Specialization in Technology: Information Technology and Electronics (major) | Technik-Schwerpunkt: Informationstechnik und Elektronik Vertiefungsmodule (major)

Module Description

CIT4330010: Brain, Mind and Cognition | Brain, Mind and Cognition [BMCSem]

Version of module description: Gültig ab winterterm 2023/24

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 135	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Abgabe von mindestens 3 (von maximal 5) schriftlich formulierten Hausarbeiten, in denen das Verständnis der Literatur nachgewiesen wird sowie aktive Teilnahme an den Diskussionen dazu - Notengewicht von 60% zur Gesamtnote

Abgabe eines zusammenfassenden Essays zum Nachweis der Fähigkeit zur Bewertung der interdisziplinären Zusammenhänge - Notengewicht von 40% zur Gesamtnote

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Ausreichende Sprachkenntnisse in Englisch, um sprachlich anspruchsvolle Literatur lesen, sowie verständliche Essays zum Thema verfassen zu können.

Content:
Im Seminarteil lesen Studierende allgemeinverständliche Literatur (bis zu 5 Bücher) zum erweiterten Themenkreis Brain, Mind and Cognition und diskutieren in der Gruppe. Es soll dabei die Frage beantwortet werden in welcher Form wir etwas aus der Literatur lernen können über den Aufbau und die Funktion von Gehirn, Geist und Kognition. Welche Inspiration können wir daraus für die technische Arbeit gewinnen? Ergänzend zum Seminar gibt es eine Vorlesung, in der Hintergrundinformation zu den Themen Neuro- und Kognitionswissenschaften mit Blick auf kognitive Roboter vermittelt werden.

Lehr- und Lernmethode

Intended Learning Outcomes:
Am Ende des Moduls haben die Studierenden zum einen einen breiten und interdisziplinären Zugang und Einblick zum Thema "Brain, Mind and Cognition" gewonnen haben und können entsprechende Konzepte verstehen und bewerten.

Studierende sind anhand der gelesenen Literatur in der Lage wissenschaftliche Fragestellungen zu identifizieren und zu formulieren. Zudem verbessern die Studierenden ihre schriftliche und mündliche Ausdrucksweise sowie die Fähigkeit zum wissenschaftlichen Dialog.

Teaching and Learning Methods:
Studierende lesen die vereinbarte Literatur innerhalb eines vorgegeben Zeitrahmens und schreiben im Anschluss einen Aufsatz über das persönliche Verständnis der Literatur. Die Aufsätze werden mittels Leitfragen angeleitet.

Die gelesene Literatur wird in einer Kontaktstunde mit Blick auf eine übergeordnete Fragestellung untereinander diskutiert.

Abschließend schreiben die Studierenden eine Zusammenfassung der Diskussionsergebnisse und der eigenen Einsichten.

Ergänzende Hintergrundinformationen zu den Büchern wird in Form von Frontalunterricht (Vorlesung) präsentiert.

Media:
Bücher und Literatur (kann z.T. in elektronischer Form via Webseite zum download angeboten werden);
Vorlesung mit Präsentationsfolien (Frontalunterricht)

Reading List:
Die Literaturliste des Kurses wird zu jedem Semester aktualisiert und vorab via Webseite veröffentlicht.

Responsible for Module:
Diepold, Klaus; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Brain, Mind and Cognition - Alternativ 2 (Seminar, 3 SWS)
Diepold K, Dötzer M, Lengl M, Ripoll M
For further information in this module, please click campus.tum.de or here.

Module Description

EI05381: Multimedia Laboratory | Projektpraktikum Multimedia [PPMM]

Version of module description: Gültig ab winterterm 2024/25

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 105	**Contact Hours:** 75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
- Final Project (Concept design and presentation, Cross-platform Application, final presentation) (100%)

The programming exercises will be finished during the lab session. The concept design and presentation is used to define and present the idea of the final project and to discuss its feasibility within the scope of the lab. After accomplishing the final project, the students will present their results and discuss them with the supervisors.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basics of Media Technology
Basics of programming

Content:
The Multimedia Lab focuses on realizing cross-platform multimedia applications using machine learning as the back-end and web as the front-end. At the beginning of the semester, the basic knowledge of machine learning, Python programming, and web programming (based on online courses and programming tasks) will be acquired in weekly lab sessions. During the semester project, the participants have the opportunity to create their own application in teamwork, for example, in the fields of visual navigation or object classification.

Intended Learning Outcomes:
After participating in the lab, the students are able to design and develop cross-platform multimedia applications and introduce them in a presentation.

Teaching and Learning Methods:
In addition to individual methods, knowledge deepening is achieved via practical training sessions in the laboratory. Weekly sessions with close supervision and selected presentations of basic concepts at the beginning of the lab sessions.

Media:
- Presentations
- Script and overview articles from the literature
- Tutorials and Software documentation

Reading List:
Recommended literature:
- https://docs.python.org/3/tutorial/index.html
- https://pytorch.org/tutorials/
- https://www.w3schools.com/.

Responsible for Module:
Steinbach, Eckehard; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Projektpraktikum Multimedia (Praktikum, 5 SWS)
Steinbach E, Chaudhari R, Eteke C, Zakour M, Xu X
For further information in this module, please click campus.tum.de or here.

Module Description

EI0622: Semiconductor Sensors | Halbleitersensoren

Version of module description: Gültig ab winterterm 2019/20

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In a written closed book exam of 60 minutes duration questions and short calculations on physical foundations and principles as well as on structure, operation and application of semiconductor sensors have to be worked out in order to test if the student knows, has understood, can explain and apply them.
During the semester, there is the possibility to elaborate and give a voluntary seminar talk on a specific subtopic of the lecture. Provided a successful presentation, the grade can be improved according to the regulations of a mid term achievement.
The final grade is composed of
- 100% final exam
In case of a successfully passed seminar talk, the grade is lifted by 1/3 of an entire grade step.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
We recommend the successful participation in the following 4th semester module:
- Festkörper-, Halbleiter- und Bauelementephysik
The supplementary participation in Technical Mechanics is helpful.

Content:
-Introduction to technical and economical application fields of semiconductor sensors
-Physical foundations of the material properties used in semiconductor sensors, short overview on specific technological process (micromachining)
-Sensor principles and their concrete application to microsensor
The following topics are specifically addressed:
-Mechanical sensors (pressure, acceleration, angular rate), theory of elasticity, physical foundations of sensing effects (piezoresistive, piezoelectric, capacitive measurement principle)

-Contact temperature sensors: thermoresistors, diodes, transistors and their operations principle
-Radiation sensors: Bolometers, quantum detectors
-Magnetic field sensors: Hall sensors, field plates, AMR sensors
Optional: topics in the field of humidity sensing, smart sensor concepts and sensor systems

Intended Learning Outcomes:
By successfully completing the module, the students learn, understand and are able to explain the physicals foundations and principles of semiconductor sensors such as electro-mechanical, thermo-electric, magento-electric signal transduction, and they are able to apply this knowledge to simple, specific problems.
They understand the basic physical material and solid state properties of the materials used in semiconductor sensors and they know and can explain their relevance for the exploitation as sensor effect.
They know and are able to explain the realization of these principles in sensor concepts and their operation. They know exemplary application scenarios and fields of the presented sensors

Teaching and Learning Methods:
The content of the module is imparted by a lecture supported by Powerpoint slides and derivations and detailed explanation of physical-technical relations at the black board. During exercise hours the content of the lecture will be practiced and the understanding of it will be deepened by solving specific problems. During the seminar hour, individual students or small groups of students present specific and selected subtopics of the lecture to their colleagues (inverted classroom approach), which they elaborate on their own by given material and/or information on related literature. This effort will be honored by a bonus on the final grade according to the regulations of a midterm activity.

Media:
The lecture will be given by
- presentations with handouts, which are provided via Moodel
- Supporting material and detailed physical derivations are developped directly at the black boards
- Excercises with solutions are provided via Moodle

Reading List:
Further reading:
- W.Heywang; Sensorik, Springer Verlag, 1993
- J. Gardner: Microsensors, Wiley, 1994
- S. Senturia, Microsystem Design, Springer, 2001

Responsible for Module:
Schrag, Gabriele; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Halbleitersensoren (Vorlesung mit integrierten Übungen, 4 SWS)
Schrag G [L], Schrag G, Leikam B

For further information in this module, please click campus.tum.de or here.

Module Description

EI0631: Media Technology | Medientechnik

Version of module description: Gültig ab winterterm 2015/16

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The type of examination is a written exam with 90 minutes duration. Students solve selected problems based on the introduced concepts and equations. Additionally, they answer questions about the lecture content and explain in their own words selected methods from the lecture. Students are allowed to bring 4 pages of handwritten notes and a non-programmable calculator. Matlab assignments with voluntary participation are offered during the semester and can be used to improve the final grade of the course.

The final grade is composed of the following elements:
- 100% final exam

Successful completion of the Matlab assignments leads to a bonus of 0.3 on the final grade in case the final is passed. The Matlab assignments are successfully completed if at least an average of 65% is obtained when submitting the solutions to the module tutor.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Higher Mathematics, Linear Algebra, Signal Processing

Following modules should have been accomplished before participation:
- Signals
- Introduction to signal processing
- Systems

Content:
image construction camera models and coordinates, mapping from world to pixel coordinates, camera calibration, sterea camera systems, image synthesis,the rasterization of geometric primitives, geometric scene description using polygon meshes and parametric surfaces, illumination of surfaces, shading, texture mapping, rendering pipeline, analog video, color TV systems, digital video, format conversion

Intended Learning Outcomes:
Upon completion of the module, students are able to:
- characterize the fundamental principles of information retrieval using the example of text and image search and to evaluate the performance of different approaches
- develop a simple system for media search and to evaluate its performance
- describe the creation of images and mathematically compute the mapping between world coordinates and pixel coordinates for single and stereo camera systems
- perform external and internal camera calibration and analyze the calibration error
- describe the fundamental principles of image synthesis including the rasterization of geometric primitives, geometric scene description using polygon meshes and parametric surfaces, illumination of surfaces, shading, texture mapping
- describe the basic steps of the rendering pipeline and evaluate it for simple scenes with point light sources
- characterize analog and digital video and to analyze their differences
- compute the influence of phase errors for color TV systems NTSC, SECAM, and PAL.
- perform the conversion between different formats for digital TV signals

Teaching and Learning Methods:
Teaching and learning methods consist of presentations during the lecture and the exercises. Moreover, the students will improve their knowledge by use of scientific literature and implement selected concepts of the lecture using matlab during the voluntary project during the semester.

Media:
Following forms of media are applied:
- presentations
- script
- exercises with solution (downloadable from the internet)

Reading List:
Following literature is recommended:
- R. Steinmetz, Multimedia-Technology Springer-Verlag, 3. überarb. Auflage, 2000.
- Foley et al, Computer Graphics: Principles and Practice, Addison Wesley, zweite Auflage, 1995.
- Manning et al., Introduction to Information Retrieval, Cambridge University Press, 2008.
- U. Schmidt, Professionelle Videotechnik, Springer-Verlag, 2000.

Responsible for Module:
Steinbach, Eckehard; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Medientechnik (Vorlesung mit integrierten Übungen, 4 SWS)
Steinbach E, Xu X
For further information in this module, please click campus.tum.de or here.

Module Description

EI4585: Project: Economic Aspects of Nanotechnology | Projektpraktikum: Wirtschaftliche Aspekte der Nanotechnologie

Version of module description: Gültig ab summerterm 2025

Module Level: Master	**Language:** German	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a report (50%) and a presentation (50%).
The report is drawn up in teamwork. The methods discussed in the seminar, such as patent analysis, crowd-funding, market analysis or business plan, are applied and scientifically evaluated, whereby the clear and precise summary of the most important facts and the conclusions drawn from them are in the foreground (15-20-page report).
In the oral presentation followed by discussion, the students show that they understand important applications, perspectives and opportunities of selected technologies in the field of nanotechnology and can evaluate them within the framework of a patent analysis, crowd-funding, market analysis or business plan. The presentation focuses on the visualization of the results and conclusive lines of argumentation. (20 minutes presentation, 20 minutes subsequent discussion).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic Lectures / Literature
- Introduction to nanoelectronics
- Introduction to nanotechnology

Content:
Fundamentals of nanotechnology. Patent applications, research and development activities in the field of nanotechnology: international comparison. Overview of important fields of application of nanotechnology. Applications of nanotechnology in selected industrial sectors: Automotive industry, aerospace industry, construction industry, textile industry, energy industry, chemistry,

information and communication technology, medicine. Opportunities and risks of nanotechnology. Nanotechnology in Germany.

Intended Learning Outcomes:
Upon successful completion of the course, students will be able to interpret the properties of nanotechnologically relevant structures and elements and understand manufacturing methods for these components. It will also be possible to compare different physical effects of elements of nanotechnology against the background of system applications. After participation, students will be able to understand important applications, perspectives and opportunities of selected technologies in the field of nanotechnology and evaluate them in the context of patent analysis, crowd funding, market analysis or a business plan.

Teaching and Learning Methods:
During the seminar, selected topics will be discussed in a team and technical contexts will be presented and deepened in small lectures. Through independent group work, patent analysis and business plans, for example, are developed and presented in the seminar. The writing of a report and a presentation also takes place in a team.

Media:
Information and teaching material is made available in the form of presentation slides, scientific publications, handouts and topic-specific scripts.

Reading List:
Presentation slides, topic-specific short instructions, technical descriptions and scientific publications will be handed out by the tutor during the course.

The following literature is recommended:
- H. Paschen et al., Nanotechnologie Springer-Verlag, 2004.
- J. Schulte (Hrsg.), Nanotechnologie: Globale Strategien, Branchentrends und Anwendungen, Wiley, 2005.

Responsible for Module:
Weig, Eva; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Projektpraktikum: Wirtschaftliche Aspekte der Nanotechnologie (Forschungspraktikum, 3 SWS)
Becherer M, Haider M

Projektpraktikum: Wirtschaftliche Aspekte der Nanotechnologie (Forschungspraktikum, 4 SWS)
Becherer M [L], Becherer M, Haider M
For further information in this module, please click campus.tum.de or here.

Module Description

EI70320: Channel Coding | Channel Coding [Channel Coding]

Version of module description: Gültig ab summerterm 2020

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 75	**Contact Hours:** 75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In a final written exam of 90 minutes students demonstrate their understanding of the presented coding schemes, various code classes, and their applications by answering comprehensive questions and solving calculation problems. They further demonstrate that they can evaluate, design, and decode suitable code classes for different applications.
Permitted supporting materials in the exam are two A4 pages of notes (printed or handwritten) and a non-programmable calculator.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Mathematical basics (linear algebra)

Content:
This course deals with modern coding approaches for coding and storage. No previous knowledge of channel coding is required.

- Applications of Channel Coding
- Channel Coding Principles:
Channel Models, Decoding Principles, Hamming Metric
- Finite Fields:
Groups, Fields, Prime Fields, Extension Fields, Vector Spaces
- Linear Block Codes:
Definition, Encoding, Coset Decoding, Bounds (Hamming Bound, Singleton Bound, Gilbert-Varshamov Bound), Hamming Codes, Perfect Codes
- Reed-Solomon Codes:
MDS Codes, Definition, Key Equation, Unique Decoding, List Decoding

- BCH Codes:
Minimal Polynomials, Generator and Parity-Check Polynomial, BCH Bound, Efficient Decoding
- Convolutional Codes:
State Diagram, Shift Register, Viterbi Decoding
- Reed-Muller Codes:
Definition, Simplex Code, Plotkin Construction
- Concatenated Codes:
Basic Concepts

Intended Learning Outcomes:
After attending the course, students will be able to
• understand the aim of channel coding and demonstrate the principles of channel coding,
• characterize different code classes,
• apply the mathematics of finite fields to linear codes,
• select suitable coding schemes, adjust the parameters and evaluate the result,
• derive decoding algorithms,
• understand bounds on the cardinality of codes,
• for a given coding scheme and a given application, evaluate the error-correction capability and its limits in comparison to known bounds and other code classes,
• understand coding schemes not covered in the lecture after appropriate literature research.

Teaching and Learning Methods:
Lecture: The fundamental theoretical contents are presented in the lecture (by a slide presentation and on the black board) and illustrated with examples. Students are encouraged to ask questions and discuss the topics of the lecture.

Tutorial: In an accompanying tutorial, the contents of the lecture are applied to examples.

Media:
The lecture is given with slides; examples and additional explanations are done on the black board.

Reading List:
Lecture notes are provided.
The following additional literature is recommended:
- Justesen, J. and Hoholdt, T.: “A Course in Error-Correcting Codes”, European Mathematical Society, 2004.
- Roth, R. M.: “Introduction to Coding Theory”, Cambridge Univ. Press, 2006
- Bossert, M.: “Kanalcodierung”. 3Rd edition, Oldenburg, 2013 (English version: “Channel Coding for Communications”, Wiley, 1999)

Responsible for Module:
Wachter-Zeh, Antonia; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Channel Coding (Vorlesung mit integrierten Übungen, 5 SWS)
Wachter-Zeh A, Maßny L, Walter F, Banerjee A, Bariffi J
For further information in this module, please click campus.tum.de or here.

Module Description

EI71004: Communication Acoustics | Communication Acoustics

MOOC of the German TU9 acoustics institutes

Version of module description: Gültig ab summerterm 2017

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The written examination (90 min) will cover material from the wide topical range of the module which is aimed at providing a general understanding of communication acoustics, audio technology and auditory preception. Understanding and the individual ability to solve problems will be examined in a 90 minute-long written exam through solving numerical problems and answering in-depth and tranfer questions about acoustical communication.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Mathematics and logarithms;
Fundamentals of signals and systems are helpful (will be reiterated upon in the lecture)

Content:
1. Fundamentals of acoustics (Müller, Vorländer) 1.1 sound field quantities, wave equation
1.2 plane waves / spherical waves
1.3 energy/intensity, decibel
1.4 sound sources: voice / musical instruments / noise
1.5 sound reflection, absorption, diffraction
1.6 statistical room acoustics, reverberation

2. Fundamentals of signals and systems (Ahrens)
2.1 Complex notation, harmonic signals
2.2 Fourier series, Fourier transformation, time and frequency domain (DFT, FFT)
2.3 LTI systems, impulse response and transfer function
2.4 Digital filters

2.5 Short introduction to non-linear systems

3. Anatomy and physiology of the hearing system (Fels)
3.1 Peripheral auditory system
3.2 Physical binaural cues and binaural hearing
3.3 Fundamentals of binaural technology
3.4 Reproduction of binaural recordings

4. Psychoacoustics (Seeber)
- Hearing threshold
- Auditory masking
- Auditory frequency selectivity and critical bands
- Loudness of sounds
- Pitch, pitch strength, and timbre
- Sharpness
- Fluctuation strength and roughness
- Binaural unmasking for speech understanding
- Psychoacoustic methods

5. Electroacoustics (Altinsoy)
5.1 Introduction to electroacoustical systems and transmission
5.2 Electromechanical and electroacoustical analogies
5.3 Amplitude frequency response, harmonic distortion, intermodulation distortion, noise level and signal-to-noise ration
5.4 Transducer principles
5.5 Microphones
5.6 Loudspeakers
5.7 Headphones and earphones

6. Speech acoustics (Möller)
6.1 Anatomy of the human speech production system
6.2 Excitation (periodic excitation: mechanism, fundamental frequency, spectrum; aperiodic excitation: noisy excitation, step function)
6.3 Sound shaping
6.4 Speech signal characteristics
6.5 Speech sounds
6.6 Models of speech production
6.7 Speech signal analysis
6.8 Speech intelligibility

7. Sound recording and reproduction (Weinzierl)
7.1 The psychoacoustics of stereophonic reproduction
7.2 Reproduction formats: From 1.0 to 24.1.10
7.3 Recording techniques

7.4 Channel-oriented vs. object-oriented spatial audio coding

8. Virtual acoustics I: Binaural technology (Weinzierl)
8.1 The concept of binaural recording and reproduction
8.2 Recording and playback devices
8.3 Dynamic binaural synthesis and re-synthesis
8.4 On the quality of virtual acoustic environments

9. Virtual acoustics II: Sound field analysis and synthesis (Ahrens)
spatial rendering: loudspeaker arrays;
spatial capture: microphone arrays, beamforming

10. Application Room Acoustics 1 (Müller)
Geometrical acoustics, impulse responses, perception (ISO 3382 parameters),
examples of performance spaces and classrooms

11. Application Room Acoustics 2 (Vorländer)
11.1 Room impulse response, image source model
11.2 Ray Tracing model
11.3 Wave models, hybrid geom/wave models
11.4 Input data,: sources and boundary conditions, precision
11.5 Auralization and Virtual Acoustics
11.6 Interfaces to 3D audio

12. Application Automatic Speech Recognition (Möller)
Principle of speech recognition, architecture of a speech recognizer, feature extraction, Hidden Markov Models, language models

13. Application Text-to-Speech Synthesis (Möller)
Historic approaches, structure of a speech synthesizer, symbolic preprocessing, prosody generation, signal generation approaches: parametric, concatenative, unit-selection synthesis

14. Application of Psychoacoustics in Product Development (Altinsoy)

15. Product Sound Design (Altinsoy)

16. Application: Perceptual Audio Coding (Ahrens) (mp3)

Intended Learning Outcomes:
Fundamental knowledge and understanding in the covered areas of fundamentals of acoustics, sound propagation, audio technology, sound production, speech processing, psychoacoustics and communication acoustics. Ability to individually solve problems in communication acoustics.

Teaching and Learning Methods:
The module content is taught via many short video tutorials. Material for individual further study and audio examples are provided online. The exercise course deepens the understanding of the lecture content through solving numerical examples and applying it to practical problems. The exercise part is provided in video tutorials and learning progress is monitored through online questionnnaires with electronic correction. The applicability of the taught fundamentals is demonstrated on current research topics. Results and questions can be dicussed in a discussion group online with fellow students and tutors.

Media:
Lecture and exercise with many video tutorials, audio demonstrations, explanations on examples, multimedia demonstration of further material and online links, online testing of learning progress, online diskussion group.

Reading List:
Fastl, H., Zwicker, E.: Psychoacoustics - Facts and Models, 3. Auflage, Springer, Heidelberg, 2007.
Yost, W.: Fundamentals of Hearing, An Introduction, 5. Auflage, Brill Academic Pub, 2013.
Vorlaender, M.: Auralization. Springer, 2008.
Blauert, J.: Spatial Hearing. MIT Press, 1997.
Pulkki, V. and Karjalainen: Communication Acoustics. Wiley, 2015.

Responsible for Module:
Seeber, Bernhard; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Communication Acoustics (Vorlesung mit integrierten Übungen, 4 SWS)
Seeber B, Müller G, Bajool M, Yadav S
For further information in this module, please click campus.tum.de or here.

Module Description

EI7355: Nanosystems | Nanosystems [NanoSys]

Version of module description: Gültig ab winterterm 2024/25

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a written exam (60 minutes, 100%). In the written exam, students will demonstrate theoretical knowledge of applied methods of nanosystems, nanodevices, and nanometrology techniques by answering questions under time constraints and without aids. Students will demonstrate the ability to explain fundamental concepts of nanosystems in a condensed form using sketches and block diagrams of instrumentation, measurement and fabrication setups.

In the laboratory part offered to accompany the lecture, the emphasis is on hands-on training of students in a real metrology laboratory environment. The voluntary examination performance for this includes a measurement report (2 pages), which demonstrates that the students have deepened their knowledge from the practical laboratory and have acquired a comprehensive understanding of the measuring instruments and the devices under investigation. The students show that they can use analysis tools and visualization programs to check the results they have obtained themselves.
A grade bonus of 0.3 will be applied to the final grade for successful completion of the voluntary assignment. i.e. hands-on experience, data processing, and summary of important aspects.

Repeat Examination:

(Recommended) Prerequisites:
Basic physical concepts, materials, electronic devices, fundamentals of Nanoelectronics.

The student should have (but it is not mandatory) taken classes in
- Nanoelectronics
- Nanotechnology

Content:
In this module, starting from fundamentals of nanofabrication and nanotechnology, concepts and requirements of nanosystems will be discussed. Numerous examples of nanosystems already existing today (logic gates, integrated memories, hard disks, ...) will be presented and discussed. Characterization methods (optical, electrical, particle-based, magnetic) will be linked to structuring methods of nanotechnology, which are indispensable for the ultimate scaling of nanoobjects. Selected current research fields in nanoelectronics, nanomagnetics and optoelectronics, as well as in the application areas of logic, memory and sensing, will be used to exemplify the boundary conditions for (commercially) successful nanosystems.

In the part of the lecture, where the focus is on current research topics in micromagnetism, the students will get to know a research topic practically in parallel to lectures within the framework of a laboratory project. In small groups of max. 3 students, the characterization of e.g. ferromagnetic resonance effects in ferrimagnetic / ferromagnetic thin films using vector network analyzers and lock-in techniques will be directly experienced in the laboratory experiment and directly linked to what has been learned in the lectures.

Intended Learning Outcomes:
After completion of the module, students are able to evaluate nanodevices and their system integration.They are able to comprehensively review various different physical effects for their application in nanosystems. They know how to evaluate a physical effect in terms of scaling abilities to form a system. They are able to document and present the results of their experiments in form of a scientific report and graphs.

Teaching and Learning Methods:
The theoretical background to understand the operation of nanosystems will be provided in the lectures with traditional methods (power point presentations, discussion, questions in the lecture notes). Part of the module will be carried out in a hands-on lab. Small groups will work in a coordinated fashion towards the measurement and metrology of magnetic thin film devices.

Media:
The following types of media will used:
- Presentation slides
- Lecture Notes
- Black board
- Hands-on lab

Reading List:
- Rainer Waser (Ed.), "Nanoelectronics and Information Technology" Advanced Electronic Materials and Novel Devices, Wiley-VCH, Third Edition, 2012.
- Sami Franssila, "Introduction to Microfabrication", John Wiley & Sons, 2010.
- J.M.D. Coey, Magnetism and Magnetic Materials, Cambridge University Press, 2009.
- Additional reading material and useful web sources will be provided to the students with the lecture notes / MOODLE course.

Responsible for Module:
Becherer, Markus; Prof. Dr.-Ing. habil.

Courses (Type of course, Weekly hours per semester), Instructor:
Nanosystems (Vorlesung, 4 SWS)
Becherer M [L], Becherer M (Greil J)
For further information in this module, please click campus.tum.de or here.

Module Description

EI7356: Network Planning | Network Planning

Version of module description: Gültig ab winterterm 2020/21

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Written examination

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic Knowledge of Communication Networks

The following modules should be passed before taking the course:
- Communication Networks Lab
- Broadband Communication Networks

Content:
Introduction: Motivation, Range of Tasks, Application Areas, Classification, Planning Process, Traffic Engineering
Related Optimization Fundamentals: Mathematical Formulation, Categories, Solution Methods (principles of exact and heuristic methods)
Traffic and Demand Modeling: Traffic Types, Modeling, Forecasting
Network Topology Design: Initial Planning, Extension Planning, Site Selection
Network Dimensioning: Approaches for Circuit and Packet Switched Networks, Optimization Problems, Representative Heuristics
Resilience Planning: Redundancy Concepts, Disjointness, Resource Sharing
Generalizations: Multilayer Planning, Multiperiod Planning
Access Networks Planning: Overview, Selected Problems
Mobile Networks Planning: Overview (delineation with Resource Management in Wireless Networks course)
Post-Planning Analysis: Network Simulation, Availability Analysis

In Practice: Network Planning Tools, Economics Aspects

Intended Learning Outcomes:
The aim is to have detailed knowledge of the methods for planning of communication networks and the skills to apply them.
Students will practically model and solve planning problems with the student version of AMPL.

Teaching and Learning Methods:
Lerning method:
In addition to the individual methods of the students further knowledge is gained by own lab experiments and reading of books. Sample examinations are available.

Teaching method:
During the lectures students are instructed in a teacher-centered style. The exercises are a mixture of question-based exercises and lab experiments. Interation between students and teacher is steadily performed.

Media:
The following kinds of media are used:
- Presentations: slides, software usage
- Exercises and slides as download
- Whiteboard
- Software at terminals in lecture room

Reading List:
The following literature is recommended:
- W: D. Grover, Mesh-based Survivable Networks," Prentice Hall, 2003.
- M. Pioro and D. Medhi, "Routing, Flow, and Capacity Design in Communication and Computer Networks," Morgan Kaufmann, 2004.

Responsible for Module:
Kellerer, Wolfgang; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Network Planning (Vorlesung mit integrierten Übungen, 3 SWS)
Schupke D
For further information in this module, please click campus.tum.de or here.

Module Description

EI73871: Technical Acoustics and Noise Abatement | Technische Akustik und Lärmbekämpfung

Version of module description: Gültig ab winterterm 2024/25

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
During the 90-min written exam, students will be asked to demonstrate a fundamental knowledge and understanding of the lecture content in technical acoustics. The exam contains multiple questions including: 1) multiple-choice type, 2) calculations of practically-relevant problems in technical acoustics and of problems in general (theoretical) acoustics. The questions examine the understanding of fundamental concepts in acoustics and the ability to design noise abatement measures and include the reproduction of learned knowledge. A collection of basic formulas will be provided for the exam.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge of calculus for engineers (e.g. logarithm, differential calculus) required, basics of sound propagation from lecture Audio Communication (B.Sc.) recommended.

Content:
Introduction: acoustics and noise control, principles of noise reduction, sound fields, level calculation.
Origin and propagation of sound: simple oscillators, resonators, types of sound waves.
Point sources, geometrical acoustics, absorption, room acoustics: room modes, statistical room acoustics, reverberation time, simulation methods, psychoacoustics of rooms.
Airborne sound insulation, body-borne sound insulation.
Sound measurement technology and sound impact: Measurement microphones, weighted sound level (A, C, D), time constants (I, F, S), equivalent sound pressure level Leq, sound analysis with absolute and relative constant bandwidth, sound of rotating machinery, third-octave band analysis,

insertion loss. Calculation procedures: loudness level, loudness, psychoacoustic annoyance, Speech Interference level (SIL), Temporary and Permanent Threshold Shifts (TTS & PTS). Noise control according to (European) law, codes and norms: noise at workplaces, noise from machines, industrial noise (“TA Lärm”), noise from road traffic, railroads and aircrafts. Practical introduction to acoustic measurements: applicable norms, use of measurement equipment, conduction of measurements in the anechoic chamber, analysis of measurements, creation of measurement reports.

Intended Learning Outcomes:
Upon successful completion of the module students will be able to apply their understanding of fundamental aspects in acoustics to basic problems of noise control and noise reduction, to analyze them and to propose solutions. Therefore, students will be able to independently conduct simple acoustical measurements and to calculate and asses sound propagation and effects of sound insulation. Furthermore, students can assess and evaluate means of technical acoustics on the basis of important codes and norms, measurement instructions, as well as legal limits.

Teaching and Learning Methods:
Lecture with many practical demonstrations, exercise session on how to calculate sound propagation of different sound sources (distance and direction-based characteristics), sound propagation in rooms, and the effects of sound insulation methods and resonators; conduct individual, guided acoustical measurements in the anechoic chamber; self-study of acoustic fundamentals, norms and mathematical methods and multimedia content (e.g. video tutorials).

Media:
Lecture with comprehensive (audio) demonstrations, projection of written content, written compilation of content and formulas (Moodle), (multimedia) presentation of practical examples and additional information in class, separate exercise session on calculating and solving practical problems; hands-on introduction to acoustical measurements in the institute’s anechoic chamber.

Reading List:
M. Möser: Technische Akustik, 10. Aufl. Springer, 2015.
G. Müller, M. Möser (Hrsg.): Taschenbuch der Technischen Akustik, 3. Auflage, Springer, 2004.

Responsible for Module:
Seeber, Bernhard; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Technical Acoustics and Noise Abatement (Vorlesung, 4 SWS)
Seeber B, Yadav S, Azaripasand P, Bajool M
For further information in this module, please click campus.tum.de or here.

Module Description

EI7585: Clinical Applications of Computational Medicine | Clinical Applications of Computational Medicine

Version of module description: Gültig ab winterterm 2013/14

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 150	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
After three introductory lectures, the students work in small groups on different projects. Projects are focused on actual clinical applications from some of these areas: multiple sclerosis, obstetrics, cardiovascular disease, fall prevention/detection and sport medicine. The projects will be fixed in detail after the introductory lectures according to the special interests and expertise of the students and the resources. The work done in previous semesters are available at the website of the department to serve as orientation.
In general, a project encompasses these tasks: study design, data collection, algorithm development and validation, data analysis and summary of results.
Students should prepare a report (maximum 4 pages) including the details of their work as well as a set of slides for the final presentation. The The results will be presented to the audience and defended at the end of the semester. External guests are invited to attend and participate in the final presentation.
The quality of the written report, the presentation and the discussion contribute each as 1/3 of the final grade.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Analysis, classical mechanics, fundamentals in electrical engineering, basics in social psychology, basic knowledge of R/Matlab and statistics

Content:
Computational Medicine is a new scientific field in the intersection between mathematics, physics, biostatistics, computer science, electronics, biomedical engineering and medicine. We focus on actual clinical applications of complex, interdisciplinary solutions for problems in healthcare. Using examples from areas mostly from multiple sclerosis, obstetrics, cardiovascular disease, fall prevention/detection and sport medicine we will explore some of the following important aspects: data collection, biostatistical modelling, filtering, pattern recognition, alarms, prediction, validation, development & certification of web-based tools for clinical decision making.

Intended Learning Outcomes:
At the end of the module the students are able to understand the problems and key success factors for business models in computational medicine/telemedicine with examples in selected medical areas (multiple sclerosis, obstetrics, cardiovascular disease, fall prevention/detection, exercise therapy).
They are able to apply basic signal processing techniques to solve specific problems (filtering and analysis of data from mobile accelerometry/ECG). They also should be able to understand the scientific method to conduct exploratory research generating and testing hypothesis, looking at events, collecting data, analyzing information and reporting the results. In addition, it is expected that they improve their written and oral communications skills by the creation of a scientific report and holding a public presentation.

Teaching and Learning Methods:
Zunächst wir in einer Reihe von 3 Vorlesungen das Basiswissen zu den einzelnen Themen vermittelt. Darufhin erfolgt eine den Fähigeiten und Interessenslage angepassten Themenauswahl ("matching") zur Vertiefung. Kleingruppen (1-3 Studenten) führen mit entsprechender Unterstützung ein kleines Projekt durch, das am Ende präsentiert und diskutiert wird. Also ist die Lehr- und Lernmethode ein Mix aus Vorlesung, Seminar, Übung und Labor.

Media:
multimediale Präsentationen, ""hands-on"" Erfahrung mit Medizinprodukten/Messgeräten, interaktive OLAP-Web-Tools, Besuche bei Medizintechnikfirma/klinischen Partnern.

Reading List:
" Motl RW, Weikert M, Suh Y, Sosnoff JJ, Pula J, Soaz C, Schimpl M, Lederer C, Daumer M: Accuracy of the actibelt® Accelerometer for Measuring Walking Speed in a Controlled Environment among Persons with Multiple Sclerosis. Gait and Posture (2011 Sep 22. [Epub ahead of print])
" Schimpl M, Moore C, Lederer C, Neuhaus A, Sambrook J, Danesh J, Ouwehand W, Daumer M: Association between walking speed and age in healthy, free-living individuals using mobile accelerometry - a cross-sectional study. PLoS ONE 6(8): e23299. doi:10.1371/journal.pone.0023299
" Schimpl M, Lederer C, Daumer M: Development and validation of a new method to measure walking speed in free-living environments using the actibelt platform. PLoS ONE 6(8): e23080. doi:10.1371/journal.pone.0023080

" Scalfari A, Neuhaus A, Daumer M, Ebers GC, Muraro PA: Age and disability accumulation in Multiple Sclerosis. Neurology (published ahead of print September 14, 2011)
" Daumer M, Neuhaus A, Herbert J. Ebers G: Prognosis of the individual course of disease: the elements of time, hetereogeneity and precision, Journal of the Neurological Sciences 287: S50-S55, 2009
" Ebers G., Heigenhauser L., Daumer M., Lederer C., Noseworthy J.: Disability as an outcome in clinical trials . Neurology 71 (9), 624-631, 2008
" Daumer M, Held U, Ickstadt K, Heinz M, Schach S, Ebers G: Reducing the Probability of false positive Research Findings by pre-publication Validation Experience with a large Multiple Sclerosis Database. BMC Medical Research Methodology 8:18, 2008
" Schunkert, H. et al. for the Cardiogenics Consortium: Repeated Replication and a Prospective Meta-Analysis of the Association Between Chromosome 9p21.3 and Coronary Artery Disease. Circulation 117, 1675-1684, 2008
" Daumer M, Scholz M, Boulesteix AL, Pildner von Steinburg S, Schiermeier S, Hatzmann W, Schneider KTM: The Normal Fetal Heart Rate Study: Analysis Plan , Available at Nature Precedings http://precedings.nature.com/documents/980/version/2, 2007
" Daumer M., Neuhaus A., Lederer C., Scholz M., Wolinsky JS and Heiderhoff M.: Prognosis of the individual course of disease steps in developing a decision support tool for Multiple Sclerosis. BMC Medical Informatics and Decision Making 2007, 7:11
" Daumer M, Thaler K, Kruis E, Feneberg W, Staude G, Scholz M: Steps towards a miniaturized, robust and autonomous measurement device for the long-term monitoring of the activity of patients ActiBelt . Biomedizinische Technik, Biomedical Engineering 52: 149-55, 2007
" Noseworthy J., Kappos L., Daumer M.: Competing interests in Multiple Sclerosis research , The Lancet 361, S. 350f, 2003
" Daumer M.: Online Monitoring von Changepoints in: Biomedizinische Technik, 42, Ergänzungsband 2, Verlag Schiele und Schön, S. 214-215, 1998
" Daumer M., Nahm W., Scholz M., Dannegger F., Kochs E., Morfill G.: Konzept für eine internet-basierte Datenbank zur Unterstützung von Projekten in der Biosignalanalyse , Ergänzungsband Biomed Tech, 43 (3), S. 23-27, 1998

Responsible for Module:
Diepold, Klaus; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Clinical Applications of Computational Medicine (Vorlesung, 2 SWS)
Daumer M (Baumhoer R)
For further information in this module, please click campus.tum.de or here.

Module Description

EI7644: Communication Network Reliability | Communication Network Reliability [CNRel]

Version of module description: Gültig ab summerterm 2022

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module examination consists of a graded written exam of 90 minutes duration and an exercise on network reliability (simulation and analysis).
In the written exam students demonstrate by answering questions their theoretical knowledge of network reliability including the parameters, methodologies, and solutions. Students also demonstrate their ability to evaluate and analyse connection availiability and network reliability.
The capability for learning some particular topics more in detail will be examined through specific literature studies during the semester and the presentation of selected topics.
The final grade is composed of the following elements:
- 60% final exam
- 40% exercise of reliability.

Repeat Examination:
Next semester / End of Semester

(Recommended) Prerequisites:
The knowledge of following modules are recommended:
- Broadband Communication Networks

Content:
Introduction to network realiability and main concepts and parameters. Mathematical models (including failure and repair models). Basic span- and path- restoration techniques. Logical network desgn. Operational aspects of real-time restoration and self-organizing pre-planning agains failures. Restoration in IP networks. Techniques for mesh-restorable networks. p-Cycles. Dual-failure restorability and availability in mesh networks.

Intended Learning Outcomes:
Upon succesful completion of the module students gained an understanding of network reliability, and learn how to model and analyze connection availability and network reliability. Students also understand different protection and restoration techniques.

Teaching and Learning Methods:
Lectures, Presentation, Individual work

Media:
The following kinds of media are used:
- Presentations
- Lecture notes
- Exercises and solutions

Reading List:
The following books are recommended:
- “Mesh-based Survivable Transport Networks: Options and Strategies for Optical, MPLS, SONET and ATM Networking ” by Wayne D. Grover
- “Reliability of Computer Systems and networks” by L. Shooman

Responsible for Module:
Kellerer, Wolfgang; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Communication Network Reliability (Vorlesung mit integrierten Übungen, 4 SWS)
Mas Machuca C
For further information in this module, please click campus.tum.de or here.