Simulation (e.g. simple predator-prey relationships, intraspecific competition, various predators or prey species, ...), fishing dynamics (optimal fishing quotas, Maltus model, Verhulst model), dimensionless variables, implementation with Octave, Matlab, Scilab, R
- Transfer to other situations and systems as, e.g. epidemiology ...
- Introduction to partial differential equations (e.g. diffusion equation describing the spread of pollutants in the aquatic environment using FEM or FDM, groundwater modelling, …)
- Stochastic simulations (Monte Carlo simulations, Forest-fire simulations, ...)
- Advanced data processing (multivariate statistics, cluster analysis and data mining in environmental studies)

**Teaching methods**

Lectures and trainings with workgroup exercises (using GNU Octave, Matlab, Scilab, Excel, R)
Guest lectures planned (e.g. Applied Groundwater Modelling)

**Entry requirements**

Successful completion of the module "Statistics and Data Processing" is recommended

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better, successful participation in exercises

**Use of module ( in other study programs )**

Open to students of other study programs upon successful participation in "Statistics and Data Processing" (or equivalent statistics or mathematics module of other programs)

**Weight towards final grade**

3,125 %

**Person in charge of module**

Prof. Dr. Frank Zimmer

Additional information
Literatur:
Borcard, D.; Gillet, F.; Legendre, P. (2011): Numerical Ecology with R.New York: Springer
Quarteroni, A. M. ; Saleri, F. ; Gervasio, P. (2010): Scientific Computing with MATLAB and Octave. 3rd edition,

Berlin: Springer.
Geiser, J. (2008): Groundwater Contamination: Discretization and Simulation of Systems for Convection-Diffusion-Dispersion Reactions, Nova Science Pub Inc.
Woessner, W. W.; Anderson, M. P. (1992): Applied Groundwater Modeling: Simulation of Flow and Advective Transport, Academic Pr Inc.

## EE_W.03 Innovative Solutions in Environment and Energy

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_W.03 | 150 h | 5 CP | 4th semester | Summer semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture 30 h / 2 semester hours per week (SWS)<br>Seminar 30 h / 2 SWS | 60 h / 4 SWS | 90 h / 6 SWS | 25 students |

**Learning outcomes / Competences and qualifications profile**

The module provides basic knowledge on innovation, inventions, patents and knowledge management in companies. The students have gained an overview of the various techniques of environmental technology and renewable energy. They are able to assess the benefits advantages, risks and limitations of the different techniques and can discuss and analyse current developments in environmental technologies and renewable energy. The students have deepened their understanding of the demand for environmental technology and renewable energy upon state-of-the-art publications. They have discussed possible solutions to current questions and problems and presented a corresponding concept.

**Content**

- Innovation, inventions and patents
- Knowledge management
- innovative solutions in environmental technology (case examples)
- innovative solutions in (renewable) energy and energy storage (case examples)
- Putting energy- and environmental Research into practice

**Teaching methods**

Lecture; Tuition in seminars

**Entry requirements**

Completion of the following modules is recommended:

- "Introduction to Environmental Sciences"
- "Fundamentals of Energy Management"
- "Technology, Energy Technology"

**Types of assessment**

Graded seminar paper

**Requirements for the award of credit points**

Presentation of results, grade 4.0 or better for the seminar paper

**Use of module ( in other study programs )**

Open to students of other study programs

**Weight towards final grade**

3,125 %

**Person in charge of module**

Prof. Dr. Daniela Lud; Prof. Dr. Irmgard Buder

**Additional information**

Meusburger P., Glückler J., el Meskioui M. (2013) Knowledge and the Economy. Springer

Pimentel D. (Editor) (2008): Biofuels, Solar and Wind as Renewable Energy Systems, Benefits and Risks. Springer

Recent scientific journal articles from e.g.:

Energy, Sustainability and Society

Environmental and Resource Economics

Environmental Science and Pollution Research

## EE_W.04 Advanced Environmental Analytical Chemistry

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_W.04 | 150 | 5 CP | 5th semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture "Advanced topics in Environmental Analytical Chemistry": 30 h / 2 semester hours per week (SWS)<br>Exercises with excursions and practical training "Advanced Environmental Analytical Chemistry": 30 h / 2 SWS | 60 h / 4 SWS | 90 h / 6 SWS | 25 students |

**Learning outcomes / Competences and qualifications profile**

Upon completion of this course, the student will be able to describe the principle analytical techniques and methods for detecting and quantifying contaminants in environmental samples. They will be able to explain the significance of sampling methods and sample preparation for the quality of analytical data. The can describe and value external and internal sources of errors in the sampling and analysis chain; outline and apply an analytical approach for a practical analytical problem and use, evaluate and present analytical data from primary literature e.g. in a protocol or scientific paper.

**Content**

- Sampling methods and preparation of samples for analysis
- Principles of analytical techniques for detecting and quantifying environmental contaminants as for example chromatographic techniques, atom absorption spectroscopy, bio-essays
- Analysis of

In recent years there has been a considerable increase in analytical techniques that are available for the chemical analysis of environmental samples. The number of less invasive, faster measurement techniques including on-site measurement techniques has also increased. There is growing attention for emerging contaminants and the principles of green chemistry are integrated in analytical chemistry. This module explains the principles and the use of general and advanced analytical techniques for detecting and quantifying environmental contaminants and gives insight into current developments of analytical chemistry. The lecture will also provide insight into the significance of sampling methods and sample preparation for the quality of analytical data and will address sources of errors. Based on the fundamental knowledge about analytical techniques, the practical will deepen laboratory skills of environmental analytical chemistry and provide insight in methods like GC or HPLC, AAS, bioassays and electrochemical methods.

**Teaching methods**

Lectures and trainings with workgroup exercises, practicals and/or excursions

**Entry requirements**

Completion of the modules EE_2.01 General and Inorganic Chemistry and EE_3.01 Organic Chemistry and Analytical Chemistry is required

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better, successful participation in exercises

**Use of module ( in other study programs )**

Open to students of other study programs upon successful participation in "Organic and Analytical Chemistry" (or equivalent Chemistry module)

**Weight towards final grade**

| |
|---|
| 3,125 % |
| **Person in charge of module**<br>Prof. Dr. Daniela Lud; Prof. Dr. Irmgard Buder |
| **Additional information**<br>Literature:<br>Cammann K. (2010) Instrumentelle Analytische Chemie verfahren, Anwendungen, Qualitätssicherung. Spektrum<br>Danzer, K. (2007) Analytical Chemistry Theoretical and Metrological Fundamentals Springer<br>Kellner, R., Mermet, J.-M., Otto, M., Valcárel, M. Widmer, H. M. (2004): Analytical Chemistry, 2 Ed. Wiley VCH Weinheim<br>Selected scientific publications such as:<br>Schriks, M.; Heringa, M. B.; van der Kooi, M. M. E.; de Voogt, P.; van Wezel, A. P. (2010): Toxicological relevance of emerging contaminants for drinking water quality. Water Research 44: 461-476.<br>VanWijngaarden et al. (2001): Radiometric sand–mud characterisation in the Rhine–Meuse estuary Part A. Fingerprinting. Geomorphology 43: 87– 101. |

## EE_W.05 Electromobility

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_W.05 | 150 h | 5 CP | 5th semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture with exercises "Electromobility": 60 h / 4 semester hours per week (SWS) | 60 h / 4 SWS | 90 h / 6 SWS | 25 students |

**Learning outcomes / Competences and qualifications profile**

Upon completion of this course, the student will be able to:

- understand and evaluate different concepts of drive systems including motors
- understand fundamental principles in vehicle technology,
- basics of accumulators and fuel cells (electrochemistry)
- to define and apply the term „sustainability“ on mobility with passenger cars
- to evaluate mobility under sustainability aspects in a scientific manner

**Content**

- Impact of traffic on the environment, Criteria for sustainable transportation
- Can electric vehicles contribute to sustainable transportation?
- Comparison electric engines and internal combustion engines (ICE)
- Mobile storage of electricity (accumulators)
- Mobile production of electricity (electro generator, fuel cell)
- Challenges and requirements for vehicle construction of electric cars
- Will cars become “smart”? New concepts of mobility
- Stabilisation of the electric power supply by car batteries?

**Teaching methods**

Lecture with exercises in workgroups

**Entry requirements**

None

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better

**Use of module ( in other study programs )**

Open to students of other study programs

**Weight towards final grade**

3,125 %

**Person in charge of module**

Prof. Dr. Irmgard Buder

**Additional information**

Literature:

Pistoia, G. (2010): Electric and Hybrid Vehicles: Power Sources, Models, Sustainability. Amsterdam: Elsevier.

Wallentowitz, H.; Freialdenhoven, A. (2011): Strategien zur Elektrifizierung des Antriebsstranges. Wiesbaden: Vieweg und Teubner.

Hüttl, R. F.; Pischetsrieder, B.; Spath, D. (eds.) (2010): Elektromobilität - Potenziale und wissenschaftlich-technische Herausforderungen. Berlin: Springer.

Reddy T. B. (2011): Linden’s Handbook of Batteries fourth Ed. Mac Graw Hill New York

Chau, K. T. (2015) Electric Vehicles Machines and Drives Design, Analysis and Application John VWiley and Sons LTD Singapore

## EE_W.06 Advanced Auditing and Certification Procedures

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_W.06 | 150 h | 5 CP | 5th semester | Winter semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture"Advanced auditing procedures": 30 h / 2 semester hours per week (SWS)<br>Exercises "Advanced auditing procedures": 30 h / 2 SWS<br>"Advanced auditing procedures": 30 h / 2 semester hours per week (SWS)<br>Exercises, field practicals "Advanced auditing procedures": 30 h / 2 SWS | 60 h / 4 SWS | 90 h / 6 SWS | 25 students |

**Learning outcomes / Competences and qualifications profile**

Upon completion of this course, the student will be able to:

- define the terms "audit" and "certification" and explain the role of auditing (regarding quality, safety, environment and energy) in the assessment and improvement of environmental performance of companies and organizations;
- explain different types e.g. of environmental audits and energy audits;
- describe the general timeline of audits, identify the elements of this timeline (planning, commitment, goals, protocols and checklists, auditing process, evaluation, reporting, planned actions, further steps) and apply these in basic practical cases;
- Students have also acquired:
- an understanding of the role of (e.g. Environmental) Audit and (e.g. Environmental) Management Systems for the ongoing improvement of environmental performance of organizations; and know how sustainability concepts can be linked with Environmental Auditing;
- a basic understanding of how auditing data are collected in a systematic way;
- a basic understanding of assessment and evaluation of performance of the data collected;
- practise in the use of limit values and assessment criteria during the evaluation process and in general technical reporting skills

**Content**

This module provides relevant background information for a more advanced understanding of auditing and certification procedures as tools to evaluate environmental performance of companies and organizations, to clarify undesired environmental effects of current activities and to identify possibilities for changes of current practice. The lecture will introduce different types of environmental audit such as compliance audit, health and safety audit, site audit, energy audit and due dilligence audit. The lecture will provide insight into timeline and elements of environmental audits (planning, commitment, goals, protocols and checklists, auditing process, evaluation, reporting, planned actions, further steps). Based on knowledge about the different types of environmental audits and their general timeline and elements, the role of auditing in Environmental Management Systems will be explained. Students will also be introduced to current developments e.g. integrating sustainability concepts and auditing. During the exercises the contents of the lecture will be applied using online tools and practical cases.

**Teaching methods**

Lectures and exercises on practical cases

| |
|---|
| **Entry requirements**<br>Completion of the module "Legal Fundamentals" is recommended |
| **Types of assessment**<br>Graded examination |
| **Requirements for the award of credit points**<br>Module examination grade 4.0 or better, successful participation in exercises |
| **Use of module ( in other study programs )**<br>Open to students of other programs upon successful participation in "Legal Fundamentals" (or equivalent) |
| **Weight towards final grade**<br>3,125 % |
| **Person in charge of module**<br>Prof. Dr. Daniela Lud |
| **Additional information**<br>Literature:<br>Azapagic, A. and Perdan, S. (2011) Sustainable Development in Practice Case studies for engineers and scientists. Chichester: Wiley-Blackwell<br>Epstein, M. J. (2008): Making Sustainability Work. Best Practices. Sheffield: Green Leaf Publishing;<br>Kuhre, W. L. (1995): ISO 14001 certification: Environmental Management Systems: A practical guide for preparing effective environmental management systems. Upper Saddle River: Prentice Hall.<br>Morvay, Z. K. and Gvozdenac, D.D. (2008) Applied Industrial Energy and Environmental Management Chichester: Wiley IEEE Press<br>Selected scientific publications from scientific journals such as<br>Environmental Management |

## EE_W.07 Environmental Monitoring

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_W.07 | 150 h | 5 CP | 4th or 5th semester | Winter semester or Summer semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture "Environmental Monitoring" 30 h / 2 semester hours per week (SWS)<br>Exercises with excursions and practical training 30 h / 2 semester hours per week (SWS) | 60 h / 4 SWS | 90 h / 6 SWS | 20 students |

**Learning outcomes / Competences and qualifications profile**

Upon completion of the course students will have gained theoretical and practical experience on environmental monitoring methodologies, the processing and aggregation of environmental data, the organizations responsible for monitoring activities and common ways of making monitoring data available to the public. They will be familiar with data quality assurance and quality control. The students will have gained an overview of relevant regional, national and EU-legislation. They will be able to use the appropriate terms and nomenclature and they will have acquired an understanding of monitoring methods and how environmental monitoring is organized and performed in the real world. The participants will have discussed actual problems of water management, air pollution and related health effects.

**Content**

- Lecture addressing approaches of environmental monitoring, the legal background, parameters monitored and their value as indicators for environmental pressures
- Collection of particulate matter as an example for an important air pollutant
- Acquisition, processing and evaluation of meteorological data
- Application of microbiological methods to investigate the safety and quality of drinking water and surface water bodies
- Deepening of the understanding of analytical techniques to determine pollutant concentrations in drinking water, surface water, ground water and waste water
- Excursions to actors in water management and environmental protection in order to provide insight into current activities of authorities responsible for the protection of the environment
- Exercises with the objective to deepen the understanding of the scientific background of environmental monitoring
- Discussion of benefits, risks and limitations of monitoring techniques

**Teaching methods**

Lectures, trainings, excursions, exercises and experimental work

**Entry requirements**

None

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module examination grade 4.0 or better, successful participation in exercises

**Use of module ( in other study programs )**

Open to students of other study programs

**Weight towards final grade**

3,125 %

**Person in charge of module**

PD Prof. Dr. Ute Hansen

**Additional information**

Schlesinger & Bernhardt (2013) Biogeochemistry, Elsevier
Wiersma, G.B. (2004) Environmental Monitoring, CRC Press
Botkin & Keller (2012) Environmental Science, John Wiley & Sons
Artiola, Pepper & Brusseau (eds.) Environmental Monitoring and Characterization, Elsevier 2004

## EE_W.08 Environmental Economics

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_W.08 | 150 h | 5 CP | 4th or 5th semester | Winter semester or Summer semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Environmental Economics<br>2 semester hours lectures plus 2 hours exercises per week (SWS) | 60 h / 4 SWS | 90 h | 50 students |

**Learning outcomes / Competences and qualifications profile**

Upon completion of this course, the student will be able to:

- relate the concept of allocation of scarce resources to economics as well as to environmental problems;
- appreciate alternative perspectives on the nature of environmental problems;
- use various methods to evaluate environmental goods and services;
- understand the implications of a pareto-improvement;
- demonstrate how various market based options for environmental policy work, including emission charges and transferable permits;
- apply the flexible mechanisms in the Kyoto protocol to environmental impact caused by industrial activity;
- perform a cost-benefit analysis.

**Content**

Environmental Economics is the application of the principles of economics to the study of how environmental and natural resources are developed and managed. It addresses the economic implications of environmental impacts caused by human activity and introduces some concepts of economical appreciation of ecosystem services. It combines theoretical analysis with discussions on specific environmental policies as applied to water management, air pollution, the energy sector, and climate change. Within these examples, particular topics like the microeconomic analysis of environmental regulations, the problem of social cost, the policy instrument choice, and the estimation of environmental improvements will be covered.
At the threshold to the complementary course on energy economics the lecture highlights some energy-related externalities and examines their regulation. In particular questions like "What are the externalities of traditional fuel sources like coal?", "In which ways has regional pollution been regulated?" and "What are the economics of climate change?" will be discussed.

**Teaching methods**

Lecture with exercises in workgroups

**Entry requirements**

None

**Types of assessment**

Written examination, written assignments

**Requirements for the award of credit points**

Module exam grade 4.0 or better

**Use of module ( in other study programs )**

**Weight towards final grade**

3,125 %

**Person in charge of module**

Prof. Dr. Kai J. Tiedemann

**Additional information**

Literature:

Mäler, K.-G.; Vincent, J. R. (eds.) (2003): Handbook of Environmental Economics. Amsterdam: Elsevier.
Perman, R. (2003): Natural Resource and Environmental Economics. Harlow: Pearson Addison Wesley.
Tietenberg, T.; Lewis, L. (2011): Environmental & Natural Resources Economics, International Edition. Upper Saddle River, NJ: Pearson Education.

## EE_W.09 Energy Economics

| Code | Workload | Credits | Level of module | Frequency of offer | Duration |
|---|---|---|---|---|---|
| EE_W09 | 150 h | 5 CP | 4th or 5th semester | Winter semester or Summer semester | 1 semester |

| Courses | Teaching time | Self-study | Planned group size |
|---|---|---|---|
| Lecture with exercises<br>Energy Economics<br>2 semester hours lectures plus 2 hours exercises per week (SWS) | 60 h / 4 SWS | 90 h / 6 SWS | 50 students |

**Learning outcomes / Competences and qualifications profile**

Upon completion of this course student will be able

- To understand basic economic concepts that influence energy production, energy distribution and end-use
- To understand how local, regional, and global institutions affect energy markets and prices
- To relate historical and contemporary public policy issues to energy management in the EU and globally
- To apply this knowledge to analyse specific energy industries and policy questions
- To evaluate the sustainability of different forms of fuel and energy production

**Content**

The lecture "Energy Economic" has the objective to apply economics to particular issues of energy markets, issues of energy distribution, investment in conventional and renewable energy, and energy storage. It gives an overview of key economic concepts applied on energy markets and highlights special conditions of energy markets, such as extraction of fossil fuels and exploitation of renewable energy.
As in the complementary course of Environmental Economics the lecture highlights energy related externalities e.g. pollution by mining and extraction of fossil fuels, climate change due to increased CO2 emissions and other negative impacts of energy use. Concepts of regulation of pollutants by economic incentives as cap and trade and concepts of support for energy saving measures and more sustainable technologies are discussed and valuated.

**Teaching methods**

Lecture with exercises in workgroups

**Entry requirements**

None

**Types of assessment**

Graded examination

**Requirements for the award of credit points**

Module exam grade 4.0 or better;

**Use of module ( in other study programs )**

Open to students of other study programs

**Weight towards final grade**

3,125 %

**Person in charge of module**

Prof. Dr. Irmgard Buder

**Additional information**

Literature:

Subhes C. Bhattacharyya (2011): Energy Economics -Concepts, Issues, Markets and Governance, Springer London Dordrecht Heidelberg New York
Dahl, C. A. (2004): International Energy Markets: Understanding Pricing, Policies and Profits, PennWell Tulsa, OK.
Tietenberg, T.; Lewis, L. (2011): Environmental & Natural Resources Economics, Pearson Education International Edition, Upper Saddle River, NJ
David A. Anderson (2014): Environmental Economics and Natural Resource Management, Routledge 4th edition, 2 Park Square, Milton Park Abingdon, Oxon, OX 14 RN