Module Handbook

Applied Physics

Master of Science Date of Information: 29.04.26

Master Data Applied Physics

Name
Applied Physics
Short Form
APP2
Degree
Master of Science
Faculty
Faculty of Engineering
Semesters
3
Credit Points (CP)
90
Specification
Framework Examination Regulations
2024-RPO
Examination Regulations
2026
Accredited by
Accredited Until
Note
Hours per CP
30
Degree Program Head
Prof. Dr. rer. nat. Stefan Kontermann

Degree Program Objectives

Professional Competencies

Mathematical Methods

Graduates are able to apply mathematical methods and simulations using a goal-focused approach.

User-Centered Physical Technology

Graduates are able to develop, test, and use new physically based technical applications.

Experimental Work

Graduates are able to answer physical questions independently or by using complex experiments or simulations.

Methodological Competencies

Problem Solving

Graduates are able to independently identify complex problems, even in unfamiliar and multidisciplinary situations, and to select and implement appropriate solutions based on the latest scientific findings.

Scientific Research and Development

Graduates are able to formulate research questions, select appropriate research methods, present their research findings, and interpret them, including to improve technical products and processes.

Social Competencies

Leadership Skills

Graduates are able to assume increasing responsibility within a team and as a leader, to involve team members in tasks in a goal-oriented manner while taking the group's situation into account, and to reflect on their own role.

Communication

Graduates are able to present complex subject-related problems, solutions, ideas, and concepts in an argumentatively sound manner to both experts and non-experts, and to further develop them by incorporating their perspectives.

Teamwork Abilities

Graduates are able to work in a goal-oriented manner within a team, to reflect on their own and other's perspectives, to identify potential conflicts in collaboration, and to find solution-oriented, constructive ways of dealing with conflicts.

Personal Competencies

Self-Awareness

Graduates are able to critically assess their own abilities and to reflect on and further develop their professional practice.

Time Management and Self-Management

Graduates are able to plan and prioritize tasks efficiently, to carry them out with motivation and discipline, and to complete them within the given timeframe.

Intercultural Competencies

Graduates are able to reflect on professional communications with regard to different intercultural perspectives and discussion cultures, and to act appropriately in intercultural encounters.

Curriculum

Applied Physics (M.Sc.), PO 2026

The modules are listed in the recommended order of study.

Modules and Courses	CP	SWS	Rec. Semester	Course Format(s)	Course Comp. Type	Examination Formats	vV
Selection from Electives Professional Skills: 5 CP	**5**		**1.**				
Selection from Specialization (1st Semester): 10 CP	**10**		**1.**				
Advanced Mathematics	**5**	**4**	**1.**			**PL**: K o. MP	
Advanced Mathematics		4	1.	SU			
Particles and Quanta	**5**	**4**	**1. - 2.**			**PL**: MP o. K	
Advanced Classical Mechanics		2	1. - 2.	SU			
Quantum Physics		2	1. - 2.	SU			
Modelling and Experiment Design	**5**	**5**	**1. - 2.**			**PL**: K u. PT	
Modelling and Simulation of Physical Systems		3	1. - 2.	SU			
Design of Experiments		2	1. - 2.	SU			
Statistical and Solid State Physics	**5**	**5**	**1. - 2.**			**PL**: K o. MP	
Statistical Physics		2	1. - 2.	SU			
Physics of Electrical and Optical Materials		3	1. - 2.	SU			
Electrodynamics and Photonics	**5**	**4**	**1. - 2.**			**PL**: K o. MP	
Electrodynamics and Photonics		4	1. - 2.	SU			
Selection from Specialization (2nd Semester): 10 CP	**10**		**2.**				
Research Project ***(see footnote 1)***	**10**	**2**	**2.**			**PL**: H u. PR	
Research Project		0	2.	Proj			
Physics Colloquium		2	2.	S			
Master's Thesis	**30**	**0**	**3.**			**PL**: KOL **PL**: TH	true
Master's Thesis		0	3.	MA			
Electives: Professional Skills – Students must select one 5CP-module. Note: All students must take a German proficiency test during the introductory week. For students who do not achieve level B1 in the test, the module German as a Foreign Language is compulsory. Students will be placed in an appropriate course to enable them to make progress towards the next language level. Students with a German language university degree or entrance qualification are exempt from the level test and module.			~				
German as a Foreign Language 1 ***(see footnote 2)***	**5**	**4**	**1.**			**PL**: F	
German as a Foreign Language 1		3	1.	S			
Language of Technology		1	1.	S			
Comprehensive Competencies	**5**	**4**	**1.**			**PL**: K o. K u. POR o. POR	
Advanced Project Management		2	1.	SU			
Leadership		2	1.	SU + S			
Scientific Communication	**5**	**4**	**1. - 2.**			**PL**: A **SL**: PR [MET]	
Presentation Skills		2	1. - 2.	SU			
Scientific Writing		2	1. - 2.	SU			
AI Laboratory	**5**	**4**	**1. - 2.**			**PL**: PT	
AI Laboratory		4	1. - 2.	P			
Innovation Management & Entrepreneurship	**5**	**4**	**1. - 2.**			**PL**: POR o. H o. PR	
Innovation Management		2	1. - 2.	SU			
Entrepreneurship		2	1. - 2.	SU			
Electives: Specialization			~				
Energy and Hydrogen Technology			~				
Energy System Components and Signal Processing	**5**	**4**	**1. - 2.**			**PL**: K	
Materials for Energy Distribution		2	1. - 2.	SU			
Signal Processing in Applied Physics		2	1. - 2.	SU			
Sustainable Energy Systems	**5**	**4**	**1. - 2.**			**PL**: MP	
Energy Distribution Grids		2	1. - 2.	SU			
Smart Large Scale Energy Storage Systems		2	1. - 2.	SU			
Micro- and Nanotechnology			~				
Surfaces and Nanotechnology	**5**	**4**	**1. - 2.**			**PL**: PR	
Nanotechnology		2	1. - 2.	SU			
Surface Physics		2	1. - 2.	SU			

Modules might be offered annually, so your actual study schedule depends on whether you start in the winter or summer semester.

Courses in the format of a Practical Course (P) require mandatory attendance. The attendance requirement is fulfilled when at least 80% of class sessions are attended in full. Certain sessions may be declared mandatory at the beginning of the course. If more than 80% of class sessions require mandatory attendance, make-up sessions will be offered for excused absences, as far as organizationally possible. Group assignments and session dates, if applicable, will be announced at the start of the course.

Modules and Courses	CP	SWS	Rec. Semester	Course Format(s)	Course Comp. Type	Examination Formats	vV
Microfluidics and Microfabrication	**5**	**4**	**1. - 2.**		**PL**: MP		
Microfluidics		2	1. - 2.	SU			
Microfabrication		2	1. - 2.	SU			
Photonics and Quantum Technology			~				
Laser Physics	**5**	**4**	**1. - 2.**		**PL**: MP o. K o. K u. PR		
Quantum Electronics		2	1. - 2.	SU			
Laser Applications		2	1. - 2.	SU			
Quantum Physics and Technology	**5**	**4**	**1. - 2.**		**PL**: MP o. MP u. PR		
Quantum Technologies		2	1. - 2.	SU			
Advanced Quantum Physics		2	1. - 2.	SU			

Table Abbreviations:

CP: Credit Points According to ECTS, **MET:** Successfully Completed, **PL:** Graded Course Component, **SL:** Pass/fail Course Component, **SWS:** Contact Hours per Week, **SoSe** Summer Semester, **vV:** Formal Requirements **WiSe** Winter Semester, **∼:** Dependending on Selection, ("true": For details, see the examination regulations)

Course Format(s):

SU: Seminar-style , **P:** Laboratory , **MA:** Master's Thesis , **S:** Seminar , **Proj:** Project

Examination Format(s):

A: Written Assignment , **F:** Foreign Language Examination , **H:** Term Paper , **K:** Written Examination , **KOL:** Thesis Defense , **MP:** Oral Exam , **POR:** Portfolio , **PR:** Presentation , **PT:** Practical/Artistic Work , **TH:** Thesis

[1] The Physics Colloquium requires mandatory attendance. The attendance requirement is fulfilled when at least 80% of class sessions are attended in full. Certain sessions may be declared mandatory at the beginning of the course.

[2] The module Deutsch als Fremdsprache (German as a Foreign Language) requires mandatory attendance. The attendance requirement is fulfilled when at least 75% of class sessions are attended in full. Certain sessions may be declared mandatory at the beginning of the course.

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Modul

Advanced Mathematics

Module Code
Y-M30

Short Form
AMath

Module Requirement
Compulsory

Credits
5 CP

Duration
1 Semester

Frequency
Every semester

Language(s)
English

Scheduled Semester
1.(recommended)

Type of Examination
Module Level Assessment

Also Included In

- Applied Physics (M.Sc.), PO2026
- Biomedical Engineering (M.Sc.), PO2026

Curriculum Notes

Module Coordinator
Prof. Dr. Friedhelm Schönfeld

Required Prequisites
None

Recommended Prequisites
None

Module Objectives
Upon successful completion of the module, students are able to,

- explain and apply the basic concepts and properties of vector spaces and linear operators,
- classify and apply transformation laws of tensors of different order,
- analyze real-world data by applying statistical and optimization methods,
- evaluate integrals over vector fields applying the theorems of Gauss and Stokes,
- identify and interpret the significant partial differential equations in physics,
- adapt solution methods for partial differential equations, effectively applying these techniques to practical scenarios.

This module contributes to the following degree program objectives
User-Centered Physical Technology, Mathematical Methods, Experimental Work, Problem Solving, Scientific Research and Development

Type of Course Component: Graded Course Component

Examination Format: Written Examination o. Oral Exam

Grading Type: Graded

(If multiple examination formats are available, the exact format of examination and, if appliable, the exact duration of examination is o be determined by the Examination Board at the beginning of the course and publicized within the faculty.)

Contribution to Final Grade
By credit

Total Module Workload in Hours
150, including 42 hours of class attendance (4 contact hours per week) and 108 hours of self-study, including exam preparation

Remarks

Related Courses

Required Course(s)

- Advanced Mathematics (SU, 1. Sem., 4 SWS)

Related Course

Advanced Mathematics

Course Code	**Short Form**	**Workload**	**Semester**
Y-M30V		CP	1.

Course Types	**Frequency**	**Language(s)**
Seminar-style	Every semester	English

Also included in
- Applied Physics (M.Sc.), PO2026
- Biomedical Engineering (M.Sc.), PO2026

Course Responsible

Recommended Prerequisites
- Profound knowledge of linear algebra and analysis

Course Contents
1. Basics of Vector Spaces
   Definition and properties of vector spaces
2. Linear Operators and Matrices
   Definition and examples of linear operators
   Matrix representation and transformation behavior
   Eigenvalues and eigenvectors
3. Fundamentals of Data Analysis and Optimization
   Gradient descent method
   Linear and logistic regression
   Selected methods for dimensional reduction
4. Vector Analysis
   Integral theorems of Gauss and Stokes
   Applications in potential theory
5. Partial Differential Equations
   Overview of key PDEs: wave, diffusion, heat conduction, Navier-Stokes equations
   Physical interpretations and derivation
   Solution Methods for PDEs

Teaching Methods and Media
Short lectures are combined with interactive parts. Use of multimedia resources, such as videos and software demonstrations, enriches the lecture presentations. The time between the lectures is dedicated to discussions, problem-solving sessions, and collaborative work. Students are encouraged to present their solutions at the board. By placing students at the center of the learning process, this approach not only enhances their understanding of applied mathematics but also equips them with essential skills for their academic and professional futures.

References
Christian Lang u. Norbert Pucker, Mathematische Methoden der Physik, Elsevier Spektrum Akademischer Verlag, ISBN 3-8274-158-6
George B. Arfken u. Hans J. Weber, Mathematical Methods for Physicists, Elsevier Academic Press, ISBN 978-0-12-088584-8
Tilo Arens et al., Mathematik, Spektrum Akademischer Verlag, ISBN 978-3-8274-1758-9

Notes

Modul

Particles and Quanta

Module Code
APP2-28

Short Form

Module Requirement
Compulsory

Credits
5 CP

Duration
1 Semester

Frequency
Winter semester only

Language(s)
English

Scheduled Semester
1., 2.(recommended)

Type of Examination
Module Level Assessment

Also Included In

- Applied Physics (M.Sc.), PO2026

Curriculum Notes

Module Coordinator
Prof. Dr. Jochen Rau

Required Prequisites
None

Recommended Prequisites
None

Module Objectives
Upon successful completion of the module, students are able to,

- Apply Lagrangian and Hamiltonian formalisms to analyze classical systems and derive equations of motion.
- Name and explain key quantum concepts and how they differ from classical physics.
- Solve quantum mechanical problems in the Hilbert space formalism, using the mathematical language of state vectors, observables and unitary time evolution.
- Recognize symmetries and conservation laws.
- More generally, students will gain proficiency in approaching physical problems analytically and deploying appropriate mathematical tools.

This module contributes to the following degree program objectives
Mathematical Methods, Problem Solving

Type of Course Component: Graded Course Component

Examination Format: Oral Exam o. Written Examination

Grading Type: Graded

(If multiple examination formats are available, the exact format of examination and, if appliable, the exact duration of examination is o be determined by the Examination Board at the beginning of the course and publicized within the faculty.)

Contribution to Final Grade
By credit

Total Module Workload in Hours
150, including 42 hours of class attendance (4 contact hours per week) and 108 hours of self-study, including exam preparation

Remarks

Related Courses

Required Course(s)

- Advanced Classical Mechanics (SU, 1., 2. Sem., 2 SWS)
- Quantum Physics (SU, 1., 2. Sem., 2 SWS)

Related Course

Advanced Classical Mechanics

Course Code	Short Form	Workload	Semester
APP2-28V1		CP	1., 2.

Course Types	Frequency	Language(s)
Seminar-style	Winter semester only	English

Also included in
- Applied Physics (M.Sc.), PO2026

Course Responsible
Prof. Dr. Detlef Lehmann

Recommended Prerequisites
None

Course Contents
Lagrange-Formalism:
- derivation of the Euler-Lagrange equations
- simple examples with polar, cylinder and spherical coordinates
- double pendulum and systems of N coupled oscillators
- mathematical supplements: ODEs and the matrix exponential
- the Brachistochrone problem

Hamilton-Formalism:
- Hamilton function and Hamilton equations
- equivalence to Lagrange formalism
- Hamilton-Jacobi equation and classical action
- the classical limit of quantum mechanics

Teaching Methods and Media
seminaristischer Unterricht (Tafelanschrieb, Folien, Skript, Online-Unterlagen) und Übungen (Einzel- und Gruppenarbeit) / Seminar-style teaching (blackboard, slides, script, online documents) and exercises (individual and group work)

References

- Torsten Fliessbach: Mechanik (Lehrbuch zur Theoretischen Physik I), Spektrum Akademischer Verlag
- Vorlesungsskript / lecture notes
- Nolting, Wolfgang: Grundkurs Theoretische Physik 2: Analytische Mechanik, Springer Verlag
- Nolting, Wolfgang: Theoretical Physics 2: Analytical Mechanics, Springer (english)
- Landau, Lifschitz: Lehrbuch der theoretischen Physik, Band 1: Mechanik; Verlag Harri Deutsch
- Landau, Lifschitz: Course of Theoretical Physics, Vol.1: Mechanics, Elslevier India (english)

Notes

Related Course

Quantum Physics

Course Code	Short Form	Workload	Semester
APP2-28V2		CP	1., 2.

Course Types	Frequency	Language(s)
Seminar-style	Winter semester only	English

Also included in
- Applied Physics (M.Sc.), PO2026

Course Responsible
Prof. Dr. Jochen Rau

Recommended Prerequisites
None

Course Contents
- Quantum phenomena
- Quantum measurement
- Hilbert space, states, observables
- Time evolution, symmetries, conservation laws
- Scattering, tunneling, binding
- Simple potentials: square well, harmonic oscillator
- Hydrogen atom

Teaching Methods and Media
- Interactive Lectures
- Discussion & Reflection
- Group work
- Simulation tools

References

- Rau, J. , Quantum Physics (Oxford University Press, 2026)
- Griffiths, D. , Schroeter, D. Introduction to Quantum Mechanics (Cambridge University Press 2018)
- Townsend J., A modern Approach to Quantum Mechanics (University Science Books, 2012)
- Ballentine, L. E. Quantum Mechanics: A Modern Development (World Scientific, 2014)

Notes

Modul

Modelling and Experiment Design

Module Code
APP2-29

Short Form

Module Requirement
Compulsory

Credits
5 CP

Duration
1 Semester

Frequency
Winter semester only

Language(s)
English

Scheduled Semester
1., 2.(recommended)

Type of Examination
Module Level Assessment

Also Included In
- Applied Physics (M.Sc.), PO2026

Curriculum Notes

Module Coordinator
Prof. Dr. rer. nat. Stefan Kontermann

Required Prequisites
None

Recommended Prequisites
None

Module Objectives
Upon successful completion of the module, students are able to,
- Identify and define fundamental concepts of programming in a high-level languages, e.B. Matlab, Python relevant to physical system simulations.
- Explain the principles of creating interactive programs in MATLAB to calculate and graph properties of specific physical systems.
- Discuss the various test methods and evaluation criteria used to assess the quality of simulation programs.
- Utilize algorithms and tools for Finite Element Method (FEM) simulations to analyze physical systems effectively.
- Analyze the algorithm and operation of a simulation tool, assessing its strengths and limitations in modeling complex physical phenomena.
- Examine simulation results for various topics, such as planetary motion or optical layers, to identify patterns and validate theoretical predictions.
- Evaluate the accuracy of simulation results by comparing them with experimental data or established theoretical models.
- Design comprehensive simulations for advanced topics, e.g. Gaussian laser beams, complex optical systems, coupled torsion pendulums, Foucault pendulums integrating interactive features and visualizing the properties of such specific physical systems in MATLAB.
- Propose innovative approaches to improve simulation techniques and methodologies for modeling physical systems, demonstrating a synthesis of theoretical knowledge and practical application.
- Practice leadership during the team work part of this module by rotating the team leader, who coordinates the programming activities and tasks of the team members.

This module contributes to the following degree program objectives
Mathematical Methods, Problem Solving, Teamwork Abilities, Leadership Skills, Communication

Type of Course Component: Graded Course Component

Examination Format: Written Examination u. Practical/Artistic Work

Grading Type: Graded

(If multiple examination formats are available, the exact format of examination and, if appliable, the exact duration of examination is o be determined by the Examination Board at the beginning of the course and publicized within the faculty.)

Contribution to Final Grade
By credit

Total Module Workload in Hours
150, including 52.5 hours of class attendance (5 contact hours per week) and 97.5 hours of self-study, including exam preparation

Remarks

Related Courses
Required Course(s)
- Modelling and Simulation of Physical Systems (SU, 1., 2. Sem., 3 SWS)
- Design of Experiments (SU, 1., 2. Sem., 2 SWS)

Related Course

Modelling and Simulation of Physical Systems

Course Code	Short Form	Workload	Semester
APP2-29V1		CP	1., 2.

Course Types	Frequency	Language(s)
Seminar-style	Winter semester only	English

Also included in

- Applied Physics (M.Sc.), PO2026

Course Responsible

Prof. Dr. rer. nat. Stefan Kontermann

Recommended Prerequisites

None

Course Contents

- Learning the high-level language MATLAB or similar; Creating interactive programs to calculate and graph the properties of a specific physical system using MATLAB
- Test methods and evaluation criteria for simulation programs
- Algorithm and operation of a FEM simulation tool
- Examples of simulation task topics: coupled torsion pendulums, Foucault pendulums, planetary motion, optical layers, optical systems, Fourier optics, modes in planar waveguides, Gaussian laser beams.

Teaching Methods and Media

- Script
- Presentation slides
- Programming exercises
- Simulation project in working groups. Groups are preferably composed of group members of different nationalities.
- Use of the Matlab software
- Use of the Matlab software

References

- “MATLAB: A Practical Introduction to Programming and Problem Solving” by Stormy Attaway
- “MATLAB for Engineers” by Holly Moore
- MATLAB: An Introduction with Applications” by Amos Gilat and Vish Subramaniam
- “Programming in MATLAB” by D. A. B. S. R. M. K. Rajasekaran

Notes

Related Course

Design of Experiments

Course Code	Short Form	Workload	Semester
APP2-29V2		CP	1., 2.

Course Types	Frequency	Language(s)
Seminar-style	Winter semester only	English

Also included in

- Applied Physics (M.Sc.), PO2026

Course Responsible
Prof. Dr. Jochen Rau

Recommended Prerequisites
None

Course Contents

- Goals, challenges, terminology, overall approach
- Potential pitfalls and biases
- Review of probability theory
- Parameter estimation
- Simple and multiple regression, interaction, mediation
- Model selection, hypothesis testing
- Optimal design

Teaching Methods and Media

- Interactive Lectures
- Discussion & Reflection
- Group work
- Simulation tools

References

- Spiegelhalter, D., The Art of Statistics (Pelican, 2018)
- Olofsson, P., Probabilities: The little numbers that rule our lives (Wiley, 2010)
- Sivia, D. and Skilling, J., Data Analysis: A Bayesian Tutorial (Oxford University Press, 2006)
- Pearl, J., Glymour, M., Jewell, N., Causal Inference in Statistics (Wiley, 2016)
- Montgomery, D. C., Design and Analysis of Experiments (Wiley, 2012)

Notes

Modul

Statistical and Solid State Physics

Module Code
APP2-31

Short Form

Module Requirement
Compulsory

Credits
5 CP

Duration
1 Semester

Frequency
Summer semester only

Language(s)
English

Scheduled Semester
1., 2.(recommended)

Type of Examination
Module Level Assessment

Also Included In

- Applied Physics (M.Sc.), PO2026

Curriculum Notes

Module Coordinator
Prof. Dr. Markus Bender, Prof. Dr. Jochen Rau

Required Prequisites
None

Recommended Prequisites
None

Module Objectives
Upon successful completion of the module, students are able to,

- explain the role of probability, information and entropy in statistical physics
- construct the appropriate statistical ensemble for the description of a macroscopic system
- derive the basic thermodynamical properties of finite-dimensional systems and perfect classical and quantum gases
- describe the origin of band structures in solids
- decide if a crystalline solid is a semiconductor / a conductor
- apply the physics of band structures to design semiconductor devices
- evaluate necessary steps and techniques for semiconductor fabrication

This module contributes to the following degree program objectives
User-Centered Physical Technology, Mathematical Methods, Experimental Work, Scientific Research and Development, Problem Solving

Type of Course Component: Graded Course Component

Examination Format: Written Examination o. Oral Exam

Grading Type: Graded

(If multiple examination formats are available, the exact format of examination and, if appliable, the exact duration of examination is o be determined by the Examination Board at the beginning of the course and publicized within the faculty.)

Contribution to Final Grade
By credit

Total Module Workload in Hours
150, including 52.5 hours of class attendance (5 contact hours per week) and 97.5 hours of self-study, including exam preparation

Remarks

Related Courses
Required Course(s)
- Statistical Physics (SU, 1., 2. Sem., 2 SWS)
- Physics of Electrical and Optical Materials (SU, 1., 2. Sem., 3 SWS)

Related Course

Statistical Physics

Course Code	**Short Form**	**Workload**	**Semester**
APP2-31V1		CP	1., 2.
Course Types	**Frequency**	**Language(s)**	
Seminar-style	Summer semester only	English	

Also included in

- Applied Physics (M.Sc.), PO2026

Course Responsible

Dr. Susanna Gallas

Recommended Prerequisites

None

Course Contents

- Probability
- Information and entropy
- Macrostate, statistical ensembles
- Concepts from quantum physics: mixed state, composite system
- Simple systems: oscillator, rotor, spin a magnetic field, paramagnet
- Perfect gas (classical, Bose, Fermi)
- The four laws of thermodynamics

Teaching Methods and Media

- Interactive Lectures
- Discussion & Reflection
- Group work

References

- Rau, J. , Statistical Physics and Thermodynamics (Oxford University Press, 2017)
- Balian, R., From Microphysics to Macrophysics, Vols. 1+2 (Springer, 2007)

Notes

Related Course

Physics of Electrical and Optical Materials

Course Code	Short Form	Workload	Semester
APP2-31V2		CP	1., 2.

Course Types	Frequency	Language(s)
Seminar-style	Summer semester only	English

Also included in

- Applied Physics (M.Sc.), PO2026

Course Responsible
Prof. Dr. Markus Bender

Recommended Prerequisites
None

Course Contents

- The origin of band structures
- Charge transport in solids
  - Charge transport in metals
  - Charge Transport in semiconductors
- p-n-transition
- electronic components explained by their band structure
- optical properties explained by band structure
- short introduction into fabrication of semiconductors

Teaching Methods and Media
Lecture, Powerpoint, Whiteboard, Exercises, Presentation of students

References

- Mermin / Ashcroft: Solid State Physics
- Burns: Solid State Physics
- Grosso / Pastori Parravicini: Solid State Physics
- Kittel McEuen: Introduction to Solid State Physics

in German:

- Stiny: Aktive elektronische Bauelemente
- Schwesinger / Dehne / Adler: Lehrbuch Mikrosystemtechnik

Notes

Modul

Electrodynamics and Photonics

Module Code
APP2-32

Short Form

Module Requirement
Compulsory

Credits
5 CP

Duration
1 Semester

Frequency
Summer semester only

Language(s)
English

Scheduled Semester
1., 2.(recommended)

Type of Examination
Module Level Assessment

Also Included In
- Applied Physics (M.Sc.), PO2026

Curriculum Notes

Module Coordinator
Prof. Dr. rer. nat. Stefan Kontermann

Required Prequisites
None

Recommended Prequisites
None

Module Objectives
Upon successful completion of the module, students are able to,
- Identify and describe the fundamental concepts of electromagnetic waves, including their mathematical representation and key properties.
- Explain the principles of polarization, complex refractive index, dispersion, and absorption in various materials.
- Discuss the significance of evanescent waves and their role in optical phenomena.
- Utilize the Drude model to analyze light-matter interactions and predict changes in material properties under electromagnetic influence.
- Apply the Fresnel equations to determine reflection and transmission coefficients for different materials, including metals and dielectrics.
- Analyze the behavior of electromagnetic waves at interfaces, assessing how different media affect wave propagation.
- Differentiate between the effects of different types of interfaces (e.g., metal vs. dielectric) on reflection and transmission.
- Evaluate the implications of dispersion and absorption in practical applications, such as fiber optics and photonic devices.
- Judge reported experimental results related to wave phenomena and light-matter interactions, assessing the validity of the theoretical models used.
- For driving forward innovative applications, propose an experiment to investigate a specific aspect of electromagnetic wave behavior, incorporating principles of Fourier optics and angle spectrum decomposition demonstrating a synthesis of theoretical knowledge and practical implementation.

This module contributes to the following degree program objectives
User-Centered Physical Technology, Scientific Research and Development, Problem Solving

Type of Course Component: Graded Course Component

Examination Format: Written Examination o. Oral Exam

Grading Type: Graded

(If multiple examination formats are available, the exact format of examination and, if appliable, the exact duration of examination is o be determined by the Examination Board at the beginning of the course and publicized within the faculty.)

Contribution to Final Grade
By credit

Total Module Workload in Hours
150, including 42 hours of class attendance (4 contact hours per week) and 108 hours of self-study, including exam preparation

Remarks

Related Courses
Required Course(s)

- Electrodynamics and Photonics (SU, 1., 2. Sem., 4 SWS)

Related Course

Electrodynamics and Photonics

Course Code	Short Form	Workload	Semester
APP2-32V		CP	1., 2.

Course Types	Frequency	Language(s)
Seminar-style	Summer semester only	English

Also included in

- Applied Physics (M.Sc.), PO2026

Course Responsible

Recommended Prerequisites

None

Course Contents

- Mathematical description of electromagnetic waves
- Polarization, complex refractive index, dispersion, absorption
- Evanescent waves
- Drude model and light-matter interaction
- EM waves at interfaces / interface optics
- Fourier optics / Angle spectrum decomposition
- Fresnel equations
- Reflection and transmission on metals and dielectrics

Teaching Methods and Media

- Blackboard writing
- Discussion of physical phenomena and possible designs for experiments in the related field
- Presentation slides
- Exercise sheets

References

B. Saleh, M.Teich: Fundamentals of Photonics
G. A. Reider: Photonik
D. Meschede: Optik, Licht und Laser
A. Buckman: Guided Wave Photonics
M. Ohtsu, K. Kobayashi: Optical Near Fields

Notes

Modul

Research Project

Module Code
APP2-33

Short Form

Module Requirement
Compulsory

Credits
10 CP

Duration
1 Semester

Frequency
Every semester

Language(s)
English

Scheduled Semester
2.(recommended)

Type of Examination
Module Level Assessment

Also Included In

- Applied Physics (M.Sc.), PO2026

Curriculum Notes
The Physics Colloquium requires mandatory attendance. The attendance requirement is fulfilled when at least 80% of class sessions are attended in full. Certain sessions may be declared mandatory at the beginning of the course.

Module Coordinator

Required Prequisites
None

Recommended Prequisites
None

Module Objectives
Upon successful completion of the module, students are able to,

- Identify and list key concepts related to research methodologies and scientific practices in applied physics.
- Describe the specific scientific working methods involved in the research process, including information acquisition, knowledge deepening, and the formulation of research questions.
- Demonstrate the ability to apply theoretical knowledge from the course to solve complex problems encountered during the research project under guided supervision.
- Implement experimental planning, execution, and evaluation procedures to investigate specific physical and technical problems effectively.
- Analyze the results of experiments conducted during the research project, interpreting findings in relation to established theories and research literature.
- Assess the effectiveness of various scientific methods and approaches utilized in the research project, evaluating their strengths and weaknesses in addressing research questions.
- Design and execute a coherent research or development task that aligns with the objectives of the research project, showcasing the ability to manage time and resources effectively.
- Present and document research findings clearly and professionally, preparing materials suitable for academic evaluation and potential future publication, thereby laying the groundwork for the master's thesis.
- Recognize intercultural situations and prepare accordingly

This module contributes to the following degree program objectives
Experimental Work, Communication, Intercultural Competencies

Type of Course Component: Graded Course Component

Examination Format: Term Paper u. Presentation

Grading Type: Graded

(If multiple examination formats are available, the exact format of examination and, if appliable, the exact duration of examination is o be determined by the Examination Board at the beginning of the course and publicized within the faculty.)

Contribution to Final Grade
By credit

Total Module Workload in Hours
300, including 21 hours of class attendance (2 contact hours per week) and 279 hours of self-study, including exam preparation

Remarks

Related Courses
Required Course(s)

- Research Project (Proj, 2. Sem., 0 SWS)
- Physics Colloquium (S, 2. Sem., 2 SWS)

Related Course

Research Project

Course Code
APP2-33V1

Short Form

Workload
CP

Semester
2.

Course Types
Project

Frequency
Every semester

Language(s)
English

Also included in

- Applied Physics (M.Sc.), PO2026

Course Responsible

Recommended Prerequisites
None

Course Contents
The students work on a specific research topic by designing, conducting and evaluating experiments or simulations. The research project is accomplished in a research physics laboratory at the Hochschule, a research institution or in industry.

Teaching Methods and Media
The students participate in a research project, usually in the form of an internship in a research physics laboratory at the Hochschule, a research institution or in industry.

References
Publications in the respective research area:

- Scientific Publications
- Project reports
- Patents.

Notes

Related Course

Physics Colloquium

Course Code	Short Form	Workload	Semester
APP2-33V2		CP	2.

Course Types	Frequency	Language(s)
Seminar	Every semester	English

Also included in

- Applied Physics (M.Sc.), PO2026

Course Responsible

Recommended Prerequisites
None

Course Contents
Scientific talks on current topics in research and development in the field of Applied Physics with a focus on

- Photonics and Quantum Technology
- Micro- and Nano-Technology
- Energy and hydrogen technology
- Overview on intercultural situations

Teaching Methods and Media
Scientific talks by students and invited experts in the field of Applied Physics. For acquiring intercultural skills,1-2 teaching units about intercultural competencies are part of the lecture series.

References

Notes

Modul

Master's Thesis

Module Code
APP2-22

Short Form

Module Requirement
Compulsory

Credits
30 CP

Duration
1 Semester

Frequency
Every semester

Language(s)
English

Scheduled Semester
3.(recommended)

Type of Examination
Module Level Assessment

Also Included In

- Applied Physics (M.Sc.), PO2026

Curriculum Notes

Module Coordinator
Prof. Dr. rer. nat. Stefan Kontermann, Prof. Dr. Jochen Rau

Required Prequisites

- Students with 50+ CP in this program may enter the Master's Thesis module.

Recommended Prequisites
None

Module Objectives
Upon successful completion of the module, students are able to,

- Explain the key concepts, theories, and methodologies relevant to the research topic chosen for the master's thesis.
- Apply theoretical knowledge and methodological skills to solve complex problems in research and development contexts.
- Describe the specific scientific working methods necessary for conducting independent research, including information acquisition, experimental planning, and result documentation.
- Utilize the knowledge and skills acquired during the course of study to independently plan, conduct, and evaluate experiments related to the thesis topic.
- Demonstrate the ability to apply scientific methods to address physical and technical problems effectively within a specified timeframe.
- Analyze the current state of research in the chosen field, critically evaluating relevant literature and identifying gaps that the thesis work aims to address.
- Examine experimental data and results, interpreting findings in relation to theoretical frameworks and existing knowledge.
- Assess the effectiveness of various research methodologies and approaches employed during the thesis work, evaluating their strengths and limitations in addressing the research question.
- Evaluate the overall research process, including communication with a supervisor and, if applicable, teamwork dynamics, reflecting on how these elements contribute to the successful completion of the thesis.
- Present and document the research findings in a clear and professional manner, preparing a master thesis and associated presentation that effectively communicates the significance and implications of the results.

This module contributes to the following degree program objectives
Mathematical Methods, Experimental Work, User-Centered Physical Technology, Problem Solving, Scientific Research and Development, Communication, Time Management and Self-Management, Self-Awareness

Type of Course Component: Graded Course Component	**Examination Format:** Thesis	**Grading Type:** Graded
Type of Course Component: Graded Course Component	**Examination Format:** Thesis Defense	**Grading Type:** Graded

(If multiple examination formats are available, the exact format of examination and, if appliable, the exact duration of examination is o be determined by the Examination Board at the beginning of the course and publicized within the faculty.)

Contribution to Final Grade
By credit

Total Module Workload in Hours
900, including 0 hours of class attendance (0 contact hours per week) and 900 hours of self-study, including exam preparation

Remarks

Related Courses
Required Course(s)
- Master's Thesis (MA, 3. Sem., 0 SWS)

Related Course

Master's Thesis

Course Code	**Short Form**	**Workload**	**Semester**
APP2-22V		CP	3.

Course Types	**Frequency**	**Language(s)**
Master's Thesis	Every semester	English

Also included in

- Applied Physics (M.Sc.), PO2026

Course Responsible

Recommended Prerequisites
None

Course Contents
Research and development task in applied physics, presentation of the results in the masters thesis, as part of the colloquium for the masters thesis and, if applicable, to the team at the collaborating company

Teaching Methods and Media
Independently address and document a larger problem using scientific methods. Prepare a written report on the key findings of the research question/problem related to the topic of the master's thesis. The results of the thesis will be presented and discussed in an oral presentation.

References
Current specialist literature on the topic of the master's thesis.

Notes

Modul

Deutsch als Fremdsprache 1

Module Code	**Short Form**	**Module Requirement**
LLZ_50301M		Core Elective

Credits	**Duration**	**Frequency**	**Language(s)**
5 CP	1 Semester	Every semester	German

Scheduled Semester	**Type of Examination**
1.(recommended)	Module Level Assessment

Also Included In

- (Int.), PO
- AI and Advanced Information Technologies (M.Eng.), PO2026
- Applied Physics (M.Sc.), PO2026
- Biomedical Engineering (M.Sc.), PO2026
- Computational Mathematics (B.Sc.), PO2027

Curriculum Notes

The module Deutsch als Fremdsprache (German as a Foreign Language) requires mandatory attendance. The attendance requirement is fulfilled when at least 75% of class sessions are attended in full. Certain sessions may be declared mandatory at the beginning of the course.

Module Coordinator

Louise Klein

Required Prequisites

None

Recommended Prequisites

None

Module Objectives

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

- entsprechend ihrem Sprachniveau nach dem Gemeinsamen Europäischen Referenzrahmen: die Hauptinhalte von Lese- und Hörtexten zu verstehen, sich zu bestimmten Themen zu äußern, sich zu verständigen. / corresponding to their respective language level according to the Common European Framework: to understand the main content of written and spoken text; to produce language on specific topics; to communicate.

This module contributes to the following degree program objectives

Communication

Type of Course Component: Graded Course Component **Examination Format:** Foreign Language Examination **Grading Type:** Graded

(If multiple examination formats are available, the exact format of examination and, if appliable, the exact duration of examination is o be determined by the Examination Board at the beginning of the course and publicized within the faculty.)

Contribution to Final Grade

By credit

Total Module Workload in Hours

150, including 42 hours of class attendance (4 contact hours per week) and 108 hours of self-study, including exam preparation

Remarks

Teilnehmende werden in einen Kurs auf dem entsprechenden Niveau eingeteilt. Vor der Teilnahme am Deutschkurs absolvieren Teilnehmende mit bestehenden Deutschkenntnissen einen Einstufungstest. / Participants will be placed in a course at the appropriate level. Before the course, participants with existing German skills will take a placement test.

Related Courses
Wahlpflichtveranstaltung/en:

- German as a Foreign Language 1 (S, 1. Sem., 3 SWS)
- Language of Technology (S, 1. Sem., 1 SWS)

Related Course

Deutsch als Fremdsprache 1

Course Code	Short Form	Workload	Semester
		CP	1.

Course Types	Frequency	Language(s)
Seminar	Every semester	German

Also included in

- (Int.), PO
- AI and Advanced Information Technologies (M.Eng.), PO2026
- Applied Physics (M.Sc.), PO2026
- Biomedical Engineering (M.Sc.), PO2026
- Computational Mathematics (B.Sc.), PO2027

Course Responsible

Recommended Prerequisites
None

Course Contents
Entsprechend der Niveaustufe des GER / *According to the relevant CEF level*:

- passende und notwendige grammatikalische Strukturen / *appropriate and necessary grammar structures*
- passendes und notwendiges Vokabular / *appropriate and necessary vocabulary*
- kommunikative Situationen im Hochschul- sowie Berufsleben / *communicative situations in university and professional life*

Teaching Methods and Media
in-person teaching
Die Lehrveranstaltung verfolgt den Ansatz des kommunikativen Fremdsprachenlernens. Folgende didaktische Methoden werden angewandt, um die Sprachfertigkeiten zu erweitern: Einzel-, Partner- und Gruppenarbeiten, Präsentationen, Diskussionen, bewegte Lehre. Blended Learning- und Online-Phasen (Quizzes, Projekte, Online-Aufgaben) werden integriert, um das selbstgesteuerte Lernen zu fördern. / *The course adopts the communicative language learning approach. We will use the following learning methods to increase language competence: individual, pair and group work, presentations, discussions, movement in learning. Blended learning and digital elements (quizzes, projects, online activities) are incorporated to support the development of independent learning skills.*

References
Lehrwerke und authentisches Lehrmaterial auf dem entsprechenden Niveau. Dies wird zu Beginn der Lehrveranstaltung bekannt gegeben. / *Coursebooks and authentic material at the appropriate level. This will be announced at the start of the course.*

Notes

Related Course

Fachsprache Technik

Course Code

Short Form

Workload
CP

Semester
1.

Course Types
Seminar

Frequency
Every semester

Language(s)
German

Also included in

- (Int.), PO
- AI and Advanced Information Technologies (M.Eng.), PO2026
- Applied Physics (M.Sc.), PO2026
- Biomedical Engineering (M.Sc.), PO2026
- Computational Mathematics (B.Sc.), PO2027

Course Responsible

Recommended Prerequisites
None

Course Contents
Entsprechend der Niveaustufe des GER / *According to the relevant CEF level*:

- Wortschatz zur Fachsprache der Technik, passend zum GER / techncial vocabulary appropriate to CEF level
- kommunikative Situationen im technischen Kontext / communicative situations in technical contexts

Teaching Methods and Media
in-person teaching
Die Lehrveranstaltung verfolgt den Ansatz des kommunikativen Fremdsprachenlernens. Folgende didaktische Methoden können angewandt werden, um die Sprachfertigkeiten zu erweitern: Einzel-, Partner- und Gruppenarbeiten, Präsentationen, Diskussionen, bewegte Lehre. Blended Learning- und Online-Phasen (Quizzes, Projekte, Online-Aufgaben) werden integriert, um das selbstgesteuerte Lernen zu fördern. / *The course adopts the communicative language learning approach. The following learning methods may be used to increase language competence: individual, pair and group work, presentations, discussions, movement in learning. Blended learning and digital elements (quizzes, projects, online activities) are incorporated to support the development of independent learning skills.*

References
Lehrwerke und authentisches Lehrmaterial im technischen Bereich auf dem entsprechenden Niveau. Dies wird zu Beginn der Lehrveranstaltung bekannt gegeben. / *Coursebooks and authentic material on technological topics at the appropriate level. This will be announced at the start of the course.*

Notes

Modul

Comprehensive Competencies

Module Code
Y-M4

Short Form

Module Requirement
Core Elective

Credits
5 CP

Duration
1 Semester

Frequency
Every semester

Language(s)
English

Scheduled Semester
1.(recommended)

Type of Examination
Module Level Assessment

Also Included In

- AI and Advanced Information Technologies (M.Eng.), PO2026
- Applied Physics (M.Sc.), PO2026
- Biomedical Engineering (M.Sc.), PO2026
- Innovative Product Development and Manufacturing (part-time) (M.Eng.), PO2026
- Mechanical Engineering (M.Eng.), PO2026
- Sustainable and Digital Aviation (part-time) (M.Eng.), PO2026

Curriculum Notes

Module Coordinator
Prof. Dr.-Ing. Karlheinz Sossenheimer, Dr. Edgar Thomas

Required Prequisites
None

Recommended Prequisites
None

Module Objectives
Upon successful completion of the module, students are able to,

- apply methods and instruments for planning, managing and implementing projects in order to successfully achieve results in interdisciplinary teams.
- evaluate and assess projects economically in order to make well-founded decisions in the context of resource and time management.
- analyse mega and business process reengineering projects and develop change management strategies to effectively transform companies.
- analyze economic, technical, and interdisciplinary contexts and to develop solutions in teams both independently and collaboratively.
- leading groups and recognising and communicating technical and interdisciplinary relationships in order to promote team dynamics and motivation.
- take responsibility in the company and in society and to apply the tools of project management and personnel management in order to use their competences in a targeted manner.
- to think in a goal- and implementation-oriented manner, as well as to analyze and design economic and technical aspects within an overall context. They are capable of developing sustainable solutions that can be assessed based on specific criteria.
- analyse their leadership skills in dealing with gender and diversity and take these into account when managing teams.

This module contributes to the following degree program objectives
Problem Solving, Communication, Teamwork Abilities, Leadership Skills, Time Management and Self-Management, Self-Awareness

Type of Course Component: Graded Course Component

Examination Format: Written Examination o. Written Examination u. Portfolio o. Portfolio

Grading Type: Graded

(If multiple examination formats are available, the exact format of examination and, if appliable, the exact duration of examination is o be determined by the Examination Board at the beginning of the course and publicized within the faculty.)

Contribution to Final Grade
By credit

Total Module Workload in Hours
150, including 42 hours of class attendance (4 contact hours per week) and 108 hours of self-study, including exam preparation

Remarks

Related Courses
Wahlpflichtveranstaltung/en:
- Advanced Project Management (SU, 1. Sem., 2 SWS)
- Leadership (SU, 1. Sem., 1 SWS und S, 1. Sem., 1 SWS)

Related Course

Advanced Project Management

Course Code	Short Form	Workload	Semester
Y-M4V1		CP	1.

Course Types	Frequency	Language(s)
Seminar-style	Every semester	English

Also included in

- AI and Advanced Information Technologies (M.Eng.), PO2026
- Applied Physics (M.Sc.), PO2026
- Biomedical Engineering (M.Sc.), PO2026
- Electrical Engineering and Management (part-time) (M.Eng.), PO2026
- Industrial Engineering (part-time) (M.Eng.), PO2026
- Innovative Product Development and Manufacturing (part-time) (M.Eng.), PO2026
- Mechanical Engineering (M.Eng.), PO2026
- Sustainable and Digital Aviation (part-time) (M.Eng.), PO2026

Course Responsible
Prof. Dr.-Ing. Karlheinz Sossenheimer

Recommended Prerequisites
None

Course Contents

- Einführung in das Projektmanagement / Introduction to project management
- Berechnung von Netzplan und Aufbau Gantt Diagramm (PM) / Calculation of network plan and structure of Gantt chart (PM)
- Methodik und Grundlagen der Earned Value Analyse zur Überwachung von Projekten / Methodology and basics of earned value analysis for monitoring projects
- Personalmanagement in Projekten / Personnel management in projects
- Aufgabe/Verantwortung/Kompetenz der Projektbeteiligten / Task/responsibility/competence of project participants
- Soziale Kompetenz / Social competence:
  - Projektkultur / Project culture
  - Konfliktmanagement und Teamarbeit / Conflict management and teamwork
  - Umgang mit Gender und Diversität in der Teamarbeit / Dealing with gender and diversity in teamwork
- Multiprojektmanagement und Methoden der wirtschaftlichen Analyse von Projekten / Multi-project management and methods of economic analysis of projects
- Moderne agile Methoden des Projektmanagements z. B. SCRUM / Modern agile methods of project management e.g. SCRUM
- Projektmanagement im Business Process Reengineering / Project management in business process reengineering
- Change Management in Unternehmen / Change management in companies
- Claim Management im Projekt / Claim management in projects
- Risiken von Megaprojekten / Risks of megaprojects
- Methoden der Wirtschaftlichkeitsanalysen in Projekten / Methods of profitability analyses in projects
- Vertragsmanagement und Verhandlungstechniken / Contract management and negotiation techniques
- Nutzung von PM-Software: SAP-R3-PS, MS-Project / Use of PM software: SAP-R3-PS, MS-Project

Teaching Methods and Media
Deutsch
Der Inhalt der Lehrveranstaltung wird vermittelt durch:

- Vorlesungen zur Vermittlung theoretischer Grundlagen
- Praktische Übungen und Fallstudien zur Anwendung des Gelernten und um den Praxisbezug herzustellen
- Diskussionen zur Vertiefung des Verständnisses

Zu allen Vorlesungen werden ggf. Videos der Lehrveranstaltungen angeboten und mit den Studierenden geteilt. Der Stoff der Lehrveranstaltung kann mit blended Learning-Methoden und E-Learning anhand dieser Videos erarbeitet werden. Es wird damit ein effektiveres und abwechslungsreiches Lernumfeld geschaffen.
English
The content of the course is taught through:

- Lectures to convey theoretical principles
- Practical exercises and case studies to apply what has been learnt and to establish practical relevance
- Discussions to deepen understanding

If applicable, videos of the lectures are offered and shared with the students. The course material can be worked through using blended learning methods and e-learning based on these videos. This creates a more effective and varied learning environment.

References

- Vorlesungsskript Advanced Projektmanagement
- J. Kuster, E. Huber, R. Lippmann, A. Schmid, E. Schneider, U. Witschi, R. Wüst (2022):
  Handbuch Projektmanagement, 5., erweit. Aufl.
  ISBN 978-3-662-65472-9.
- Kompetenzbasiertes Projektmanagement (PM4) Handbuch für Praxis und Weiterbildung im Projektmanagement in zwei Bänden,
  GPM
  Deutsche Gesellschaft für Projektmanagement e. V., 2019, ISBN 978-3-924841-78-2 (eBook).
- Kerzner, H. (2022). **Project management: A systems approach to planning, scheduling, and controlling (13th ed.).** Wiley.
- Project Management Institute. (2021). **A guide to the project management body of knowledge (PMBOK guide) (7th ed.).** Project Management Institute.
- Turner, J. R. (2014). **Handbook of project-based management: Leading strategic change in organizations (4th ed.).** McGraw-Hill Education.
- Meredith, J. R., Shafer, S. M., & Mantel, S. J. (2020). **Project management: A managerial approach (10th ed.).** Wiley.
- Pinto, J. K. (2019). **Project management: Achieving competitive advantage (5th ed.).** Pearson.
- Shenhar, A. J., & Dvir, D. (2007). **Reinventing project management: The diamond approach to successful growth and innovation.** Harvard Business School Press.
- Larson, E. W., & Gray, C. F. (2021). **Project management: The managerial process (8th ed.).** McGraw-Hill Education
- In case of an english course, further information about respective literature in english will be provided.*

Notes

Die Lehrveranstaltung Advanced Project Management wird in den Studiengängen Elektrotechnik und Management (berufsbegleitend) (M.Eng.) und Wirtschaftsingenieurwesen (berufsbegleitend) (M.Eng.) nur im Sommersemester sowie auf Deutsch oder Englisch angeboten.

Related Course

Leadership

Course Code	Short Form	Workload	Semester
Y-M4V2		CP	1.

Course Types	Frequency	Language(s)
Seminar-style, Seminar	Every semester	English

Also included in

- AI and Advanced Information Technologies (M.Eng.), PO2026
- Applied Physics (M.Sc.), PO2026
- Biomedical Engineering (M.Sc.), PO2026
- Electrical Engineering and Management (part-time) (M.Eng.), PO2026
- Industrial Engineering (part-time) (M.Eng.), PO2026
- Innovative Product Development and Manufacturing (part-time) (M.Eng.), PO2026
- Mechanical Engineering (M.Eng.), PO2026
- Sustainable and Digital Aviation (part-time) (M.Eng.), PO2026

Course Responsible
Dr. Edgar Thomas

Recommended Prerequisites
None

Course Contents
Deutsch
1 Die Entwicklung von Führungsbeziehungen markiert einen Paradigmenwechsel, der zwischen hierarchischer Vorgesetztenführung (starre, individuumszentrierte, objektivistische Perspektive) und Menschenführung (dynamische Interaktions- und Beziehungsperspektive) unterscheidet. Die Veranstaltung behandelt in diesem Zusammenhang:

- Relevanz dieses modernen Führungsverständnisses.
- Führungstheorien (z. B. Machtführung, Dyadentheorie der Führung).
- Ausgewählte Führungsstilmodelle wie Reifegradmodell, Full-Range-of-Leadership-Modell (transaktionaler, transformationaler Führungsstil) und Super-Leadership-Modell (Selbstführung).
- Psychologische Aspekte von Führung und Teamdynamik motivationstheoretisch (z. B. BIG 3, Selbstwirksamkeitserwartungen) und kommunikationstheoretisch (z. B. Entscheidung zwischen symmetrischer und asymmetrischer Kommunikation).
- Berücksichtigung von Gender und Diversität in Führungsbeziehungen.

2 Die Gestaltung durch Führungsinstrumente prägt eine professionelle Führungsarbeit in der Praxis und spielt eine entscheidende Rolle bei der Erreichung von Mitarbeitenden- und Unternehmenszielen. Die Veranstaltung behandelt in diesem Zusammenhang:

- Traditionelle Management-by-Konzepte.
- Feedbackorientierte Führung (z. B. strukturierte Gespräche mit Mitarbeitenden führen).
- Potenzialorientierte Führung (z. B. Förderung der individuellen Employability und Performance Management).
- Talentorientierte Führung (z. B. Personalportfolio und Karriereplanung als Förderinstrument der Personalentwicklung 4.0).
- Kooperative Führung.
- Wirksame und nachhaltige Führung mittels Kennzahlensystemen.
- Emotional-Resonante Führung.
- Führung selbstführender Teams.

3 Im Kontext einer professionellen Führung mit **Leadership-Kompetenz** behandelt die Veranstaltung, wie eine Führungskraft beispielsweise lernt, das eigene Verhalten und die eigene Wirkung auf andere zu reflektieren und sich kontinuierlich weiterzubilden, mit Stress und Ambivalenzen umzugehen, um die eigene Leistungsfähigkeit und die der Mitarbeitenden zu erhalten oder auch unter Unsicherheit fundierte und schnelle Entscheidungen zu treffen.
4 Agile und werteorientierte Führung in der digitalen Arbeitswelt stellt besondere Anforderungen an Führungskräfte und den Umgang mit ihren Mitarbeitenden. Die Veranstaltung arbeitet heraus, dass eine offene und wirkungsorientierte Kommunikation Vertrauen fördert und empowerte Mitarbeitende zur Übernahme von Verantwortung ermutigt werden, was die intrinsische Motivation und das Engagement steigert. Es werden zentrale Merkmale agiler Führung identifiziert, wonach erfolgreiche Führung einerseits immer auch Selbstführung (Self Leadership) voraussetzt und andererseits bedeutet, nicht nur aus der Erfahrung, sondern auch “von der Zukunft her (zu) führen” (vgl. C. Otto Scharmer).

English
1 The Development of Leadership Relationships marks a paradigm shift that distinguishes between hierarchical superior leadership (rigid, individual-centered, objectivist perspective) and people-oriented leadership (dynamic interaction and relationship perspective). In this context, the lecture deals with:
- Relevance of this modern understanding of leadership.
- Various leadership theories (e.g., power leadership, dyadic theory of leadership).
- Selected leadership style models such as the maturity model, the Full-Range-of-Leadership model (transactional, transformational leadership style), and the Super-Leadership model (self-leadership).
- Psychological aspects of leadership and team dynamics from motivational theory's perspective (e.g., BIG 3, self-efficacy expectations) and communication theory's perspective (e.g., decision between symmetrical and asymmetrical communication).
- Consideration of gender and diversity in leadership relationships.

2 The Design through Leadership Tools shapes professional leadership work in practice and plays a crucial role in achieving employee and company goals. In this context, the lecture deals with:
- Traditional management-by-concepts.
- Feedback-oriented leadership (e.g., conducting structured conversations with employees).
- Potential-oriented leadership (e.g., promoting individual employability and performance management).
- Talent-oriented leadership (e.g., personnel portfolio and career planning as a development tool for Human Resource Development 4.0).
- Cooperative leadership.
- Effective and sustainable leadership using performance measurement systems.
- Emotionally resonant leadership.
- Leading self-managing teams.

3 In the context of professional leadership with **leadership competence**, the lecture figures out, how a leader learns to reflect on his own behavior and impact on others, continuously educates himselve, manages stress and ambivalence to maintain his own performance and that of his employees, or make informed and swift decisions under uncertainty.
4 Agile and Value-Oriented Leadership in the digital work environment presents special demands on leaders and their interactions with employees. The lecture figures out, that open and impact-oriented communication fosters trust and encourages empowered employees to take on responsibility, which increases intrinsic motivation and engagement. Key characteristics of agile leadership are identified, according to which successful leadership always requires self-leadership and, moreover, to lead not only from experience but also from the future (cf. C. Otto Scharmer).

Teaching Methods and Media
Deutsch
Konzept:
Kompetenzdidaktische Lernsettings antizipieren die Handlungslogik der Kompetenzanwendung (Gestalten und Anwenden) in der Aneignungslogik des Lernprozesses (Aneignung) und üben diese ein (Erleben und Üben).
Aneignung:
Die Studierenden nutzen die ihnen zur Verfügung gestellten Informationen, Zugänge, Impulsreferate und Aufgaben zur Bearbeitung von Lernprojekten (Fallaufgaben), zur Beantwortung eigener Fragen und zum Abgleich der individuellen Lernziele mit den Modulzielen.
Erleben und Üben:
Die Studierenden übernehmen Verantwortung für die Gestaltung ihres individuellen Lernprozesses in realen und konstruierten Schlüsselsituationen. Methoden- und Medienwahl in den Übungsphasen: Selbstlern- und Reflexionstools, Fallarbeiten/Fallstudien mit Praxisbezug, Falldiskussionen und Fallpräsentationen, SWOT-Analysen, Rollenspiel mit Praxisbezug, Expertenteams zur Wissensaneignung und Puzzlegruppen zum Informationsaustausch, eingeschobene Übungsaufgaben, Leittextmethode, Blitzlicht, Hitparade, Videosequenzen, Impulsreferate. Gleichzeitig steht die Stärkung der Selbstlernkompetenz im Mittelpunkt der Übungsphase.
Gestaltung und Anwendung:
Der Grad der Kompetenzausprägung zeigt sich in der Fähigkeit der Studierenden, komplexe Probleme selbstorganisiert zu lösen:
(a) in fallbezogenen Prüfungsaufgaben (Lehre) und
(b) in berufsbezogenen Arbeitsprozessen (Praxis).
Blended Learning:
Kombination von asynchronen, angeleiteten Selbstlernphasen und synchronen, begleiteten Gruppenlernphasen. Die Lernsettings finden in Präsenz, Online oder Hybrid statt. Synchrone und asynchrone Phasen werden sinnvoll miteinander verknüpft (Synchron-Asynchron-Verankerung). Anmerkung: Bei einer Teilnehmerzahl von mehr als 20 Studierenden ist auf eine geeignete Methodenwahl zu achten.
English
Concept:
Competence-didactic learning settings anticipate the action logic of competence application (designing and applying) within the acquisition logic of the learning process (appropriation) and practice it (experiencing and practicing).
Appropriation:
Students utilize the information, resources, impulse presentations, and tasks provided to them for processing learning projects (case tasks), answering their own questions, and aligning their individual learning goals with the module objectives.
Experiencing and Practicing:

Students take responsibility for designing their individual learning process in real and constructed key situations. Method and media choices during the practice phases include: self-learning and reflection tools, case studies with practical relevance, case discussions and presentations, SWOT analyses, role plays with practical relevance, expert teams for knowledge acquisition, and puzzle groups for information exchange, interspersed practice tasks, guided text methods, flashlights, charts, video sequences, and impulse presentations. At the same time, strengthening self-learning competence is the focus during the practice phase.

Design and Application:

The degree of competence manifestation is reflected in the ability of students to solve complex problems in a self-organized manner: (a) in case-related examination tasks (teaching) and (b) in profession-related work processes (practice).

Blended Learning:

This involves a combination of asynchronous, guided self-learning phases and synchronous, facilitated group learning phases. The learning settings take place in-person, online, or hybrid. Synchronous and asynchronous phases are meaningfully interconnected (synchronous-asynchronous anchoring). Note: For a participant number of more than 20 students, an appropriate choice of methods should be considered.

References

- Arnold, R. (2014):
  Leadership by Personality. Von der emotionalen zur spirituellen Führung Ein Dialog, Wiesbaden (Springer Gabler).
- Bass, B. M. (1990): **From transactional to transformational leadership: Learning to share the vision.** Organizational Dynamics, 18(3), 1931. https://doi.org/10.1016/0090-2616(90)90061-S
- Burns, J. M. (1978): **Leadership.** Harper & Row.
- Furtner, M; Baldegger, U. (2014):
  Self-Leadership und Führung. Theorien, Modelle und praktische Umsetzung, Wiesbaden (Springer Gabler).
- Goleman, D. (2000): **Leadership that gets results.** Harvard Business Review, 78(2), 7890.
- Northouse, P. G. (2021): **Leadership: Theory and practice (9th ed.).** Sage.
- Kotter, J. P. (1990): **A force for change: How leadership differs from management.** Free Press.
- Scharmer, C. Otto (2009):
  Theorie U. Von der Zukunft her führen, Heidelberg (Carl-Auer).
- Thomas, E. (2025):
  Studientext Personalführung inkl. Personalführung in der Praxis (Fallarbeiten, Fallstudien und Übungsaufgaben), Vorlesungsscript.
- Wagner, D.:
  Praxishandbuch Personalmanagement, Freiburg et al. (online) [07.02.2025].
- Weibler, J. (2023):
  Personalführung. Personen, Beziehungen, Kontexte, Wirkungen. 4. Auflage Vahlen.
- Yukl, G. (2013): **Leadership in organizations (8th ed.).** Pearson.
- Leadership-Lexikon:
  (Leadership insiders: Was Führung im Innersten zusammenhält Führungswissen für die Führungspraxis), unter https://www.leadership-insiders.de/ [07.02.2025].

In case of an english course, further information about respective literature in english will be provided.

Notes

Die Lehrveranstaltung Leadership wird in den Studiengängen Elektrotechnik und Management (berufsbegleitend) (M.Eng.) und Wirtschaftsingenieurwesen (berufsbegleitend) (M.Eng.) nur im Sommersemester sowie auf Deutsch oder Englisch angeboten.

Modul

Scientific Communication

Module Code
APP2-25

Short Form

Module Requirement
Core Elective

Credits
5 CP

Duration
1 Semester

Frequency
Winter semester only

Language(s)
English

Scheduled Semester
1., 2.(recommended)

Type of Examination
Module Level Assessment

Also Included In

- Applied Physics (M.Sc.), PO2026

Curriculum Notes

Module Coordinator
M.A. Michaela Paefgen-Laß

Required Prequisites
None

Recommended Prequisites
None

Module Objectives
Upon successful completion of the module, students are able to,

- plan, draft, revise and present academic texts and talks in English, aligning written and oral formats to purpose and audience
- evaluate, synthesize and communicate scientific sources and evidence clearly and concisely in both written and spoken form
- produce a structured short paper (literature review) and a short presentation that each convey clear core messages and scholarly argumentation
- manage the scholarly communication process from planning and drafting through revision, rehearsal and media preparation
- apply conventions of scientific writing and appropriate presentation practices (structure, voice, body language, visuals) to enhance clarity and credibility
- reflect on personal writing and presentation habits, manage performance-related stress, and adopt strategies for continued development
- assess the responsible use of AI and other digital tools in research writing, presentation preparation and dissemination
- explain key aspects of scientific publication and communication, including paper structure, types of publications, and the peer-review process
- analyse their written texts intended for publication, speech and personal appearance in dealing with gender and diversity and take these into account when communicating in a scientific environment

This module contributes to the following degree program objectives
Problem Solving, Scientific Research and Development, Communication, Time Management and Self-Management, Self-Awareness

Type of Course Component: Graded Course Component	**Examination Format:** Written Assignment	**Grading Type:** Graded
Type of Course Component: Pass/Fail Course Component	**Examination Format:** Presentation	**Grading Type:** Pass/Fail

(If multiple examination formats are available, the exact format of examination and, if appliable, the exact duration of examination is o be determined by the Examination Board at the beginning of the course and publicized within the faculty.)

Contribution to Final Grade
By credit

Total Module Workload in Hours
150, including 42 hours of class attendance (4 contact hours per week) and 108 hours of self-study, including exam preparation

Remarks

Related Courses
<u>Wahlpflichtveranstaltung/en:</u>
- Presentation Skills (SU, 1., 2. Sem., 2 SWS)
- Scientific Writing (SU, 1., 2. Sem., 2 SWS)

Related Course

Presentation Skills

Course Code	Short Form	Workload	Semester
APP2-25V1		CP	1., 2.

Course Types	Frequency	Language(s)
Seminar-style	Winter semester only	English

Also included in

- Applied Physics (M.Sc.), PO2026

Course Responsible

Recommended Prerequisites

None

Course Contents

The course is structured around five main fields of competency:

- Personal presence: Clear wording, controlled voice and confident body language to engage the audience.
- Content: Didactic reduction to essentials, link core concepts to uptodate knowledge and vivid examples.
- Structure & flow: Strong opening, clear main messages with evidence, concise summary and outlook.
- Mindset & focus: Manage thoughts, breathing and emotions; adapt attitude to audience and context.
- Media & visuals: Appropiate slide design for different purposes (e.g. presentation vs. script) and purposeful material or tools to support the talk.

Teaching Methods and Media

- Short theory inputs
- Interactive exercises
- Practice presentations
- Structured peer feedback

References

- Emden, J. v., Becker, L. (2004): Presentation Skills for Students.
- Carnegie, D. (1962): The Quick and Easy Way to Effective Speaking.
- Franck, N. (2001): Rhetorik für Wissenschaftler.

Notes

Related Course

Scientific Writing

Course Code	Short Form	Workload	Semester
APP2-25V2		CP	1., 2.

Course Types	Frequency	Language(s)
Seminar-style	Winter semester only	English

Also included in

- Applied Physics (M.Sc.), PO2026

Course Responsible
M.A. Michaela Paefgen-Laß

Recommended Prerequisites
None

Course Contents
This module introduces students to scientific writing in English, with a focus on clarity, structure, and communicative precision. Participants learn how to structure a scientific paper, use appropriate writing styles, and critically revise texts, with a particular focus on publication-oriented writing. It emphasizes a process-based approach and includes the reflective and ethical use of generative AI tools throughout the writing process. Students learn to write a scientific short paper and to reflect on their authorship and the impact of technology on writing. In addition to academic writing skills, students explore principles of science communication and practice writing for both expert and non-expert audiences. The module supports the preparation of research papers and scientific communication in academic and professional contexts.

- Introduction to academic writing: purpose, structure and audience
- Basics of academic writing (style, clarity, conventions)
- Typical structures (IMRaD, abstract, referencing)
- Avoiding common grammatical and stylistic mistakes
- Effective use of sources and citation styles
- Writing process awareness: self-reflection on writing, How-to manage the writing process, overcoming blocks, finding voice, editing
- Scientific integrity: authorship, plagiarism, and good practice
- AI in the writing process: benefits, limitations, risks, and reflection
- Writing an abstract
- Writing a short literature review
- Scientific publishing: Types of scientific publications (original paper, review, short communication), Peer review process, selection of journals, open access, dealing with rejection and feedback
- Critical reading of academic texts
- Modern forms of scientific communication (Science journalism, posters, micro publishing, social platforms), writing for different target groups

Teaching Methods and Media

- Interactive exercises (e.g., text sprints, peer feedback, revision workshops)
- Group and individual writing tasks
- Use of digital writing tools and AI assistants
- Self-directed learning with structured assignments

References

- Selected academic articles from relevant fields
- Handouts

Notes

Modul

AI Laboratory

Module Code
Y-M17

Short Form

Module Requirement
Core Elective

Credits
5 CP

Duration
1 Semester

Frequency
Summer semester only

Language(s)
English

Scheduled Semester
1., 2.(recommended)

Type of Examination
Module Level Assessment

Also Included In

- AI and Advanced Information Technologies (M.Eng.), PO2026
- Applied Physics (M.Sc.), PO2026
- Mechanical Engineering (M.Eng.), PO2026

Curriculum Notes

Module Coordinator
Prof. Dr. Matthias Schäfer

Required Prequisites
None

Recommended Prequisites
None

Module Objectives
Upon successful completion of the module, students are able to,

- define basic terms and concepts of artificial intelligence.
- describe the differences between the human brain and artificial intelligence.
- explain the basic principles of neural networks and implement simple neural networks in a programming environment.
- identify and analyze use cases of AI in the industry.
- apply data preparation techniques such as anonymization and chunking.
- evaluate the advantages and disadvantages of generative models compared to traditional models.
- design and create a concept for a data visualization using common frameworks and programming packages.
- develop and integrate standards and norms for the management of AI in a company.
- critically assess the sustainability of different machine learning approaches and explain strategies for more efficient and responsible model development.
- collaborate effectively in small teams and to apply principles on team roles, leadership, and intercultural competencies

This module contributes to the following degree program objectives
Problem Solving, Scientific Research and Development

Type of Course Component: Graded Course Component

Examination Format: Practical/Artistic Work

Grading Type: Graded

(If multiple examination formats are available, the exact format of examination and, if appliable, the exact duration of examination is o be determined by the Examination Board at the beginning of the course and publicized within the faculty.)

Contribution to Final Grade
By credit

Total Module Workload in Hours
150, including 42 hours of class attendance (4 contact hours per week) and 108 hours of self-study, including exam preparation

Remarks

Related Courses
Wahlpflichtveranstaltung/en:
- AI Laboratory (P, 1., 2. Sem., 4 SWS)

Related Course

AI Laboratory

Course Code
Y-M17V

Short Form

Workload
CP

Semester
1., 2.

Course Types
Laboratory

Frequency
Summer semester only

Language(s)
English

Also included in

- AI and Advanced Information Technologies (M.Eng.), PO2026
- Applied Physics (M.Sc.), PO2026
- Mechanical Engineering (M.Eng.), PO2026

Course Responsible
Prof. Dr. Matthias Schäfer

Recommended Prerequisites
None

Course Contents

- Tools and Environments
  - Installing and configuring Python, Conda/virtual environments
  - Introduction to libraries commonly used in data science (NumPy, pandas, Matplotlib, scikit-learn, TensorFlow/PyTorch)
  - Version control with Git and GitHub/GitLab
- Data Collection and Cleaning
  - Reading/wrangling various data formats (CSV, Excel, JSON, database queries)
  - Handling missing values, outliers, and inconsistencies in engineering-related datasets
  - Consideration of gender-equitable datasets, diverse voices and perspectives, and the identification and mitigation of potential bias.
  - Critical assessment of data sources and preparation methods, taking into account ethical considerations, diversity, and fairness in AI systems.
- Anonymization and Chunking
  - Data privacy fundamentals: masking sensitive information and applying anonymization techniques
  - Chunking or partitioning large datasets for efficient processing and model training
- Basic Machine Learning Workflows
  - Implementing linear and logistic regression for simple predictive tasks
  - Exploring classification (k-NN, decision trees) on engineering-specific datasets (e.g., sensor readings)
- Neural Network Fundamentals
  - Building a simple feedforward network from scratch using TensorFlow or PyTorch
  - Hands-on backpropagation demonstration: weight updates, loss functions, activation functions
- Intermediate Deep Learning Techniques
  - Convolutional Neural Networks (CNNs)
  - Recurrent Neural Networks (RNNs) or Transformers
- Generative Models & Advanced Techniques
  - Exploring Generative Adversarial Networks (GANs)
  - Autoencoders & Variational Autoencoders (VAEs)
- Model Evaluation & Explainability
  - Model Evaluation Metrics
  - Explainable AI and Interpretation (using frameworks like LIME or SHAP to interpret model predictions)
- Data Visualization & Dashboarding
  - Building Interactive Dashboards
  - Project-Based Visualization Concept
- AI Project Management & Integration
  - Standards & Norms for AI
  - MLOps & Deployment

Teaching Methods and Media

- Practical Lab Sessions: Implementing neural networks, data handling, and visualization tasks

- Project Work: Students develop an end-to-end mini AI project, from data preparation to model deployment

References

- Stuart Russell and Peter Norvig: Artificial Intelligence: A Modern Approach, latest edition, Pearson.
- Tom M. Mitchell: Machine Learning, McGraw-Hill Education.
- Ian Goodfellow, Yoshua Bengio, and Aaron Courville: Deep Learning, MIT Press.
- François Chollet: Deep Learning with Python, Manning Publications.
- Kevin P. Murphy: Machine Learning: A Probabilistic Perspective, MIT Press.
- Aurélien Géron: Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow, OReilly Media.
- Jake VanderPlas: Python Data Science Handbook, OReilly Media.
- Jiawei Han, Micheline Kamber, and Jian Pei: Data Mining: Concepts and Techniques, Morgan Kaufmann.
- Foster Provost and Tom Fawcett: Data Science for Business, OReilly Media.
- Edward R. Tufte: The Visual Display of Quantitative Information, Graphics Press.
- Cole Nussbaumer Knaflic: Storytelling with Data: A Data Visualization Guide for Business Professionals, Wiley.

Notes

Modul

Innovation Management & Entrepreneurship

Module Code
Y-M7

Short Form

Module Requirement
Core Elective

Credits
5 CP

Duration
1 Semester

Frequency
Summer semester only

Language(s)
English

Scheduled Semester
1., 2.(recommended)

Type of Examination
Module Level Assessment

Also Included In

- AI and Advanced Information Technologies (M.Eng.), PO2026
- Applied Physics (M.Sc.), PO2026
- Biomedical Engineering (M.Sc.), PO2026
- Electrical Engineering and Management (part-time) (M.Eng.), PO2026
- Industrial Engineering (part-time) (M.Eng.), PO2026
- Mechanical Engineering (M.Eng.), PO2026
- Sustainable and Digital Aviation (part-time) (M.Eng.), PO2026

Curriculum Notes

Module Coordinator
Prof. Dr. Thomas Heimer

Required Prequisites
None

Recommended Prequisites
None

Module Objectives

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

- den Ablauf von Innovationsprozessen, von der Definition der Forschungsfrage bis hin zur Marktdiffusion, sowie die Indikatoren für die strategische Steuerung der einzelnen Phasen zu erklären / to explain the process of innovation, from the definition of the research question to market diffusion, as well as the indicators for the strategic management of the individual phases.
- Kenntnisse aus der Forschung der Innovationstheorie zur Entwicklung von innovativen Geschäftsideen anzuwenden und Faktoren für ein erfolgreiches Unternehmertum im Hinblick auf deren Umsetzung zu analysieren / to apply know-ledge of innovation theory to develop innovative business ideas and to analyze factors for successful entrepreneurship with regard to their implementation.
- ein Konzept für eine eigene Unternehmensgründung zu entwickeln und die unterschiedlichen Themenstellungen des Business-Plans, unter Berücksichtigung auch von Diversitäts- und Genderaspekten, selbständig auszuarbeiten / to develop a concept for one's own business start-up and independently elaborate on the various aspects of the business plan, also taking into account diversity and gender aspects.
- zu erklären, wodurch sich Unternehmer:innen auszeichnen und welche Ziele sie verfolgen / to explain what distinguishes entrepreneurs and what goals they pursue.
- eigene neue Ideen und Lösungen zu entwickeln / to develop new ideas and solutions independently.
- die anfallenden Aufgaben zur Planung einer Gründung ziel- und umsetzungsorientiert sowie im Rahmen eines gegebenen Zeitrahmens zu bewältigen / to handle the tasks involved in planning a start-up in a goal-oriented and implementation-focused manner, within a given timeframe.
- bei einer Bearbeitung im Team Aufgaben zu organisieren und gemeinsam eine Lösung zu erarbeiten, unter Berücksichtigung des Einflusses von Genderaspekten bei Teamzusammensetzungen auf Innovationsprozesse / to organize tasks and collaboratively work towards a solution when working in a team, taking into account the influence of gender aspects in team composition on innovation processes.
- wesentliche Elemente einer Unternehmensgründung professionell zu präsentieren und zu kommunizieren / to professionally present and communicate the essential elements of a business start-up.
- Kernelemente der modernen Innovationstheorie zur gesellschaftlichen Ausgestaltung von Technologien zu beschreiben / to describe the core elements of modern innovation theory for the social shaping of technologies.
- innovative Technologie- und Investitionsentscheidungen (z.B. neue Produktionsanlagen, Automatisierungslösungen, digitale Konzepte...) aus Sicht technischer Führungskräfte im Spannungsfeld von Machbarkeit, Kosten, Risiken und Nachhaltigkeitszielen zu begründen / to justify innovative technology and investment decisions (e.g. new production facilities, automation solutions, digital concepts...) from the perspective of technical managers in the area of feasibility, costs, risks and sustainability goals.

This module contributes to the following degree program objectives

Problem Solving, Scientific Research and Development, Teamwork Abilities, Leadership Skills, Communication, Time Management and Self-Management, Self-Awareness

Type of Course Component: Graded Course Component

Examination Format: Portfolio o. Term Paper o. Presentation

Grading Type: Graded

(If multiple examination formats are available, the exact format of examination and, if appliable, the exact duration of examination is o be determined by the Examination Board at the beginning of the course and publicized within the faculty.)

Contribution to Final Grade

By credit

Total Module Workload in Hours

150, including 42 hours of class attendance (4 contact hours per week) and 108 hours of self-study, including exam preparation

Remarks

Related Courses

Wahlpflichtveranstaltung/en:

- Innovation Management (SU, 1., 2. Sem., 2 SWS)
- Entrepreneurship (SU, 1., 2. Sem., 2 SWS)

Related Course

Innovation Management

Course Code	Short Form	Workload	Semester
Y-M7V1		CP	1., 2.

Course Types	Frequency	Language(s)
Seminar-style	Summer semester only	English

Also included in

- AI and Advanced Information Technologies (M.Eng.), PO2026
- Applied Physics (M.Sc.), PO2026
- Biomedical Engineering (M.Sc.), PO2026
- Electrical Engineering and Management (part-time) (M.Eng.), PO2026
- Industrial Engineering (part-time) (M.Eng.), PO2026
- Mechanical Engineering (M.Eng.), PO2026
- Sustainable and Digital Aviation (part-time) (M.Eng.), PO2026

Course Responsible
Prof. Dr. Thomas Heimer, Martin Schipper

Recommended Prerequisites
None

Course Contents

- Die Rolle von Innovationen in einer Volkswirtschaft / The role of innovations in an economy.
- Sozio-ökonomische Steuerung des Technikgeneseprozesses / Socio-economic management of the technology genesis process.
- Methoden der Diffusionssteuerung / Methods of diffusion management.
- Adoptionsverhalten bei technischen Standards, Probleme und Risiken / Adoption behavior regarding technical standards, problems and risks.
- Strategisches Innovationsmanagement / Strategic innovation management.

Teaching Methods and Media
In Innovation Management ist basierend auf der Vorlesung ein Thema vertiefend auszuarbeiten, zu präsentieren und schriftlich zu fixieren. In innovation management a selected topic based on the teaching in the first part of the course is to be generated and to be presented and finally to be developed as a seminar paper.

References

- Afuah, Allan: Innovation Management: strategies, implementation, and profits / Allan Afuah - 2nd ed. - 2003.
- Drucker, Peter F.: Innovation and Entrepreneurship: practice and principles / Peter F. Drucker - 1993.
- Gerybadze, Alexander, 2004, Technologie- und Innovationsmanagement, Vahlen Verlag.
- Dosi, G., 1982, Technological Paradigms and technological trajectories, in: Research Policy, Vol. 11.

Notes

Related Course

Entrepreneurship

Course Code	**Short Form**	**Workload**	**Semester**
Y-M7V2		CP	1., 2.
Course Types	**Frequency**	**Language(s)**	
Seminar-style	Summer semester only	English	

Also included in

- AI and Advanced Information Technologies (M.Eng.), PO2026
- Applied Physics (M.Sc.), PO2026
- Biomedical Engineering (M.Sc.), PO2026
- Electrical Engineering and Management (part-time) (M.Eng.), PO2026
- Industrial Engineering (part-time) (M.Eng.), PO2026
- Mechanical Engineering (M.Eng.), PO2026
- Sustainable and Digital Aviation (part-time) (M.Eng.), PO2026

Course Responsible
Prof. Dr. Thomas Heimer

Recommended Prerequisites
None

Course Contents

- Die Bedeutung von Unternehmensgründungen für die deutsche Wirtschaft / The importance of start-ups for the German economy.
- Innovation und Entrepreneurship - zwei Seiten der selben Münze / Innovation and entrepreneurship - two sides of the same coin.
- Was ist Entrepreneurship? - Definitionen / What is entrepreneurship? - Definitions.
- Was zeichnet Entrepreneur:innen aus? Von den geborenen Führer:innen zu modernen Ansätzen / What distinguishes entrepreneurs? From born leaders to modern approaches.
- Was macht Unternehmensgründungen erfolgreich? Finanzierung von Unternehmensgründungen / What makes start-ups successful? Financing of start-ups.
- Durchführung einer virtuellen Unternehmensgründung / Implementation of a virtual start-up.

Teaching Methods and Media
In Entrepreneurship ist ein Business Plan zu erstellen, das benötigte Eigenkapital zu pitchen und der Plan schriftlich auszuarbeiten. In entrepreneurship a business plan has to be generated, the required equity has to be pitched and the business plan shall be finalised as a paper at the end.

References

- Christine K. Volkmann, Kim Oliver Tokarski; Entrepreneurship: Gründung und Wachstum von jungen Unternehmen - Lucius & Lucius Verlagsgesellschaft, Stuttgart 2006.
- Empirical Entrepreneurship in Europe: new perspectives/ed. by Michael Dowling - 2007.
- Entrepreneurship Research in Europe: outcomes and perspectives/ed. by Alain Fayolle - 2005.
- Venkataraman, S.; Sarasvathy, Saras D.: Strategy and Entrepreneurship: outlines of an untold story/S. Venkataraman and Saras D. Sarasvathy, in: The Blackwell Handbook of Strategic Management S. 650-668.

Notes

Modul

Energy System Components and Signal Processing

Module Code
APP2-20

Short Form

Module Requirement
Core Elective

Credits
5 CP

Duration
1 Semester

Frequency
Summer semester only

Language(s)
English

Scheduled Semester
1., 2.(recommended)

Type of Examination
Module Level Assessment

Also Included In
- Applied Physics (M.Sc.), PO2026

Curriculum Notes

Module Coordinator
Prof. Dr. Ulrich Rost

Required Prequisites
None

Recommended Prequisites
None

Module Objectives
Upon successful completion of the module, students are able to,
- apply basic physical and chemical knowledge for the analysis and development of galvanic cells (electrolyzers, fuel cells, batteries, redox flow storage).
- select measurement methods to determine technical parameters.
- handle safety issues relating to hydrogen applications and implement suitable measures experimentally. This includes understanding the processes taking place at the interfaces and interpreting the phenomena that occur.
- implement theoretical concepts such as Nernst, Butler-Vollmer, Tafel equation etc. in experimental design.
- select the relevant components for the construction of a galvanic element and to qualify them with regard to their properties.

This module contributes to the following degree program objectives
User-Centered Physical Technology, Problem Solving

Type of Course Component: Graded Course Component

Examination Format: Written Examination

Grading Type: Graded

(If multiple examination formats are available, the exact format of examination and, if appliable, the exact duration of examination is o be determined by the Examination Board at the beginning of the course and publicized within the faculty.)

Contribution to Final Grade
By credit

Total Module Workload in Hours
150, including 42 hours of class attendance (4 contact hours per week) and 108 hours of self-study, including exam preparation

Remarks

Related Courses

Wahlpflichtveranstaltung/en:

- Materials for Energy Distribution (SU, 1., 2. Sem., 2 SWS)
- Signal Processing in Applied Physics (SU, 1., 2. Sem., 2 SWS)

Related Course

Materials for Energy Distribution

Course Code	Short Form	Workload	Semester
APP2-20V		CP	1., 2.

Course Types	Frequency	Language(s)
Seminar-style	Summer semester only	English

Also included in

- Applied Physics (M.Sc.), PO2026

Course Responsible

Recommended Prerequisites
None

Course Contents
To understand fuel cells and batteries, which belong to the group of galvanic elements, it is necessary to gain knowledge about the materials and measuring methods used. At the end of the lecture, students should have a clear understanding of the interfaces within the components, in particular batteries and fuel cells, be able to distinguish these in electrical, electrochemical and material flow-related phenomena, select the appropriate measurement methods for this purpose and analyse the signals of the measurements with suitable methods and draw appropriate conclusions. In addition to impedance spectroscopy, voltammetry, CT methods and other common methods are used.

Teaching Methods and Media
Lecture, blackboard notes, exercises, presentations

References
Bard, A. J.; Faulkner, L. R.: Electrochemical Methods: Fundamentals and Applications. 2. Aufl., Wiley, 2001. Larminie, J.; Dicks, A.: Fuel Cell Systems Explained. 2. Aufl., Wiley, 2003. *Newman, J.; Thomas-Alyea, K. E.: Electrochemical Systems. Wiley, 2004.

Notes

Related Course

Signal Processing: Theory and Applications

Course Code	Short Form	Workload	Semester
Y-M20V		CP	1., 2.

Course Types	Frequency	Language(s)
Seminar-style	Summer semester only	English

Also included in
- Applied Physics (M.Sc.), PO2026

Course Responsible
Dr. Karl Schnell

Recommended Prerequisites
None

Course Contents
- Classification of signals and systems
- Standard signals
- Modelling of systems based on technical-physical examples
- Mathematical description and calculation of linear-time-invariant systems in the image domain by means of Fourier transform, Laplace transform, z-transform, correlations
- Stability of systems
- Filter design and applications for biomedical signals
- Linearization of nonlinear systems
- Coupled systems
- Methods of continuous and discrete signal processing, filter design and applications
- Signal processing using wavelet transformation
- Analog and digital filters
- Stochastic processes and statistical analysis

Teaching Methods and Media
The course will combine seminaristic lectures for a solid theoretical foundation with practical application examples implemented e.g. in MATLAB or LTspice

References

- Sundararajan, D. (2023): Signals and Systems - A practical Approach, Second Edition, Springer.
- Deergha Rao, K. (2018): Signals and Systems, Birkhäuser.
- Bernhard, Stefan; Brensing, Andreas; Witte, Karl-Heinz (2022): Biosignal Processsing, De Gruyter.
- Bruce, Eugene N. (2000): Biomedical Signal Processing and Signal Modelling, Wiley.

Notes

Modul

Sustainable Energy Systems

Module Code
APP2-27

Short Form

Module Requirement
Core Elective

Credits
5 CP

Duration
1 Semester

Frequency
Winter semester only

Language(s)
English

Scheduled Semester
1., 2.(recommended)

Type of Examination
Module Level Assessment

Also Included In

- Applied Physics (M.Sc.), PO2026

Curriculum Notes

Module Coordinator
Prof. Dr. Ulrich Rost

Required Prequisites
None

Recommended Prequisites
None

Module Objectives
Upon successful completion of the module, students are able to,

- define key terms and concepts in energy distribution and storage (e.g., electrical, gas and heat networks; electrolyser; fuel cell; battery storage; pumped hydro storage; compressed air storage; PowertoX; LOHC.
- describe the physical fundamentals and key performance indicators of energy storage (e.g., energy density, power density, efficiency, selfdischarge, lifetime) and how these influence application choices.
- apply safety and operational rules for hydrogen systems in casestudy scenarios.
- compare and contrast largescale storage technologies (pumped hydro, compressed air, battery energy storage, thermal storage, hydrogen storage) with respect to cost, efficiency, scalability, spatial and environmental constraints.
- assess technoeconomic scenarios for providing flexibility and storage, and justify technology choices considering efficiency, cost, sustainability and safety.
- design an integrated concept to ensure supply security for a regional energy system that incorporates appropriate storage technologies and sectorcoupling measures (including rough sizing, economic estimate and safety considerations).

This module contributes to the following degree program objectives
User-Centered Physical Technology, Mathematical Methods, Time Management and Self-Management

Type of Course Component: Graded Course Component

Examination Format: Oral Exam

Grading Type: Graded

(If multiple examination formats are available, the exact format of examination and, if appliable, the exact duration of examination is o be determined by the Examination Board at the beginning of the course and publicized within the faculty.)

Contribution to Final Grade
By credit

Total Module Workload in Hours
150, including 42 hours of class attendance (4 contact hours per week) and 108 hours of self-study, including exam preparation

Remarks

Related Courses

Wahlpflichtveranstaltung/en:

- Energy Distribution Grids (SU, 1., 2. Sem., 2 SWS)
- Smart Large Scale Energy Storage Systems (SU, 1., 2. Sem., 2 SWS)

Related Course

Energy Distribution Grids

Course Code	**Short Form**	**Workload**	**Semester**
APP2-27V1		CP	1., 2.

Course Types	**Frequency**	**Language(s)**
Seminar-style	Winter semester only	English

Also included in
- Applied Physics (M.Sc.), PO2026

Course Responsible

Recommended Prerequisites
None

Course Contents
The future energy system will contain a wide range of elements. In addition to the well-known networks for electricity, gas and heat, new elements will be needed, including electrolysers, fuel cells and battery storage systems of various sizes. Furthermore, gas turbines and other forms of Power to X can also play a role in keeping the electricity grid stable in particular. The lecture teaches and develops the basic theoretical knowledge of galvanic elements (batteries, electrolysers, fuel cells, etc.), presents their integration into the energy system and examines the associated questions. Basic knowledge in thermodynamics, electrochemistry, charge transport, etc. is covered in order to optimally select the requirements for fuel cells and batteries and to analyse them using various practical examples. Starting from the overall system, selected areas of the technologies are examined, calculated and worked on as a case study in consultation with the students. Both stationary topics and on- and off-road applications are examined.

Teaching Methods and Media
Lecture, blackboard notes, exercises, presentations

References
will be announced in the course and
Glover, J. D.; Sarma, M. S.; Overbye, T. J.: Power System Analysis and Design. 6. Aufl., Cengage Learning, 2016. Grainger, J. J.; Stevenson, W. D.: Power System Analysis. 5. Aufl., McGrawHill, 1994.

Notes

Related Course

Smart Large Scale Energy Storage Systems

Course Code
APP2-27V2

Short Form

Workload
CP

Semester
1., 2.

Course Types
Seminar-style

Frequency
Winter semester only

Language(s)
English

Also included in
- Applied Physics (M.Sc.), PO2026

Course Responsible

Recommended Prerequisites
None

Course Contents
- Basics of todays and future energy system: Energy grids, load profiles and energy supply systems; Fundamentals of storage physics and key indicators
- Large-scale energy storage technologies: Pumped hydro storage system, compressed air storage system; Battery energy storage systems; Thermal energy storage; Power-to-X: Hydrogen storage (gas, liquid, metal hydrate), Hydrogen production and utilization, Hydrogen safety, E-Fuels, LOHC and hydrogen derivates
- Energy storage system integration: Grid balancing and energy security; Bi-directional charging; Sector coupling

Teaching Methods and Media
Lecture, blackboard notes, exercises, presentations

References
Dincer, I., Rosen, M. A.: Thermal Energy Storage: Systems and Applications. (Wärmespeicher) Linden, D., Reddy, T. B. (Hrsg.): Handbook of Batteries. (Batterietechnik) Machowski, J., Bialek, J. W., Bumby, J. R.: Power System Dynamics: Stability and Control. (Systemintegration/Regelung) Conejo, A. J., Carrion, M., Morales, J. M.: Decision Making Under Uncertainty in Electricity Markets. (Betriebsoptimierung mit Speichern)

Notes

Modul

Surfaces and Nanotechnology

Module Code
APP2-26

Short Form

Module Requirement
Core Elective

Credits
5 CP

Duration
1 Semester

Frequency
Summer semester only

Language(s)
English

Scheduled Semester
1., 2.(recommended)

Type of Examination
Module Level Assessment

Also Included In
- Applied Physics (M.Sc.), PO2026

Curriculum Notes

Module Coordinator
Prof. Dr. Markus Bender

Required Prequisites
None

Recommended Prequisites
None

Module Objectives
Upon successful completion of the module, students are able to,
- describe the particularities of surfaces and nano structures on the scale of few atoms
- identify the conditions for wettable / non-wettable surfaces
- explain methods, conditions and physics of thin film growth
- understand, decide and / or apply methods for surface and thin film analysis. Interpret results from the measurements at nano structures
- apply nano structures and thin films as sensor elements

This module contributes to the following degree program objectives
Mathematical Methods, User-Centered Physical Technology, Experimental Work, Scientific Research and Development, Problem Solving

Type of Course Component: Graded Course Component

Examination Format: Presentation

Grading Type: Graded

(If multiple examination formats are available, the exact format of examination and, if appliable, the exact duration of examination is o be determined by the Examination Board at the beginning of the course and publicized within the faculty.)

Contribution to Final Grade
By credit

Total Module Workload in Hours
150, including 42 hours of class attendance (4 contact hours per week) and 108 hours of self-study, including exam preparation

Remarks

Related Courses

Wahlpflichtveranstaltung/en:

- Nanotechnology (SU, 1., 2. Sem., 2 SWS)
- Surface Physics (SU, 1., 2. Sem., 2 SWS)

Related Course

Nanotechnology

Course Code	Short Form	Workload	Semester
APP2-26V1		CP	1., 2.

Course Types	Frequency	Language(s)
Seminar-style	Summer semester only	English

Also included in

- Applied Physics (M.Sc.), PO2026

Course Responsible

Recommended Prerequisites

None

Course Contents

- Definition of structures at the sub-micrometer scale
- Fabrication of nano-structures
- Investigation and analysis of nano-structures
- Physical behavior of nano-structures
- Applications and sensors

Teaching Methods and Media

Lecture with discussions, Powerpoint, whiteboard, presentation of students Items for demonstration, Lab visit including demonstrations.

References

- Ohring: The materials science of thin films
- Bushan: Handbook of Nanotechnology
- Nasirpouri: Electrodeposition of Nanostructured Materials

Notes

Related Course

Surface Physics

Course Code
APP2-26V2

Short Form

Workload
CP

Semester
1., 2.

Course Types
Seminar-style

Frequency
Summer semester only

Language(s)
English

Also included in

- Applied Physics (M.Sc.), PO2026

Course Responsible
Prof. Dr. Markus Bender

Recommended Prerequisites
None

Course Contents

- Kinetics of surfaces, surface energy, surface tension
- Wettablity, electron emission, adsorption / desorption
- Fabrication of thin films
  - PVD methods
  - CVD methods
  - special methods
- Analysis of thin films
- Special topics: Thin films and surfaces in particle accelerators, graphene etc.

Teaching Methods and Media
lecture with discussion, Powerpoint, whiteboard, presentations of students

References

- Ohring: The materials science of thin films
- Smith: Thin-film deposition
- Desjonqueres: Concepts in surface physics
- Feldman / Mayer: Fundamentals of surface and thin film analysis

Notes

Modul

Microfluidics and Microfabrication

Module Code
Y-M23

Short Form

Module Requirement
Core Elective

Credits
5 CP

Duration
1 Semester

Frequency
Winter semester only

Language(s)
English

Scheduled Semester
1., 2.(recommended)

Type of Examination
Module Level Assessment

Also Included In

- Applied Physics (M.Sc.), PO2026
- Biomedical Engineering (M.Sc.), PO2026

Curriculum Notes

Module Coordinator
Prof. Dr. Markus Bender

Required Prequisites
None

Recommended Prequisites
None

Module Objectives
Upon successful completion of the module, students are able to,

- identify applications of microtechnology and microfluidics
- analyze micromechanical and microfluidic designs
- explain the basic principles of microfluidics
- explore and apply fabrication techniques
- create devices, including design, construction, fabrication and eveluation
- critically review literature

This module contributes to the following degree program objectives
User-Centered Physical Technology, Problem Solving

Type of Course Component: Graded Course Component

Examination Format: Oral Exam

Grading Type: Graded

(If multiple examination formats are available, the exact format of examination and, if appliable, the exact duration of examination is o be determined by the Examination Board at the beginning of the course and publicized within the faculty.)

Contribution to Final Grade
By credit

Total Module Workload in Hours
150, including 42 hours of class attendance (4 contact hours per week) and 108 hours of self-study, including exam preparation

Remarks

Related Courses
Wahlpflichtveranstaltung/en:

- Microfluidics (SU, 1., 2. Sem., 2 SWS)
- Microfabrication (SU, 1., 2. Sem., 2 SWS)

Related Course

Microfluidics

Course Code	Short Form	Workload	Semester
Y-M23V1		CP	1., 2.

Course Types	Frequency	Language(s)
Seminar-style	Winter semester only	English

Also included in

- Applied Physics (M.Sc.), PO2026
- Biomedical Engineering (M.Sc.), PO2026

Course Responsible
Prof. Dr. Xiangping Li

Recommended Prerequisites
None

Course Contents

- Introduction to Microfluidics
  - Definition and historical development;
  - Importance and applications of microfluidics;
  - Overview of microfluidic systems and components;
- Fundamentals
  - Fluid Properties
  - Effects & Phenomena
  - Fluid dynamics (Couette flow, Hagen-Poiseuille-law, plug flow, Flow through a tube)
  - Electrical Analogies
  - Paper Microfluidics
  - Droplet Microfluidics
  - Digital Microfluidics
  - Centrifugal Microfluidics
- Materials and Fabrication Techniques
  - Common materials used in microfluidic devices
  - Two Photon-polymerization, photolithography, soft lithography, Laser, milling, 3D printing etc.
  - Cleanroom protocols and safety (can be combined with Lab Micropatterning)
- Applications of Microfluidics
  - Biomedical research (PCR, organ-on-a-chip etc.)
  - Environmental and chemical applications
  - Point-of-care diagnostics and drug delivery
  - Single cell technology
- Literature review

Teaching Methods and Media
Lecture with discussions, Powerpoint, whiteboard, presentation of students. Items for demonstration, Lab visit including demonstrations.

References

- Microfluidics and Lab-On-A-Chip by Andreas Manz, etc. (Royal Society of Chemistry, 2020).
- Microsystems for Pharmatechnology edited by Andreas Ditzel
- Microfluidics, Fundamentals, Devices and Applications edited by Yujun Song, etc.
- Introduction to Microfluidics by Patrick Tabeling.
- Fundamentals of Microfluidics and Lab on a Chip for Biological Analysis and Discovery by Paul C.H. Li.
- Microfluidics and Nanofluidics: Theory and Selected Applications edited by Clement Kleistreuer.

Notes

Related Course

Microfabrication

Course Code
Y-M23V2

Short Form

Workload
CP

Semester
1., 2.

Course Types
Seminar-style

Frequency
Winter semester only

Language(s)
English

Also included in

- Applied Physics (M.Sc.), PO2026
- Biomedical Engineering (M.Sc.), PO2026

Course Responsible
Prof. Dr. Markus Bender

Recommended Prerequisites
None

Course Contents

- Definitions and advanced phenomena on the micrometer scale
- Advanced microstructuring
  - Lithographic methods
  - Top down processes such as etching
  - Bottom up methods such as deposition
- Complex analysis and evaluation methods of microstructures
  - Optical microscopy
  - Raster electron or probe microscopy
  - Tactile methods
  - Other methods
- Applications: from design to MEMS sensors or microelectronics using the above methods

Teaching Methods and Media
Lecture with discussions, Powerpoint, whiteboard, presentation of students Items for demonstration, clean room visit including hands-on.

References
Völklein, Zetterer: Einführung in die Mikrosystemtechnik (Springer) Schwesinger, Dehne, Adler: Lehrbuch Mikrosystemtechnik (Oldenbourg) MEMC-Book (online) Sami Franssila: Introduction to Microfabrication, Wiley-Verlag (2011)

Notes

Modul

Laser Physics

Module Code
APP2-21

Short Form

Module Requirement
Core Elective

Credits
5 CP

Duration
1 Semester

Frequency
Summer semester only

Language(s)
English

Scheduled Semester
1., 2.(recommended)

Type of Examination
Module Level Assessment

Also Included In
- Applied Physics (M.Sc.), PO2026

Curriculum Notes

Module Coordinator
Prof. Dr. rer. nat. Hans-Dieter Bauer, Dr. Sören Schäfer

Required Prequisites
None

Recommended Prequisites
None

Module Objectives
Upon successful completion of the module, students are able to,
- explain the central physical properties of a laser as a light source and to evaluate these with respect to different applications;
- to distinguish between the most important types of lasers and to explain the background of these differences;
- explain central methods of spectroscopy and their areas of application as well as to distinguish between their capabilities with the aim of making an adequate selection between them;
- explain the most important types of interferometry and judge their accuracy of fit for different application areas
- explain and apply methods of material (micro) patterning and estimate their usability with respect to different materials;
- name important areas of laser application in diagnostics and therapy and to explain the advantages of using lasers in each case;
- design laser based experiments to solve research related questions in laser physics

This module contributes to the following degree program objectives
Experimental Work, User-Centered Physical Technology, Mathematical Methods, Problem Solving, Scientific Research and Development, Time Management and Self-Management

Type of Course Component: Graded Course Component

Examination Format: Oral Exam o. Written Examination o. Written Examination u. Presentation

Grading Type: Graded

(If multiple examination formats are available, the exact format of examination and, if appliable, the exact duration of examination is o be determined by the Examination Board at the beginning of the course and publicized within the faculty.)

Contribution to Final Grade
By credit

Total Module Workload in Hours
150, including 42 hours of class attendance (4 contact hours per week) and 108 hours of self-study, including exam preparation

Remarks

Related Courses

Wahlpflichtveranstaltung/en:

- Quantum Electronics (SU, 1., 2. Sem., 2 SWS)
- Laser Applications (SU, 1., 2. Sem., 2 SWS)

Related Course

Quantum Electronics

Course Code	Short Form	Workload	Semester
APP2-21V1		CP	1., 2.

Course Types	Frequency	Language(s)
Seminar-style	Summer semester only	English

Also included in
- Applied Physics (M.Sc.), PO2026

Course Responsible
Prof. Dr. rer. nat. Stefan Kontermann, Dr. Sören Schäfer

Recommended Prerequisites
- Grundkenntnisse der Optik und Photonik / Basic knowledge in optics and photonics

Course Contents
- mathematische Beschreibung von Laserstrahlen: Gaußsche Strahlen und deren Transformation durch optische Komponenten, Entstehung von Moden höherer Ordnung / mathematical description of laser radiation: Gaussian beams and their transformation by optical components, origin of higher order modes
- Lineare Wechselwirkung von Laserstrahlen mit Materie: Absorption und Dispersion / Linear light-matter interaction: absorption and dispersion
- Nicht-lineare Wechselwirkung von Laserstrahlen mit Materie: Erzeugung höherer Harmonischer, Kerr-Effekt, räumliche optische Solitonen / Non-linear light-matter interaction: generation of higher harmonics, Kerr effect, spatial optical solitons
- Laserpulse: Eigenschaften, Methoden der Erzeugung, Auswirkung und Kompensation von Dispersionseffekten / Laser pulses: properties, generation methods, impact and compensation of dispersion
- Photonik: Wechselwirkung von Licht mit Atomen und Molekülen, Laserkühlung, optische Pinzette / Photonics: interaction of light with atoms and molecules, laser cooling, optical tweezer

Teaching Methods and Media
Tafelanschrieb und Präsentationsfolien mit Diskussionen sowie Übungen

References
- B. Saleh, M.Teich: Fundamentals of Photonics
- G. A. Reider: Photonik
- W. Demtröder, Experimentalphysik

Notes

Related Course

Laser Applications

Course Code	Short Form	Workload	Semester
APP2-21V2		CP	1., 2.

Course Types	Frequency	Language(s)
Seminar-style	Summer semester only	English

Also included in

- Applied Physics (M.Sc.), PO2026

Course Responsible
Prof. Dr. rer. nat. Hans-Dieter Bauer, Dr. Sören Schäfer

Recommended Prerequisites
None

Course Contents

1. Grundlagen des Lasers (Laser als Lichtquelle, typische Eigenschaften, grundsätzlicher Aufbau, Betriebsmodi, wichtige Typen) - Basics of the laser (the laser as a light source, typical performance characteristics, modes of operation, important types of lasers)
2. Erzeugung und Vermessung von Laserpulsen - Generation and measurement of laser pulses
3. Wichtige Methoden der Spektroskopie - Important methods of spectroscopy
4. Wichtige Methoden der Interferometrie und Holographie - Important methods of interferometry and holography
5. Laser(mikro)materialbearbeitung - Micropatterning of materials by laser radiation
6. Anwendungen des Lasers in medizinischer Diagnostik und Therapie - Laser applications in diagnostics and therapy

Teaching Methods and Media
Blackboard writing with presentation slides and discussions

References
ppt script W. Demtröder, Laser Spectroscopy, Springer Verlag F. K. Kneubühl, M. W. Sigrist, Lasers, Teubner Verlag D. Meschede, Optics, Light and Lasers, Teubner Verlag The list is supplemented by special chapters or working materials on topics relevant to medical technology.

Notes

Modul

Quantum Physics and Technology

Module Code
APP2-24

Short Form

Module Requirement
Core Elective

Credits
5 CP

Duration
1 Semester

Frequency
Winter semester only

Language(s)
English

Scheduled Semester
1., 2.(recommended)

Type of Examination
Module Level Assessment

Also Included In

- Applied Physics (M.Sc.), PO2026

Curriculum Notes

Module Coordinator
Prof. Dr. Jochen Rau

Required Prequisites
None

Recommended Prequisites
None

Module Objectives
Upon successful completion of the module, students are able to,

- explain the role and special properties of angular momenta in quantum physics, including their measurement, coupling and conservation
- describe mathematically the control of a quantum system via fast or slow external driving
- explain quantum entanglement and its use in quantum technology
- explain key consequences of quantum indistinguishability, and analyze quantum systems that involve indistinguishable particles
- analyze the design and underlying physics of hardware implementations of quantum logic gates
- design and implement quantum algorithms using quantum programming tools
- describe and analyze quantum-enhanced sensing techniques
- analyze long-distance quantum communication methods and assess their security

This module contributes to the following degree program objectives
Mathematical Methods, User-Centered Physical Technology, Problem Solving

Type of Course Component: Graded Course Component

Examination Format: Oral Exam o. Oral Exam u. Presentation

Grading Type: Graded

(If multiple examination formats are available, the exact format of examination and, if appliable, the exact duration of examination is o be determined by the Examination Board at the beginning of the course and publicized within the faculty.)

Contribution to Final Grade
By credit

Total Module Workload in Hours
150, including 42 hours of class attendance (4 contact hours per week) and 108 hours of self-study, including exam preparation

Remarks

Related Courses

Wahlpflichtveranstaltung/en:

- Quantum Technologies (SU, 1., 2. Sem., 2 SWS)
- Advanced Quantum Physics (SU, 1., 2. Sem., 2 SWS)

Related Course

Quantum Technologies

Course Code	Short Form	Workload	Semester
APP2-24V1		CP	1., 2.

Course Types	Frequency	Language(s)
Seminar-style	Winter semester only	English

Also included in

- Applied Physics (M.Sc.), PO2026

Course Responsible
Dr. Susanna Gallas

Recommended Prerequisites
None

Course Contents

- Review of quantum technology fundamentals
- Quantum Sensing
- Quantum Computing
- Quantum Communication

Teaching Methods and Media

- Interactive Lectures
- Discussion & Reflection
- Group work
- Simulation tools
- Lab Sessions

References

- Nielsen, M. A., & Chuang, I. L. Quantum Computation and Quantum Information (Cambridge University Press, 2010)
- Mandel, L., & Wolf, E. Optical Coherence and Quantum Optics (Cambridge University Press, 1995)
- Fox, M. Quantum Optics: An Introduction (Oxford University Press, 2006)

Notes

Related Course

Advanced Quantum Physics

Course Code	Short Form	Workload	Semester
APP2-24V2		CP	1., 2.

Course Types	Frequency	Language(s)
Seminar-style	Winter semester only	English

Also included in

- Applied Physics (M.Sc.), PO2026

Course Responsible

Prof. Dr. Jochen Rau

Recommended Prerequisites

None

Course Contents

- Theory of angular momenta
- Magnetic interactions
- External driving, Rabi oscillations, adiabatic limit
- Many particles

Teaching Methods and Media

- Interactive Lectures
- Discussion & Reflection
- Group work
- Simulation tools

References

- Rau, J. , Quantum Physics (Oxford University Press, 2026)
- Griffiths, D. , Schroeter, D. Introduction to Quantum Mechanics (Cambridge University Press 2018)
- Townsend J., A modern Approach to Quantum Mechanics (University Science Books, 2012)
- Ballentine, L. E. Quantum Mechanics: A Modern Development (World Scientific, 2014)

Notes