HOCHSCHULE COBURG

Fakultät Angewandte Naturwissenschaften

Masterstudiengang

„Analytical Instruments, Measurement and Sensor Technology (AIMS)“

Module Guide

Status: Mai 2021

Inhalt

Courses Coburg University
30 ECTS in total

Programme:	*AIMS: Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Computer Based Measurement Technology**
Abbreviation, if any:	*CBMT*
Subtitle, if any:	--
Instruction events, if any:	--
Semesters:	*1 or 2*
Person responsible for the module:	*Prof. Dr. Conrad Wolf*
Lecturer:	*Prof. Dr. Conrad Wolf*
Language:	*English*
Assignment to the curriculum:	*obligatory*
Form of instruction/lecture hours per week:	*Seminar-based tuition (2 lecture hours per week)* *Computer exercises and lab experiments (2 lecture hours per week)*
Level of work:	*Tuition time: 60 hours* *Self-study: 120 hours*
Credit points:	*6*
Prerequisites:	*Introduction to electrical measurement technology, basic knowledge of a higher programming language*
Course objectives/skills:	*Knowledge and profound understanding of the fundamentals in computer-based data acquisition, networking, measurement data processing and evaluation (with emphasis on industrial measurement technology).* *Skill to implement measurement software with the graphical programming language LabVIEW.* *Skill to analyze measurement tasks and to design and implement solution concepts (selection of suitable equipment, programming, data analysis) in an industrial environment.*

Content:	Lecture: *Introduction* *Measurement basics, Electronic measurement, Computer-based measurement, Measurement chain* *Data sampling* *Computer numbers, Sample and hold, DAC, ADC, Measurement equipment, Sampling theory, Windowing* *Interfaces & protocols* *Classification* *Serial point-to-point connection (RS-232)* *Industrial fieldbus systems (Communication basics and layer model, PROFIBUS, CAN)* *Ethernet-based interfaces (Ethernet, TCP/IP, PROFINET, EtherCAT)* *Measurement data processing* *DFT, Digital filters, Cross-correlation, Digital feedback control* LabVIEW class: *Introduction* *LabVIEW development environment* *Control flow* *CASE, FOR, WHILE, Sequence, Scripting and formula nodes, Global and local variables* *Data types and structures*
	Arrays, Cluster, Waveform data, Graphs and charts, Strings *Structuring* *Sub-VIs* *File and Hardware I/O* *Basic file handling, Measurement instrumentation access* *Design Patterns* *State machine, Functional global variable, Producer and consumer Loops, Error handling, Timing* *Data Sockets* Experiments: *Remote control of a measurement instrument with LabVIEW via RS-232* *RS-232 interface parameters, MAX, virtual instrument* *Remote control of a DSO with LabVIEW* *SCPI commands, virtual instrument* *Recording of a Bode diagram with function generator and DMM* *GPIB, automated LabVIEW measurement routine* *Measurement of time signal and spectrum with DAQ board* *NI DAQmx, sampling theorem, aliasing, windowing*
Programme examination requirements:	*Written examination*
Media forms:	*Beamer and board/whiteboard,* *Electronic scripts and working documents,* *PCs with programming environment*

Literature:	*B. Buckman: Computer-based Electronic Measurement* *Prentice Hall (2001) G. D'Antona, A. Ferrero: Digital Signal Processing for Measurement Systems* *Springer (2005) R. Bishop: LabVIEW 2009 Student Edition* *Prentice Hall (2009) S. Sumathi, P. Serekha: LabVIEW Based Advanced Instrumentation Systems Springer (2007)*

Programme:	*AIMS: Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Sensor Technology**
Abbreviation, if any:	*ST*
Subtitle, if any:	--
Instruction events, if any:	--
Semesters:	*1 or 2*
Person responsible for the module:	*Prof. Dr. Michael Wick*
Lecturer:	*Prof. Dr. Michael Wick, Prof. Dr. Martin Springer, Josefine Schlemmer*
Language:	*English*
Assignment to the curriculum:	*obligatory*
Form of instruction/lecture hours per week:	*Lecture, seminar, laboratory experiments / 4 hours per week*
Level of work:	*Tuition time: 60 hours* *Self-study: 120 hours*
Credit points:	*6*
Prerequisites:	*Strong undergraduate background in physics and mathematics;* *Basic knowledge of electronics (AC circuits, amplifiers, measurement techniques)*
Course objectives/skills:	*Detailed knowledge about different sensor principles, their applications and limitations;* *Ability to select a suitable type of sensor for a specific application;* *Knowledge of current trends in sensor technology;* *Ability to integrate different sensors into a measurement system.* *Ability to solve measurement tasks with suitable sensors.*
Content:	*Lecture:* *Basic sensor principles:* • *Passive sensors (Resistive, capacitive, inductive sensors* • *Active sensors (Voltage, current and charge sources)* • *Transmission line sensors (Oscillators and sender/receiver configurations)* *Construction, function and applications of sensors.* *Typical applications of different sensor types.* *Laboratory experiments (10 per student), e.g.:* • *Position measurement (capacitive, GMR-, Hall, inductive, ultrasound, optical sensors)* • *Acceleration measurements (MEMS acceleration sensors, piezoelectric sensors)* • *Temperature and flow sensors (Coriolis flow meter, thermistors, thermocouples)*
Programme examination requirements:	*Written examination (closed book), laboratory experiment reports*
Media forms:	*Multi-media equipment, PC, visualizer, laboratory*

Literature:	*J. Fraden: Handbook of modern sensors. Springer, New York 2004* *W. Göpel, J. Hesse, J.N. Zemel (eds) : Sensors, A Comprehensive Survey. Vol. 1 – 8, Wiley-VCH, since 1989 :*

Programme:	*AIMS: Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Mathematical Data Analysis**
Abbreviation, if any:	*MDA*
Subtitle, if any:	--
Instruction events, if any:	--
Semesters:	*1 or 2*
Person responsible for the module:	*Prof. Dr. Martin Springer*
Lecturer:	*Prof. Dr. Martin Springer*
Language:	*English*
Assignment to the curriculum:	*obligatory*
Form of instruction/lecture hours per week:	*Lecture, exercises /4 hours per week*
Level of work:	*Tuition time: 60 hours* *Self-study: 120 hours*
Credit points:	*6*
Prerequisites:	• *Strong undergraduate background in mathematics* • *ability to apply standard methods of time series analysis and spectral analysis to real data by using MATLAB or R as software tools* • *basic understanding of the relevant concepts in statistics and probability theory and their application to samples of data*
Course objectives/skills:	• *Detailed knowledge of mathematical approaches to the analysis of data from time series measurements* • *Understanding of mathematical foundations of systems modelling*
Content:	*Probabilities* • *Distributions, density* • *Expectation value, variance* • *Joint distributions* • *Stationarity, ergodicity* • *Confidence intervals* *Time-series modelling* • *Introduction to random signals* • *Random processes* • *Box-Jenkins method* • *Auto-regressive moving-average (ARMA) models* • *Estimation of order and parameters of ARMA models* • *Seasonal time series models* *Correlation analysis* • *Linear regression* • *Auto-correlation function (ACF)* • *Partial auto-correlation function (PACF)* • *Cross-correlation function (CCF)* *Spectral analysis* • *Fourier transforms* • *Discrete Fourier transform* • *Power spectrum* • *Spectral theory of stationary processes*

	• *Estimation of spectrum for random and deterministic signals*
Programme examination requirements:	*Written examination*
Media forms:	*Blackboard, handout (PDF)*
Literature:	*Bendat, J.S., Piersol, A.G.: Random Data. Wiley, Hoboken 2010 (4. ed.)* *Derryberry, D.R.: Basic Data Analysis for Time Series with R. Wiley, Hoboken 2014* *Rice, J.A.: Mathematical Statistics and Data Analysis. Brooks/Cole, Andover 2007 (3. ed.)* *Woyczynski, W.A.: A First Course in Statistics for Signal Analysis. Birkhäuser, Boston 2006*

Programme:	*AIMS: Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Practical Project on Novel Applications**
Abbreviation, if any:	--
Subtitle, if any:	--
Instruction events, if any:	*Different venues*
Semester:	*1 + 3 (in the time October to March)*
Person responsible for the module:	*Prof. Dr. Michael Wick*
Lecturer:	*All professors participating in the AIMS program, guest lecturers, lecturers at conferences*
Language:	*English*
Assignment to the curriculum:	*obligatory*
Form of instruction/lecture hours per week:	*Topical lectures, conference participation, visit of industrial fairs, visit of companies, guest lectures, fulfilment of tasks at fairs (e.g. selection of suitable sensors for a given problem and corresponding suppliers), fulfilment of an own practical project combining electronics, software and hardware, individual dates, no regular lecture hours.*
Level of work:	*180 hours*
Credit points:	*6 points*
Prerequisites:	*Profound knowledge in sensor technology; Ability to work in a self-dependent way; Language skills sufficient for a written report and communication with partners from science and industry*
Course objectives/skills:	*Acquisition of a broad overview about different applications of sensors and recent developments* *Ability to understand the content and the context of conference contributions;* *Ability to write a well-structured and consistent report about contributions to conferences and the matter of scientific discussions as well as about visits of companies and of technical fairs;* *Ability to communicate with representatives of companies about novel products and applications in sensor technology* *Ability to fulfil the task of the practical project (project management, finding the right tools, components and devices to use, soldering, electrical and digital setups, problem solving, team work)*
Content:	*Participation at Nürnberg SPC-Drives Fair, interviews with exhibitors* *Participation in German History and Culture* *Visits at companies applying sensor and measurement systems* *Work on own practical project*
Programme examination requirements	*Written reports, oral and practical presentation, poster presentation*
Media forms:	*Conference equipment, PC, beamer and visualizer, posters, guided excursions, expositions*
Literature:	*Conference proceedings of the conferences outlined above.* *Information brochures and home pages of visited companies* *Information materials of companies provided at fairs, data sheets*

Programme:	*AIMS: Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Elective: Instrumentation for Nanoscience and Materials Design**
Abbreviation, if any:	
Subtitle, if any:	--
Instruction events, if any:	--
Semesters:	*1 or 2*
Person responsible for the module:	*Dr. Martin Schmid*
Lecturer:	*Dr. Martin Schmid*
Language:	*English*
Assignment to the curriculum:	*elective*
Form of instruct./lecture hours per week:	*Lecture, seminar / block lecture*
Level of work:	*Tuition time: 30 hours* *Self-study: 60 hours*
Credit points:	*3*
Prerequisites:	*Basic understanding of physics and chemistry concepts at undergraduate level.* *Basic mathematical skills at undergraduate level.*
Course objectives/skills:	*It is the objective of the course to acquaint the students with the instruments that are needed to understand and control materials on the nanoscale.* *In a first step, the students will learn about the physical and chemical properties that are of interest in the context of materials design (e.g. electronic band structures in thin film semiconductors). After completing this step, they will be able to identify, discuss and explain the relevant physical and chemical quantities for rationale materials engineering on the nanometer scale.* *In a second step the students will be familiarized with state-of-the-art instruments and research facilities that are used to measure the materials' properties discussed in the first part of the course. They will gain in-depth knowledge about the instruments that are used and will be able to critically discuss the results of individual measurements. They will be able to select the right combination of techniques for a given materials engineering problem at the nanoscale.* *In a final step, students will study examples, where the knowledge of the first parts is practically applied.*
Content:	• *Photoelectron Spectroscopies* • *Scanning Probe Techniques* • *Surface Science and Thin Film Techniques* • *Ultra-high Vacuum Technology* • *Materials for Industrial Scale Catalysis* • *Organic Electronics* • *Topological Insulators* • *Graphene*

Programme examination requirements:	*Written examination (closed book)*
Media forms:	*Multi-media equipment, PC, visualizer*
Literature:	*"Modern Techniques of Surface Science"* *D. P. Woodruff, 3rd Ed., Cambridge University Press 2016* *ISBN 978-1-107-02310-9* *"Surface Analysis – The Principal Techniques"* *Editors: J. C. Vickerman, I. S. Gilmore, 2nd Ed., Wiley,* *ISBN 978-0-470-01764-7* *"Surface Science Techniques"* *Editors: G. Bracco, B. Holst* *Springer Series in Surface Science 51,* *Springer Verlag Berlin Heidelberg 2013* *ISBN 978-3-642-34242-4*

Programme:	*AIMS: Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Elective: Methods of Instrumental Analysis**
Abbreviation, if any:	*MIA*
Subtitle, if any:	--
Instruction events, if any:	--
Semesters:	*1 or 2*
Person responsible for the module:	*Dr. Prof. Dr. Michael Wick*
Lecturer:	*Dr. Denise Müller-Friedrich, Prof. Dr. Klaus Ruthenberg, Josefine Schlemmer*
Language:	*English*
Assignment to the curriculum:	*Elective*
Form of instruction/lecture hours per week:	*Lecture and laboratory work / 4 hours per week*
Level of work:	*Tuition time: 60 hours* *Self-study: 120 hours*
Credit points:	*3*
Prerequisites:	--
Course objectives/skills:	*Learning aim: Thorough acquaintance with modern physico-chemical instrumental techniques (soft- and hardware) in separation science and the qualitative and quantitative analysis of stuff species like atoms, molecules, ions, in different materials and biological compounds.* *Taught competences: Familiarity with the principles of modern instrumental analysis* *Taught skills: Analytical problem solving; Experience with selected instrumental techniques*
Content:	• *Physico-chemical basics* • *Spectroscopical basics* • *Chromatographical basics* • *Atomic spectrometry* • *Molecular spectrometry* • *Chemical sensors* • *Applications in the following fields: environment, fuel, materials, archaeometry*
Programme examination requirements:	*Parallel oral tests, experiment reports and final examination*
Media forms:	*(Intra-)Net based information flow; Small group laboratory courses; seminaristic lecture style*
Literature:	*P. Atkins: Physical Chemistry, Oxford University Press* *G.W. Ewing: Instrumental Methods of Chemical Analysis, McGraw-Hill (New York etc.)* *R. Keller et al. (Eds.) : Analytical Chemistry, Wiley-VCH (Weinheim)* *R.M. Silverstein, F.X. Webster, D.J. Kiemle: Spectrometric Identification of Organic Compounds*

Programme:	*AIMS: Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Elective: Chemical Sensors**
Abbreviation, if any:	ChSe
Subtitle, if any:	--
Instruction events, if any:	--
Semesters:	*1*
Person responsible for the module:	*Prof. Dr. Gerd-Uwe Flechsig*
Lecturer:	*Dr. Denise Müller-Friedrich, Prof. Dr. Gerd-Uwe Flechsig, Josefine Schlemmer*
Language:	*English*
Assignment to the curriculum:	*Elective*
Form of instruction/lecture hours per week:	*Lecture and laboratory work / 2 hours per week*
Level of work:	*Tuition time: 30 hours* *Self-study: 60 hours*
Credit points:	*3*
Prerequisites:	--
Course objectives/skills:	*After having successfully completed the course, the students should* *• know the different chemical sensor concepts and their specific design features,* *• know the advantages and limitations of the sensor concepts on the basis of the theoretical knowledge of sensor principles, the materials used and sensor technologies,* *• be able to decide which sensor concept is suitable for which application*
Content:	*Various Chemical Sensor principles with specific selectivities and sensitivities have been developed as innovative tools due to the growing need of effective devices for the identification and quantification of chemical and biochemical substances for process control, environmental monitoring or medical investigations.* *The theoretical concepts of electrochemical sensors e.g. pH-sensors, ion-selective electrodes (ISEs) Lambda Probe, membrane-covered amperometric cells as well as novel sensor approaches like fiber optics and acoustic sensor devices are introduced with special emphasis on the materials used, their properties and of technological aspects related to sensor fabrication. The laboratory portion of the course compliments the lecture by providing a venue to practice current available techniques by using different chemical sensor types.*
Programme examination requirements:	*Parallel oral tests, experiment reports and final examination*
Media forms:	*(Intra-)Net based information flow; Small group laboratory courses; seminaristic lecture style*
Literature:	*Florinel-Gabriel Banica "Chemical Sensors and Biosensors: Fundamentals and Applications", Wiley VCH* *Gründler, Peter "Chemical Sensors: An Introduction for Scientists and Engineers", Springer Verlag* *Eggins, Brian R. "Chemical Sensors and Biosensors" , Wiley VCH* *P.W. Atkins, "Physical Chemistry", Wiley VCH* *Scientific journals: Sensors & Actuators: Chemical*

Programme:	*AIMS: Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Elective: Industrial Electronics – Reliability and Design for Safety of Sensing Chains**
Abbreviation, if any:	
Subtitle, if any:	--
Instruction events, if any:	--
Semesters:	*1 or 2*
Person responsible for the module:	*Prof. Dr. Marco Mugnaini*
Lecturer:	*Prof. Dr. Michael Wick*
Language:	*English*
Assignment to the curriculum:	*elective*
Form of instruct./lecture hours per week:	*Lecture, seminar / block lecture*
Level of work:	*Tuition time: 30 hours* *Self-study: 60 hours*
Credit points:	*3*
Prerequisites:	*Basic knowledge of electronics*
Course objectives/skills:	*The course will aim at providing the students with the knowledge of problem solving in the reliability context. Industrial cases as well as the most known and used database will be exploited to allow student to perform availability and safety design. Reliability aspects as well as availability can be implemented both during design and assessment phase. Students will be able to define the design criteria satisfying reliability requirements and assessment methods for retrofit purposes*.
Content:	• *Basic sensing principles* • *Basic reliability approach for sensors design* • *Reliability evaluation* • *Availability evaluation* • *Design for safety of sensing chains in industry* • *Safety in railways* *In the course the students will be challenged on the most important probability density functions to define the reliability fundamental law for any kind of component. Single and multi-configurations will be examined, and analytical solutions provided. Availability modelling will be supplied in complex configurations representative of industrial cases. Safety design according to IEC61508 basics will be addressed.*
Programme examination requirements:	*Written examination (closed book)*
Media forms:	*Multi-media equipment, PC, visualizer*
Literature:	*Reliability based design by S.S.Rao McGraw Hill* *Reliability Engineering A. Birolini Springer* *Microelectronics R.C. Jaeger T.n. Blalock Mc Graw Hill*

Programme:	*AIMS: Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Elective: Academic Reporting and Documentation**
Abbreviation, if any:	AcReDo
Subtitle, if any:	--
Instruction events, if any:	--
Semesters:	*3*
Person responsible for the module:	*Richard Fry*
Lecturer:	*Richard Fry*
Language:	*English*
Assignment to the curriculum:	*Elective*
Form of instruction/lecture hours per week:	*Lecture and practical exercises, 2 hours per week*
Level of work:	*Tuition time: 30 hours* *Self-study: 60 hours*
Credit points:	*3*
Prerequisites:	*Basic knowledge of scientific writing*
Course objectives/skills:	*Become acquainted with scientific writing on a researcher's level* *Knowing of different sorts of scientific writing* *Ability in using correct citation of different styles for different publications*
Content:	*How to plan and write a report for an experiment or a project* *How to write a thesis, expectations for a thesis at University of Coburg,* *Differences for different reports* *How to concept and prepare a scientific poster for a conference* *How to write a paper for a journal*
Programme examination requirements:	*Written examination (closed book), portfolio*
Media forms:	*Multi-media equipment, PC, visualizer, blackboard* *practical exercises, homework*
Literature:	*Rabinowitz, H., Vogel S. (Eds.): The Manual of Scientific Style. A Guide for Authors, Editors and Researchers,Elsevier professional, 2009 (ebook)* *http://www.ieee.org/conferences_ events/conferences/publishing/style_references_manual.pdf* *http://www.scientificstyleandformat.org/Home.html*

Programme:	*AIMS: Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Elective: Design of Experiments Introduction**
Abbreviation, if any:	*DoE I*
Subtitle, if any:	*Statistical design and Analysis of Experiments Mathematics and Programming*
Instruction events, if any:	--
Semester:	*3*
Person responsible for the module:	*Prof. Dr. Klaus Stefan Drese*
Lecturer:	*Prof. Dr. Klaus Stefan Drese*
Language:	*English*
Assignment to the curriculum:	*Elective*
Form of instruction/lecture hours per week	*Lecture, exercises, 2 hours per week*
Level of work:	*Tuition time: 30 h* *Self-study: 60 h*
Credit points:	*3 ECTS*
Prerequisites:	*Linear Algebra, Differential and Integral Calculus, Basic knowledge of statistics, basic programming skills*
Learning objectives /competences	***Technical skills:*** *Being able to apply statistics for data analysis* *Being able to utilize the computer statistical analysis, to visualize, interpret and communicate the results* *Being able to plan experiments, to identify well suited strategies and to select appropriate analysis methods prior to experiment execution* *Being able to identify the right statistical test and being able to execute and interpret those* *Understanding the relevance of empirical models and being able to develop own models with avoiding overfitting* ***Social skills:*** *Being able to organize in teams and to perform in a group DoE tasks/projects* *Being able to check other people planning/analysis/interpretation and to give an appropriate feedback*
Content:	*- Statistic Basics* *- Basics of Statistical tests (ANOVA, …)* *- Basic regression analysis* *- Basic planning of statistical experimentation planning (full factorial, fractional factorial, …)* *- Basics of empirical models*
Programme examination requirements:	*Written examination (with computer)*
Media forms:	*Multi-media equipment, PC, black board*

Literature:	*Lecture notes* *Montgomery, Douglas C. Design and analysis of experiments. John Wiley & sons, 2017.* *Toutenburg, Helge. Statistical analysis of designed experiments. Springer Science & Business Media, 2009. MASON, Robert L.; GUNST, Richard F.; HESS, James L. Statistical design and analysis of experiments: with applications to engineering and science. John Wiley & Sons, 2003.* *Oehlert, Gary W. A first course in design and analysis of experiments. 2010.* *Software: R, Excel, …*

Programme:	*AIMS: Analytical Instruments, Measurement and Sensor Technology*
Module designation:	***Elective: Optical Methods and Technologies***
Abbreviation, if any:	*OMT*
Subtitle, if any:	--
Instruction events, if any:	--
Semesters:	*1 or 2*
Person responsible for the module:	*Prof. Dr. Thorsten Uphues*
Lecturer:	*Prof. Dr. Thorsten Uphues*
Language:	*English*
Form of instruction/lecture hours per week:	*Lecture and lab, 2 hours per week*
Level of work:	*Tuition time: 30 h* *Self-study: 60 h*
Credit points:	*3 ECTS*
Prerequisites:	*Basic Mathematics, Linear Algebra, Calculus*
Course objectives/skills:	*This course will touch the basic principles of classical and gaussian optics, mathematical methods in optics and state-of-the- art developments in optical sensor technology, fiber technology and laser source development*
Content:	• *classical optics, gaussian optics,* • *mathematical methods in optics,* • *simple raytracing simulations,* • *optical sensor technologies,* • *basic principles in optical measurement: polarization, interference, absorption, excitation*
Programme examination requirements:	*accompanying written exercises*
Media forms:	*multi-media equipment, black board, powerpoint, zoom, moodle*
Literature:	*Hecht, E. (2002). Optics. San Francisco: Addison Wesley.* *Introduction to Modern Optics. (1990): Dover Publications.* *Reider, G. A. (2018). PHOTONICS: An introduction. SPRINGER.*

Programme:	*AIMS: Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Chinesisch/Deutsch**
Abbreviation, if any:	--
Subtitle, if any:	--
Instruction events, if any:	*Deutsch*
Semesters:	*1 oder 2*
Person responsible for the module:	*Dr. Inga Emmerling*
Lecturer:	*Regina Graßmann, Katharzyna Lisiewicz, Isabel Amberg, Frau von Erdmann*
Language:	*German*
Assignment to the curriculum:	*Obligatory for Chinese and international students*
Form of instruction/lecture hours per week:	*Seminar-based tuition / 4 lecture hours per week*
Level of work:	*Tuition time: 60 hours* *Self-study: 120 hours*
Credit points:	*6*
Prerequisites:	--
Course objectives/skills:	*The module aims to provide students with a basic usage of the German language:* *The student can understand and use familiar everyday expressions and very basic phrases aimed at the satisfaction of needs of a concrete type. He is able to introduce oneself and others and can ask and answer questions about personal details. The students learn to interact in a simple way.*
Content:	*vocabulary and grammar for self-presentation, name, work, numbers, vocabulary for other everyday topics such as money and shopping* *The following skills are trained:* • *Basic level grammar* • *Listening comprehension* • *reading comprehension* • *written and oral communication skills*
Programme examination requirements:	*Written and oral examination*
Media forms:	*Working templates, blackboard, role plays, songs, exercises, films*
Literature:	*Hueber: Themen 1 aktuell - Kursbuch+Arbeitsbuch; Ismaning, Deutschland, 2003.* *Coggle/Schenke: Willkommen! German Beginner's course, 2012 (Hodder Education,Hachette UK Company.* *Hueber: Alltag, Berug & Co. – Kursbuch+Arbeitsbuch; Ismaning, Deutschland, 2009 (Hueber Verlag)*

Modules at USST/SHANGHAI

Programme:	*AIMS: Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Nanometrology**
Abbreviation, if any:	*NM*
Subtitle, if any:	-
Instruction events, if any:	-
Semesters:	*1 or 2*
Person responsible for the module:	*Prof. Dr. YANG Hui*
Lecturer:	*Div.*
Language:	*English*
Assignment to the curriculum:	*obligatory*
Form of instruction/lecture hours per week:	*Seminar based tuition with several instrumental instructions / 4 lecture hours per week*
Level of work:	*Tuition time: 60 hours* *Self-study: 120 hours*
Credit points:	*6*
Prerequisites:	*Basic courses of physics, electronic and optics*
Course objectives/skills:	*Students should learn basic knowledge of various nano-measurement methods with understanding of the underlying interaction mechanisms, because these methods have been developed for special applications, some of them allow investigation and manipulation of nanostructures down to the atomic scale, targeted far beyond microscopy. They will learn how to analyse and design measurement process for different tasks. To achieve this purpose the students should also learn the knowledge about nanotechnology, a broad, highly interdisciplinary and still evolving field, one of most promising technology in the new century.* *1. Know the basic characteristic of nanoparticles including metal nanoparticles, nanotube, graphene and so on.* *2. Grasp micro-nano measurement technology and the fabrication technique.* *3. Grasp basic work principle of some typical optical microscope system like AFM, SEM and TEM.* *4. Know some advanced nanotechnology and its application.*
Content:	General introduction: *Principle of operation, instrumentation and probes of Scanning Tunneling Microscopy and Atomic Force Microscope and their instrumentation and analyses.* Introduction of Nanotechnology: *Include micro- and nanofabrication and stamping techniques for micro- and nanofabrication, MEMS/NEMS devices and applications. It will also introduce the basic knowledge of Carbon nanotubes and nanowires. An*

	important area is the fabrications and applications of MEMS/NEMS devices. *Chapter 1: Introduction of nano-technology* *History, development and prospect of nano-technology and science;* *Chapter 2: Characteristics of nano materials* *Definition, feature, and classification of nano materials; Introduce the basic knowledge of Carbon nanotubes and nanowires.* *Chapter 3: Measurement and analysis of nano-technology Micro- and nanofabrication and stamping techniques for micro- and nanofabrication (lithography)* *Chapter 4: MEMS/NEMS devices and applications;* *Chapter 5: Principle of operation, instrumentation and probes of Scanning Tunneling Microscopy and Atomic Force Microscope and their instrumentation and analyses;* *Chapter 6: Interferometer Measurement and Nano-positioning; Scatterometry*
Programme examination requirements:	*Written examination* *Grading: Final examination 70%+30% normal performance*
Media forms:	*Beamer and board/whiteboard, electronic scripts and working documents*
Literature:	*Handbook of Nanotechnology* *Editor-in-Chief Bharat Bhushan, Springer 2004*

Program:	*AIMS: Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Photoelectric Detection**
Abbreviation, if any:	*PD*
Subtitle, if any:	--
Instruction events, if any:	--
Semesters:	*1 or 2*
Person responsible for the module:	*Prof. YANG Hui*
Lecturer:	*Div.*
Language:	*English*
Assignment to the curriculum:	*Obligatory*
Form of instruction/lecture hours per week:	*Seminar-based tuition with several instrumental instructions / 4 lecture hours per week*
Level of work:	*Tuition time: 60 hours* *Self-study: 120 hours*
Credit points:	*6*
Prerequisites:	*Basic courses in electronics and optics*
Course objectives/skills:	*Photoelectric Detection is a kind of modern measurement technology. The purpose of this course is to make students know the basic theory how to convert electric signal into optic signal and how to convert optic signal into electric signal again. It is also very important to know the principle, characteristic and structure of photoelectric devices and elements and how to use them into the field of the detection.*
Content:	***General introduction:*** *Modern information technology, Photoelectric information technology, Photoelectric measurement, the basics of optics, the basics of circuits* ***Introduction to electric light conversion:*** *Including light–emitting diodes (LEDs), Laser diodes (LDs), superluminescent diodes (SLDs), Liquid crystal displays (LCDs), organic light-emitting diodes (OLEDs), polymer light-emitting diodes (PLEDs)* *Introduction to photoelectric conversion:* *Including MPT, photodiode, phototransistor, pyroelectric detector, Mercury Cadmium Telluride detectors, opto-isolators, CCD, PSD and so on.* *Introduction to technical applications of photoelectric detection*
Program examination requirements:	*Written examination*
Media forms:	*Beamer and board/whiteboard, LCD projection machine, PCs with ppt environment*
Literature:	• *Semiconductor Optoelectronics (MIT graduate level open course ware)*

Program:	*AIMS: Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Digital Signal Processing**
Abbreviation, if any:	*SP*
Subtitle, if any:	--
Instruction events, if any:	--
Semesters:	*1 or 2*
Person responsible for the module:	*Prof. Dr. YANG Hui*
Lecturer:	*Div.*
Language:	*English*
Assignment to the curriculum:	*obligatory*
Form of instruction/lecture hours per week:	*Lecture/ 4 hours per week*
Level of work:	*Tuition time: 60 hours* *Self-study: 120 hours*
Credit points:	*6*
Prerequisites:	*Basic mathematic knowledge, mathematic for engineers*
Course objectives/skills:	*Signal Processing, in particular Digital Signal Processing (DSP) is the discipline that studies the rules governing the behavior of discrete signals, as well as the systems used to process them. It also deals with the issues involved in processing continuous signals using digital techniques. The main advantage of digital systems in relevance to analog systems are high reliability for modifying the system`s characteristics, and low cost. For the reason explained above, the field of digital signal processing has developed so fast in the last decades that it has been incorporated into the graduate and undergraduate programs of virtually all universities.* *This course is aimed at equipping readers with tools that will enable them to design and analyze most digital signal processing systems.* *The building blocks for digital signal processing systems considered here are used to process signals which are discrete in time and in amplitude.*
Content:	*Discrete-time signal and system* • *Introduction* • *Discrete-time signal* • *Discrete-time system* • *Difference equations and time-domain response* • *Sampling of Continuous-time signals* *The z and Fourier transforms* • *Introduction* • *Definition of the z transform* • *Inverse z transform* • *Properties of the z transform* • *Transfer functions* • *Stability in the z domain* • *Frequency response* • *Fourier transform* • *Properties of the Fourier transform*

	Discrete transforms • *Introduction* • *Discrete Fourier transform* • *Properties of DFT* • *Digital filtering using the DFT* • *Fast Fourier transform* • *Other discrete transforms* • *Signal representations* *Digital filters* • *Introduction* • *Basic structures of nonrecursive digital filters* • *Basic structures of recursive digital filters* • *Digital network analysis* • *State-space description* *FIR filter approximations* • *Introduction* • *Ideal characteristics of standard filters* • *FIR filter approximation by frequency sampling* • *FIR filter approximation with windows function* • *Maximally flat FIR filter approximation* • *FIR filter approximation by optimisation* *IIR filter approximations* • *Introduction* • *Analog filter approximations* • *Continuous-time to discrete-time transformations* • *Frequency transformation in the discrete-time domain* • *Magnitude and phase approximation* • *Time-domain approximation* *Finite-precision effects* • *Introduction* • *Binary number representation* • *Product quantization* • *Signal scaling* • *Coefficient quantization* • *Limit cycles* *Multirate systems* • *Introduction* • *Basic principles* • *Decimation* • *Interpolation* • *Rational sampling-rate changes*
Program examination requirements:	*Written examination*
Media forms:	*Beamer, blackboard*
Literature:	• *Paulo S.R. Diniz, etc: Digital Signal Processing – system analysis and design, Cambridge University Press, 2002* • *Joyce Van de Vegte: Fundamentals of Digital Signal Processing, Cambridge University Press, 2002* • *A.V. Oppenheim & R.W. Schäfer: Discrete-time Signal Processing, Englewood Cliffs, NJ: Prentice-Hall, 1089*

Program:	*Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Elective: Optical Imaging and Image Processing Technologies**
Abbreviation, if any:	--
Subtitle, if any:	--
Instruction events, if any:	*Lectures, demonstration, programming lab, seminar*
Semesters:	*1 or 2*
Person responsible for the module:	*Prof. Pei Ma*
Lecturer:	*Prof. Pei Ma*
Language:	*English*
Assignment to the curriculum:	*optional*
Form of instruction/lecture hours per	*Lecture, programming, seminar, 2 hours per week*
Level of work:	*Tutorial time: 30 h Self-study: 60 h*
Credit points:	*3*
Prerequisites:	*Prior knowledge of some physics, optics, electronics and programing for engineering graduate students*
Course objectives/skills:	*The recent explosion of interest in minimally invasive medical diagnostics has been fueled in part by the development of novel optics, photonics and opto-electronics techniques, instrumentations, and computer-aided image processing methods. A large number of optically-based imaging and sensing diagnostics are now in use in both the research laboratory and medical clinic. In addition, pursuit of state of the art research in several biomedical engineering sub-fields requires a high level of sophistication in contemporary optical technologies. In this course, students will gain exposure to the most important optical imaging techniques. This course will also include sufficient reviews of classical and modern optics, and widely-used image processing methods. In addition, a number of topics will be covered representing areas undergoing rapid development and novel applications.* *Students will have the opportunity to learn and explore basic optics knowledge including ray optics, wave optics, scattering, interference, opto-electronics devices, such as light sources and detectors, optical imaging technologies including microscopy, optical coherence tomography, etc., and necessary image processing methods.*
Content:	*1. Ray Optics 2. Wave Optics 3. Scattering 4. Light Sources 5. Detectors 6. Microscopy 7. Interference 8. Optical Coherence Tomography*

	9. Image Processing - Basics *10. Image Processing - Advanced*
Intended learning outcomes	*Upon completion of this module the student should be able to* *1. Know the role of optics in biomedical diagnostic and therapy.* *2. Have a good understanding of the following contents: elastic and inelastic light scattering theory and biomedical applications, confocal and multiphoton microscopy, engineering design principles of optical instrumentation for medical diagnostics, design of minimally invasive spectroscopic diagnostics, light propagation and optical tomographic imaging in biological tissues.* *3. Be able to solve optics problems using ray tracing, matrix optics calculations and modeling of random photon activities.* *4. Be able to process images with Matlab.*
Programme examination requirements:	*Attending lectures, completing homework and programing lab reports.*
Method of Assessment	*30% Class participation* *20% Quiz* *20% Homework* *20% Programming reports* *10% Student lecture*
Media forms:	*PowerPoints,*
Literature:	*Essential reading:* *Course notes* *Recommended Reading:* *"Optical imaging devices new technologies and Applications" Ajit Khosla et al., CRC Press/Taylor & Francis Group, 2016* *"Biomedical optical imaging" James G. Fujimoto et al., Oxford University Press, 2012* *"Optical and Digital Image Processing - Fundamentals and Applications" Gabriel Cristobal et al., Wiley, 2011* *"Biomedical optics: principles and imaging" Lihong V. Wang et al., Wiley-Interscience, 2007*

Program:	*AIMS: Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Elective: Automotive Electronics and Simulation Testing**
Abbreviation, if any:	*AEST*
Subtitle, if any:	--
Instruction events, if any:	--
Semesters:	*1 or 2*
Person responsible for the module:	*Prof. Huang*
Lecturer:	*Prof. Huang*
Language:	*English*
Assignment to the curriculum:	*elective*
Form of instruction/lecture hours per week:	*Lecture/ 2 hours per week, lab session, seminar*
Level of work:	*Tuition time: 30 h* *Self-study: 60 h*
Credit points:	*3*
Prerequisites:	*Mathematics, physics, information technology, Electronics for engineering graduate students*
Course objectives/skills:	*The module aims to provide students with the up-to-date essential knowledge about electronic systems within a modern vehicle and modelling/simulation skills currently widely used in design and development of automotive electronic systems.* *Upon completion of this module the student should be able to:* *1. Understand the electronic architecture of a modern vehicle including various vehicle networks and structure of a Electronic Control Unit.* *2. Describe the principle of operation of a range of automotive sensors, and understand data acquisition system.* *4. Evaluate control systems objective and strategies, understand basic control theories.* *5. Employ computer tools in system modelling and simulation for vehicle control system design and analysis, i.e. MATLAB and SIMULINK.* *6. Understand model-based design and testing method.* *7. Understand diagnostics and advanced driver assistance systems.*
Content:	*1. Electrical architecture of a modern vehicle, vehicle network (CAN, LIN, Flexray, MOST).* *2. Automotive sensors, Data acquisition systems, Operational amplifiers.* *3. Electronic Control Units, Control principles and theories.* *4. Electronic Motor, Vehicle anti-lock brake control.* *5. Modelling and Simulink of an electric kart* *6. Model-based design and testing.* *7. Vehicle Electronic diagnostics.* *8. Advanced driver assistance systems, Hybrid*

	vehicles.
Programme examination requirements:	*coursework*
Media forms:	*Beamer, white/blackboard, PPT, PC lab with MALAB/SIMULINK*
Literature:	*Essential reading:* *1. Course notes* *Recommended Reading:* *2. Robert Bosch, "BOSCH Automotive Electrics – Automotive Electronics", 5th edition, JohnWiley &Sons Ltd.* *3. William B. Ribbens, "Understanding Automotive Electronics", Newnes - ISBN 0-2506-7008-8* *4. W. Bolton "Mechatronics – Electronic Control Systems in Mechanical and Electrical Engineering"* *5. John Turner, "Automotive Sensors"* *6. Tranter, A (2008) "Automotive Electrical and Electronic Systems" Haynes Techbooks ISBN 9781844252510*

Program:	*Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Elective: Internet of Things Design**
Abbreviation, if any:	IoT
Subtitle, if any:	--
Instruction events, if any:	*Lectures, demonstration, programming lab, seminar*
Semesters:	*1 or 2*
Person responsible for the module:	*YuGuo Sun*
Lecturer:	*YuGuo Sun*
Language:	*English*
Assignment to the curriculum:	*optional*
Form of instruction/lecture hours per	*Lecture, programing, seminar* *2 hours per week*
Level of work:	*Tuition time: 30 h* *Self-study: 60 h*
Credit points:	*3*
Prerequisites:	*Prior knowledge of some MCU, electronics and programming for engineering graduate students*
Course objectives/skills:	*The Internet of Things (IOT) is being widely used in the field of modern measurement and control industry practices. The teaching objectives and technical skills of this course are as follows:* • *Familiar with the three-tier architecture of the Internet of Things: the perception layer, the transport layer and the application layer.* • *Master the design method of three-tier architecture, including intelligent hardware design and TCP/IP Socket network programming* • *Accomplishment of a IoT-based monitoring system in a Wi-Fi network environment*
Content:	*1. The Introduction of IoT* *2. MEMS Sensor Principle: Accelerometer* *3. MEMS Sensor Principle: Gyroscope* *4. MEMS Sensor Principle: Pressure Sensor* *5. MCU C51 Programing: IDE & Sampling Demo* *6. MCU C51 Programing: Serial Communication* *7. Wi-Fi Wireless Module : AT Configuration* *8. NB-IoT Wireless Module: AT Configuration* *9. TCP/IP Programing: C++ Socket* *10. Cloud platform Data Sampling Instance*
Intended learning outcomes	*Upon completion of this module the student should be able to* • *Master the working principles of the MEMS accelerometer, gyroscope and pressure sensor* • *Master C51 Programming Technology of Signal Acquisition of MEMS Sensors* • *Master TCP/IP socket programming and cloud platform data sending method*

	• *Familiar with the methods of building a IoT monitoring system*
Program examination requirements:	*Attending lectures, completing homework and programing lab reports.*
Method of Assessment	*30% Class participation* *20% Quiz* *20% Homework* *20% Programing reports* *10% Student lecture*
Media forms:	*PowerPoints*
Literature:	*Essential reading:* *Course notes* *Recommended Reading:* *Handout by Instructor*

Programme:	*AIMS: Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Chinese/German**
Abbreviation, if any:	--
Subtitle, if any:	--
Instruction events, if any:	*Chinese (Mandarin)*
Semesters:	*1 or 2*
Person responsible for the module:	*Dr. Inga Emmerling*
Lecturer:	*Frau Nan Nan*
Language:	*Chinese (Mandarin)*
Assignment to the curriculum:	*Obligatory for German students*
Form of instruction/lecture hours per week:	*Seminar-based tuition / intensive block course*
Level of work:	*Tuition time: 60 hours* *Self-study: 120 hours*
Credit points:	*6*
Prerequisites:	--
Course objectives/skills:	*Basic understanding of Mandarin. Language structure, listening and speaking, understanding of important characters.* *The students shall be able to perform basic communications in daily life affairs in Mandarin and shall be able to read simple texts.*
Content:	*Basics of Mandarin: vocabulary and grammar for self-presentation, name, work, numbers, vocabulary and grammar for Chinese cooking and visiting a restaurant, time and appointments, money and shopping*
Programme examination requirements:	*Written and oral examination*
Media forms:	*Working templates, blackboard, role plays, songs, exercises, films*
Literature:	*Beijing language and culture university press: New practical Chinese reader workbook, Beijing, China, 2012*

Courses at Siena University

Students chose 24 technical credit points (ECTS) plus 6 ECTS languages

Programme:	*AIMS: Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Modern Communication Technologies for 5G and Beyond**
Abbreviation, if any:	*MCT 5G*
Subtitle, if any:	--
Instruction events, if any:	--
Semester:	*Summer Semester*
Person responsible for the module:	*Prof. Dr. Michael Wick*
Lecturer:	*Prof. Dr. Andrea Abrardo*
Language:	*English*
Assignment to the curriculum:	*1 or 2*
Form of instruction/lecture hours per week	*6 hours per week*
Level of work:	*Tuition time: 72 h* *Self-study: 153 h*
Credit points:	*9 Credits*
Prerequisites:	*Basic knowledge of digital communications*
Learning objectives /competences	*Understanding the evolution of cellular communications towards the 5G revolution, capable of providing an holistic vision of communications of the future, from the possibility of integrating billions of low energy consumption nodes in small areas, to the possibility of providing ultra-low latency communications for emerging services, such as self-driving cars.* *Apply basic techniques in modern digital communications and optimization to the problem of radio resource optimization in 5G new radio. Familiarize with real 5G scenarios realized in the first practical implementation of 5G in the area of Milan.*
Content:	*Introduction to wireless communication systems and cellular communications.* *The 5G revolution: holistic vision of digital communications. 5G scenarios, Massive Machine-to-Machine communications (smart cities, smart industry), Enhanced Mobile Broadband (gaming, UHD videos), Ultra-reliable Low Latency communications (self driving cars, tactile internet).* *5G New-radio, Massive MIMO systems, Flexible OFDM, Interference cancelation.* *Radio Resource Management for 5G. Heterogeneous architectures, Macro-cells, Micro and Femto cells, Device to device communications, options for centralized and distributed resource allocations. Scheduling options for New radio with flexible frame structure.* *Study of the implementation of use cases and scenarios in a real 5G network.*
Programme examination requirements:	*Oral examination and written report*

Media forms:	*Frontal lessons, compilation of a final report with an analysis of the implementation of a use case in a real 5G network.*
Literature:	*[1] 5G NR: The Next Generation Wireless Access Technology. Erik Dahlman, Stefan Parkvall, Johan Sköld.*

Programme:	*Master AIMS*
Module designation:	**Digital Embedded Electronics for Smart Industry**
Abbreviation, if any:	*DEESI*
Subtitle, if any:	--
Instruction events, if any:	--
Semester:	*Summer Semester*
Person responsible for the module:	*Prof. Dr. Michael Wick*
Lecturer:	*Prof. Dr. Tommaso Addabbo*
Language:	*English*
Assignment to the curriculum:	*1 or 2*
Form of instruction/lecture hours per week	*lectures and laboratory activity*
Level of work:	*Tuition time: 72 hours* *Self study: 153 hours*
Credit points:	*9 Credits*
Prerequisites:	*Fundamentals of computer science and electronics*
Learning objectives/competences	*This module gives the students the opportunity to get a professional edge by learning how to design industrial measurement systems (mixed-signal hardware + software) aiming at the following technical goals:* *- Design of automated and/or remotely controlled measurement systems.* *- Design of high-bandwidth signal processing units equipped with digital hardware accelerators (FPGAs, SoCs), for real-time measurements and control applications.* *- Review of measurement data coding and transmission techniques*
Content:	*Design of real-time and non-real-time digital signal processing units; design of remotely controlled measurement systems; review of information coding and transmission methods suitable for the design of industrial distributed measurement systems; design of high bandwidth information processing digital hardware accelerators based on FPGAs, for real-time measurement and control applications. Introduction to Systems on Chips. Graphical programming concepts: introduction to LabVIEW, design techniques and features. Virtual Instruments (VIs) and hardware interfaces to perform prototype testing, data acquisition, instrumentation control, datalogging, measurement analysis and report generation applications. Advanced VI design techniques: VI Server and object-oriented programming, deterministic real-time systems. Introduction to LabVIEW FPGA to extend LabVIEW to field-programmable gate array (FPGA) applications that run on reconfigurable I/O hardware.*
Programme examination requirements:	*Final design project with oral discussion*
Media forms:	*Frontal lessons, lab exercises*
Literature:	*The course material will be provided by the lecturer during the course.*

Programme:	*Master AIMS*
Module designation:	**Sensors and Microsystems**
Abbreviation, if any:	*SeMi*
Subtitle, if any:	--
Instruction events, if any:	--
Semester:	*Summer Semester*
Person responsible for the module:	*Prof. Dr. Michael Wick*
Lecturer:	*Prof. Dr. Ada Fort*
Language:	*English*
Assignment to the curriculum:	*1 or 2*
Form of instruction/lecture hours per week	*lectures and laboratory activity*
Level of work:	*Tuition time: 48 hours* *Self-study: 102 hours*
Credit points:	*6 Credits*
Prerequisites:	*Fundamental of physics, mathematics, circuit analysis, analog electronics*
Learning objectives /competences	*To learn how to design and test electronic systems and measurement systems based on sensors.*
Content:	*-Basics of sensors and sensing systems. Linear models by generalized lumped parameter networks in thermal and mechanic domains.* *-Basics on sensor technology. Micro-machining technology.* *-Resistive sensors (for temperature, strain, optical flux, gas concentration, flow). Front-end circuits forresistive sensors (Wheatstone bridge, instrumentation and differential amplifier). Low frequency-low amplitude measurement problems.* *-Reactive sensors (for position, humidity, temperature). Front-end circuits for reactive sensors.* *(AC measurement circuits, amplifiers for high impedance sources, carrier amplifiers).* *-Thermocouples and integrated temperature sensor.* *-Piezoelectric sensors (vibration).* *-Piezoelectric transducers (ultrasound). Front end circuit for piezoelectric transducers (charge amplifier). Noise in piezoelectric transducers.* *-Basics of optical measurement systems and sensors.* *-Excitation circuits for AC sensors: oscillators.* *-Filtering: basics of design of analog filters, digital filters principles.*
Programme examination requirements:	*Oral exam. The student must be able to discuss structures and applications of those sensors discussed during the course, including both the theory needed to explain their functioning and the design of suitable front-end electronics*
Media forms:	*Frontal lessons,*

Literature:	*[1] Principles of measurement systems, J.P. Bentley, Prentice Hall-IV Edition-2005* *[2] Appunti del docente* *Advanced readings:* *Electronic Circuits Design and Applications - U.Tietze, Ch. Schenk Ed: Springer-Verlag*

Programme:	*Master AIMS*
Module designation:	**Mobile Communications and IoT**
Abbreviation, if any:	*MC IoT*
Subtitle, if any:	--
Instruction events, if any:	--
Semester:	*Summer Semester*
Person responsible for the module:	*Prof. Dr. Michael Wick*
Lecturer:	*Prof. Dr. Alessandro Andreadis*
Language:	*English*
Assignment to the curriculum:	*Technical ECTS*
Form of instruction/lecture hours per week	*lectures and laboratory activity*
Level of work:	*Tuition time: 48 hours* *Self study: 102 hours*
Credit points:	*6 Credits*
Prerequisites:	*Basic knowledge of telecommunication networks and TCP and IP controls*
Learning objectives /competences	*To deeply understand the main wireless and mobile communication technologies, their functioning principles and the concepts of mobility and portability to achieve a good knowledge about the paradigm of Internet of Things and of their related technologies.*
Content:	*Fundamentals on wireless and mobility.* *Wide area networking: 2G, 3G, 4G cellular systems.* *2G: details on GSM system. Network architecture, radio interface, functioning examples and signaling (user calls, localization). Security in GSM communications.* *Data communications with cellular systems, HSCSD. GPRS system: network architecture and radio channels.* *Evolution towards 3G systems. 3G systems: UMTS. UMTS architecture, details on radio interface (UTRAN), CDMA. Evolution towards 4G systems: HSPA, LTE. 4G systems, LTE-A (e-UTRAN). Local area networks: Wireless LAN (WLAN). IEEE 802.11 Standard. Architecture and services. Physical and MAC layer, access method to the wireless channel. Frame types and format. WLAN security: WEP, WPA and WPA2 (IEEE 802.11i). Personal area networks: Wireless PAN (WPAN).* *Bluetooth details. Mobility at network level: Mobile IP and micromobility (Cellular IP). Mobility at transport level. Basics on TCP, congestion control and problems on TCP over wireless/mobile communications. TCP modifications for better performance over wireless/mobile networks.* *Internet of Things: introduction, smart objects, IoT technologies, architecture of IoT node, Machine to Machine (M2M) communication. Wireless technologies for local and wide IoT connectivity (Bluetooth Low Energy, WiFi, RFID, NFC, 802.15.4, Zigbee,...). Low Power Wan Networks (LPWAN), LoRa/LoRaWAN.*

	Laboratory activity, complete configuration and implementation example of an IoT node and sensor data communication to an application server. (Arduino board, LoRaWAN,..). *Laboratory exercises on IoT.*
Programme examination requirements:	*Oral discussion about the course topics*
Media forms:	*Power points, blackboard*
Literature:	*[1] Jochen Schiller: 'Mobile communications' - 2 ed., Addison Wesley, 2003.* *[2] J. P. Vasseur and A.Dunkels, `Interconnecting Smart Objects with IP,`Morgan Kaufmann, 2010.* *[3] William Stallings: "Wireless Communications & Networks" (2nd Edition), Pearson Education, 2011.* *Other reference books can be communicated during lectures.*

Programme:	*Master AIMS*
Module designation:	**Cybersecurity**
Abbreviation, if any:	*CS*
Subtitle, if any:	--
Instruction events, if any:	--
Semester:	*Summer Semester*
Person responsible for the module:	*Prof. Dr. Michael Wick*
Lecturer:	*Prof. Dr. Mauro Barni*
Language:	*English*
Assignment to the curriculum:	*Technical ECTS*
Form of instruction/lecture hours per week	*lectures and laboratory activity*
Level of work:	*Tuition time: 54 hours* *Self-study: 96 hours*
Credit points:	*6 Credits*
Prerequisites:	*Basic elements of calculus, probability theory, digital networks, image processing*
Learning objectives /competences	*Protecting the digital ecosystem that surrounds us and plays a more and more essential part in our lives is a pressing need that modern society can no longer ignore. The discipline studying the tools and technology that can be used to this aim is usually, and rather vaguely, referred to as cybersecurity. Such a term broadly encompasses a wide and diverse set of techniques including classical cryptographic tools, security protocols for user authentication, end-to-end communication, network monitoring and protection, intrusion detection, malware recognition, authentication and protection of multimedia contents. In this framework, the goal of this course is to give a snapshot of some of the most common threats and security measures affecting end-to-end communications and networks, especially wireless networks. The first part of the course focuses on cryptography, since cryptographic tools are the main ingredient behind most security protocols and information protection systems. Then the course passes to review the main threats to cyber-systems and present the main classes of countermeasures security engineers can take to defend against the cyber-threats. In the second part of the course, the concepts introduced in the first part are put at work in the context of communication security. Rather than attempting to provide a comprehensive treatment, which would be impossible within the time limit of the course, the students will be involved in laboratory activities according to the "learn by doing" paradigm. The laboratory activity will focus on some of the hottest security threats and countermeasures including authentication, application and transport layer security, wireless security.* *The third and last part of the course will adopt a different perspective and introduce the students to the problems related to the protection of multimedia contents, including*

	methods for copyright protection, media authentication and covert communication by means of image steganography.
Content:	*Foundations of Cryptography. This section aims at introducing the students to the basic concepts underlying modern cryptography. Basic concepts and definitions: Cryptanalysis and security models; Symmetric encryption (Block ciphers, DES, AES, Stream ciphers, Key distribution); Asymmetric cryptography (Basic concepts, trapdoor functions, Some popular public-key cryptosystems: RSA); Key distribution: Diffie-Helman key exchange protocol; Authentication (MAC functions, Hash functions, Digital signatures, Random Number generators, Signal and information processing in the encrypted domain, Application to privacy protection). Computer Security. This section puts in practice the cryptographic tools developed in the previous sections and enlarges the horizon to discuss several classes of threats against cybersystems and to present possible countermeasures: User authentication (Password-Based Authentication, Token-Based Authentication, Biometric Authentication, Remote User Authentication); Access control (Basic principles, Discretionary Access Control, Role-Based Access, Control, Attribute-Based Access Control); Malicious Software (Malware) (Classification of Malware, Propagation mechanisms, Payloads, Countermeasures); Denial of Service (DoS) attacks (Classification of DoS, Distributed DoS attacks, Defenses); Intrusion detection and prevention (Host-based intrusion, detection, Network-based intrusion detection, Firewalls). Secure Communications. This section involves the student with laboratory activity, according to the “learning by doing" paradigm: End point authentication (type of attacks: spoofing, playback, man in the middle, countermeasures: nonces, cryptography, certificates); Application layer security (how to secure e-mails, PGP and GPG examples); Traffic analyzers and packet sniffers (tools to sniff, capture and analyse packets, lab exercises on the use of Wireshark traffic analyser); Transport layer security (secure TCP connections, SSL/TLS details); Wireless LANs security (WI-FI (WEP, WPA, WPA2, IEEE_802.11i), How to hack WLAN security); Deep Web, Dark Web: main concepts, keeping anonymous your Internet traffic; Crypto-currencies: blockchain and the Bitcoin. Multimedia Security. This section introduces the problems related to the protection and authentication of multimedia contents. The basic concepts will be illustrated by means of laboratory experiments: Data hiding and watermarking; Steganography;*

	Steganalysis; Multimedia Forensics (Source identification, Tampering detection).
Programme examination requirements:	*Oral discussion regarding the theoretical aspects of the course and the laboratory experiments*
Media forms:	*Frontal lessons*
Literature:	*[1] W. Stallings, Cryptography and Network Security, Mc Graw Hill, 4-th edition* *[2] Notes of the course, available at: http://clem.dii.unisi.it/~vipp/cybersecurity.html* *[3] Additional notes provided during the course by the lecturers*

Programme:	*AIMS: Analytical Instruments, Measurement and Sensor Technology*
Module designation:	**Italian/German**
Abbreviation, if any:	--
Subtitle, if any:	--
Instruction events, if any:	
Semesters:	*1 or 2*
Person responsible for the module:	*Dr. Inga Emmerling*
Lecturer:	
Language:	*Italian/German*
Assignment to the curriculum:	*Voluntary for international/German students*
Form of instruction/lecture hours per week:	*Seminar-based tuition / intensive block course*
Level of work:	*Tuition: 60 hours* *Self-study: 120 hours*
Credit points:	*6*
Prerequisites:	--
Course objectives/skills:	*Basic understanding of Italian or German. Language structure, listening and speaking, understanding of written text.* *The students shall be able to perform basic communications in daily life affairs in Italian and shall be able to read simple texts.*
Content:	*Basics of Italian: vocabulary and grammar for self-presentation, name, work, numbers, vocabulary and grammar for Italian cooking and visiting a restaurant, time and appointments, money and shopping or German on the respective level*
Programme examination requirements:	*Written and oral examination*
Media forms:	*Working templates, blackboard, role plays, songs, exercises, films*
Literature:	