
# Module Handbook

for the study program

# Mechatronic Systems Engineering B.Sc.

Note: Due to the current pandemic situation, corona-related changes in assessment formats may occur. These will be communicated by the lecturer via Moodle

Kleve, Rev. 2 October 2020

# Content

# Curriculum Mechatronic Systems Engineering B.Sc

| Curriculum MSE | | HPW | Type | | | | | | Examination form | | CP | HPW | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | V | SL | S | Ü | Pra | Pro | Attestation | graded | | WS1 | SS2 | WS3 | SS4 | WS5 | SS6 | WS7 |
| **1st Semester** | | | | | | | | | | | | | | | | | | |
| 2000 | Introductory Mathematics | 8 | 5 | | | 3 | | | | x | 8 | 8 | | | | | | |
| 2008 | Statics and Strength of Materials | 4 | 2 | | | 2 | | | | x | 5 | 4 | | | | | | |
| 2011 | Programming | 4 | 2 | | | | 2 | | x | x | 5 | 4 | | | | | | |
| 2013 | Business Economics & Project Management | 4 | 3 | | | | 1 | | x | | 5 | 4 | | | | | | |
| 2305 | Fundamentals of Electrical Engineering | 4 | 2 | | | 1 | 1 | | x | x | 5 | 4 | | | | | | |
| 2900 | Introduction to Engineering | 3 | 2 | | 1 | | | | x | | 3 | 3 | | | | | | |
| **2nd Semester** | | | | | | | | | | | | | | | | | | |
| 2001 | Applied Mathematcis | 8 | 5 | | | 3 | | | | x | 7 | | 8 | | | | | |
| 2009 | Advanced Strength of Materials | 4 | 2 | | | 2 | | | | x | 5 | | 4 | | | | | |
| 2012 | Advanced Programming | 4 | 2 | | | | 2 | | x | x | 5 | | 4 | | | | | |
| 2304 | Analog Electronics | 4 | 2 | | | 1 | 1 | | x | x | 5 | | 4 | | | | | |
| 2701 | Engineering Drawing and Design | 4 | 2 | | | 1 | 1 | | x | x | 5 | | 4 | | | | | |
| 2706 | Manufacturing Technology | 4 | 3 | | | 1 | | | | x | 5 | | 4 | | | | | |
| **3rd Semester** | | | | | | | | | | | | | | | | | | |
| 2010 | Dynamics | 4 | 2 | | | 2 | | | | x | 5 | | | 4 | | | | |
| 2108 | Materials and Testing | 4 | 2 | | | 1 | 1 | | | x | 5 | | | 4 | | | | |
| 2306 | Microcontroller | 4 | 2 | | | | 2 | | x | x | 5 | | | 4 | | | | |
| 2705 | Engineering Design | 4 | 2 | | | 2 | | | | x | 5 | | | 4 | | | | |
| 2708 | Thermodynamics | 4 | 2 | | | 1 | 1 | | | x | 5 | | | 4 | | | | |
| 2901 | Drives & Power Electronics | 4 | 2 | | | 2 | | | | x | 5 | | | 4 | | | | |
| **4th Semester** | | | | | | | | | | | | | | | | | | |
| 2002 | Numerical Mathematics | 4 | 3 | | | 1 | | | | x | 5 | | | | 4 | | | |
| 2311 | Embbeded Systems | 4 | 2 | | | | 2 | | | x | 5 | | | | 4 | | | |
| 2902 | System Theory and Controls | 4 | 2 | | | 1 | 1 | | | x | 5 | | | | 4 | | | |
| 2904 | Modelling and Simulation | 4 | 2 | | | | 2 | | | x | 5 | | | | 4 | | | |
| | **Focus Field (see catalogue individual subjects: Focus Fields)** | | | | | | | | | | | | | | | | | |
| | Focus Field Subject 1 | 4 | | | | | | | | | 5 | | | | 4 | | | |
| | Focus Field Subject 2 | 4 | | | | | | | | | 5 | | | | 4 | | | |
| **5th Semester** | | | | | | | | | | | | | | | | | | |
| 2014 | Cross-Cultural Management and Creativity | 4 | 2 | | | 2 | | | x | | 5 | | | | | 4 | | |
| 2015 | Group Project | 1 | | | | | | 1 | x | | 5 | | | | | 1 | | |
| 2903 | Controls | 4 | 2 | | | 1 | 1 | | | x | 5 | | | | | 4 | | |
| 2907 | Sensors and Actuator Networks | 4 | 2 | | | 1 | 1 | | | x | 5 | | | | | 4 | | |
| | **Focus Field (see catalogue individual subjects: Focus Fields)** | | | | | | | | | | | | | | | | | |
| | Focus Field Subject 3 | 4 | | | | | | | | | 5 | | | | | 4 | | |
| | Focus Field Subject 4 | 4 | | | | | | | | | 5 | | | | | 4 | | |
| **6th Semester** | | | | | | | | | | | | | | | | | | |
| 2016 | Internship / Semester abroad | | | | | | | | x | | 30 | | | | | | | |
| **7th Semester** | | | | | | | | | | | | | | | | | | |
| 2017 | Bachelor Thesis | | | | | | | | | x | 12 | | | | | | | |
| 2018 | Colloquium | | | | | | | | | x | 3 | | | | | | | |
| 2510 | Technology and Innovation Management | 4 | 2 | | | | 2 | | | x | 5 | | | | | | | 4 |
| 2512 | Entrepreneurship | 2 | | | | | | 2 | x | | 2 | | | | | | | 2 |
| | Elective (see catalogue individual subjects: Electives) | 3 | | | | | | | | | 5 | | | | | | | 3 |
| | | **133** | **V** | **SL** | **S** | **Ü** | **Pra** | **Pro** | **Attestation** | **graded** | **210** | **27** | **28** | **24** | **24** | **21** | | **9** |
| **Overview** | | **HPW** | **Type** | | | | | | **Examination form** | | **CP** | **WS1** | **SS2** | **WS3** | **SS4 HPW** | **WS5** | **SS6** | **WS7** |

| Catalogue Individual Subjects MSE | | HPW | Type | | | | | | Examination form | | CP | HPW | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | V | SL | S | Ü | Pra | Pro | Attestation | graded | | WS1 | SS2 | WS3 | SS4 | WS5 | SS6 | WS7 |
| **Focus Fields */**/***/**** ** | | | | | | | | | | | | | | | | | | |
| | **Focus Field Simulation in Mechatronics** | **16** | **8** | | | **5** | **3** | | | | **20** | | | | **8** | **8** | | |
| 2710 | Fluid Mechanics | 4 | 2 | | | 1 | 1 | | | x | 5 | | | | 4 | | | |
| 2908 | Multibody Dynamics | 4 | 2 | | | 2 | | | | x | 5 | | | | 4 | | | |
| 2309 | Object-oriented Programming | 4 | 2 | | | | 2 | | | x | 5 | | | | | 4 | | |
| 2905 | Finite Element Method | 4 | 2 | | | 2 | | | | x | 5 | | | | | 4 | | |
| | **Focus Field Applied Mechatronics (ME focus)** | **16** | **8** | | | **5** | **3** | | | | **20** | | | | **8** | **8** | | |
| 2710 | Fluid Mechanics | 4 | 2 | | | 1 | 1 | | | x | 5 | | | | 4 | | | |
| 2909 | Vehicle Technology | 4 | 2 | | | 1 | 1 | | | x | 5 | | | | 4 | | | |
| 2717 | Mobile Hydraulics | 4 | 2 | | | 1 | 1 | | | x | 5 | | | | | 4 | | |
| 2910 | Robotics | 4 | 2 | | | 2 | | | | x | 5 | | | | | 4 | | |
| | **Focus Field Applied Mechatronics (EL focus)** | **16** | **8** | | | **4** | **4** | | | | **20** | | | | **8** | **8** | | |
| **2303** | **Digital Electronics** | **4** | **2** | | | **1** | **1** | | x | x | 5 | | | | 4 | | | |
| **2912** | **Optical Systems** | **4** | **2** | | | **1** | **1** | | | x | 5 | | | | 4 | | | |
| **2308** | **Signal Transmission** | **4** | **2** | | | **1** | **1** | | | x | 5 | | | | | 4 | | |
| 2314 | Practical Electronics | 4 | 2 | | | **1** | **1** | | | x | 5 | | | | | 4 | | |
| **Electives** | | | | | | | | | | | | | | | | | | |
| 2020 | Foreign Language | | | | | | | | x | | 5 | | | | | | | |
| 2021 | Module from any other Bachelor study course HSRW | | | | | | | | x | x | 5 | | | | | | | |
| 2911 | Introduction to Scientific Methods in Mechatronics | 2 | 1 | | | | 1 | | | x | 5 | | | | | | | 2 |

Explanations / Conditions

* Die Fakultät behält sich das Recht vor, sowohl eine Mindestteilnehmerzahl für das Zustandekommen eines Faches im Fokusfeld / Wahlbereich als auch eine Maximalteilnehmerzahl festzulegen. Die Möglichkeit des Erreichens der vorgeschriebenen Kreditpunktanzahl aus dem

** Aus dem Wahlbereich können mit dem Einverständnis des Prüfungsausschusses der Fakultät Technologie und Bionik auch Fächer mit einem Gesamtumfang von 5 Kreditpunkten aus dem gesamten Bachelor-Studienangebot der Hochschule Rhein Waal gewählt werden / As elective a maximum of 5 CP can be chosen with the consent of the examination committee of the faculty Technology and Bionics from any Bachelor study programme at the Rhine-Waal University of Applied Science.

*** Die Fakultät Technologie und Bionik behält sich das Recht vor, das Fächerangebot im Wahlbereich zu ändern / The faculty Technology and Bionics reserves the right to change the catalogue of electives.

**** Aufgrund von stundenplantechnischen Randbedingungen ist nicht auszuschließen, dass Fächer verschiedener Fokusfelder sowie Fächer des Wahlbereichs zeitgleich angeboten werden / Due to time tabling constraints subjects from different focus fields and electives may be

Abbreviations

HPW Semesterwochenstunden / hours per week
CP Kreditpunkte / credit points
V Vorlesung / lecture
SL Seminaristische Vorlesung / seminar lecture
S Seminar / seminar
Ü Übung / exercise
Pra Praktikum / practical work
Pro Projekt / project
WSx Wintersemester / winter semester
SSx Sommersemester / summer semester

## 2000 Introductory Mathematics

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|---|---|---|
| Module name/Module code: | Introductory Mathematics | 2000 |
| Degree: | Biomaterials Science:<br>Electrical and Electronics Engineering:<br>Industrial Engineering:<br>Mechanical Engineering:<br>Mechatronic Systems Engineering: | BMS 1 2000<br>EL 1 2000<br>IE 1 2000<br>ME 1 2000<br>MSE 1 2000 |
| Module coordinator: | Prof. Dr. A. Kehrein | |
| Lecturer: | Dr. T. Camps<br>Prof. Dr. A. Kehrein | |
| Language: | English | |
| Place in curriculum: | Core | |
| Timetabled hours: | Lecture:<br>Exercise: | 5 HPW<br>3 HPW |
| Workload: | 120 h attendance<br>90 h preparation and review<br>30 h exam preparation | |
| Credits: | 8 | |
| Recommended prerequisites: | High school: Algebra, Exponential function and Logarithm, Trigonometry | |
| Module objectives: | Students are able to gain knowledge in various ways and learn to organize their work. Students understand basic mathematical concepts and know how to apply standard mathematical methods. They are able to visualize mathematical objects and to interpret mathematical symbols and formulas. They have learned to think, to work and to express themselves with precision. Also they have acquired a feeling for handling numbers. They possess the skills to solve problems on their own and to verify the solutions. They are able to apply numerical as well as graphical solution methods to various tasks. The students will possess general problem solving skills beyond the simple application of standard procedures. | |
| Content: | • Numbers: irrational numbers and the difficulties associated with their representation on a pocket calculator or computer, complex numbers and the Fundamental Theorem of Algebra<br>• Systems of linear equations: Gaussian elimination<br>• Vector algebra and analytic geometry: linear combinations, scalar and vector products, lines and planes<br>• Limits: concept and computation, continuity, bisection method<br>• Differential calculus: definition of derivative, rules of derivation, tangent, Newton's method, monotonicity and concavity | |

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| | • Integral calculus: inversion of differentiation – indefinite integral, area calculation – definite integral, Fundamental Theorem of Calculus<br>• Integral calculus: substitution rule, integration by parts, partial fraction decomposition, improper integrals |
| Assessment: | Written digital examination |
| Forms of media: | Moodle, Webex |
| Literature: | 1. James Stewart (2011). *Calculus*. Metric International Version. 7th edition. Brooks/Cole<br><br>Further Reading:<br><br>2. James Stewart, Lothar Redlin, Saleem Watson (2012). *Algebra and Trigonometry.* 3rd international edition. Brooks/Cole [to catch up on basic mathematics] |

## 2001 Applied Mathematics

| Module name/Module code: | Applied Mathematics | 2001 |
|---|---|---|
| Degree: | Biomaterials Science:<br>Electrical and Electronics Engineering:<br>Industrial Engineering:<br>Mechanical Engineering:<br>Mechatronic Systems Engineering: | BMS 2 2001<br>EL 2 2001<br>IE 2 2001<br>ME 2 2001<br>MSE 2 2001 |
| Module coordinator: | Prof. Dr. A. Kehrein | |
| Lecturer: | Dr. T. Camps<br>Prof. Dr. A. Kehrein<br>Prof. Dr. M. Krauledat<br>Prof. Dr. A. Struck | |
| Language: | English | |
| Place in curriculum: | Core | |
| Timetabled hours: | Lecture:<br>Exercise: | 5 HPW<br>3 HPW |
| Workload: | 120 h attendance<br>75 h preparation and review<br>30 h exam preparation | |
| Credits: | 7 | |
| Recommended prerequisites: | 2000 Introductory Mathematics | |
| Module objectives: | Students are able to use advanced mathematical concepts and methods. In particular, they are able to work with multivariate functions and master modelling with differential equations.<br><br>Students learn to model situatons that involve uncertainty and to calculate with discrete as well as continuous random variables. They learn how to draw conclusions about a population when only sample data is available. In particular, measurements are interpreted as samples. The fundamentals of probability theory that are necessary for this purpose are demonstrated empirically by data from student experiments.<br><br>Students practice their general social skills by working in small teams on their homework. They specifically train to communicate in precise mathematical terms. By means of their homework, students improve their problem solving skills. | |
| Content: | • Linear algebra: matrices, determinants, inverse matrix, eigenvalue problems<br>• Series: approximations using partial sums, convergence and divergence tests, power series, Taylor series<br>• Differential calculus of several variables: partial derivatives, gradient, extrema | |

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| | • Ordinary differential equations: direction field, separating variables, linear differential equations of first and second order<br>• Probability: Modelling random experiments, meaning of probability, Law of Large Numbers, conditional probability, probability trees, Bayes' theorem<br>• Random variables: discrete and continuous, probability mass functions and probability density functions, normal distribution<br>• Sample theory: sample average, central limit theorem, variance of sample average |
| Assessment: | Written examination |
| Forms of media: | Whiteboard, Projector |
| Literature: | 1. James Stewart (2016): *Calculus*. Metric International Version. 8th edition. Brooks/Cole<br><br>2. John Devore (2008) *Probability and Statistics for Engineering and the Sciences*. 7th int. student edition. Brooks/Cole<br><br>3. DeVeaux, Velleman, Bock (2004) *Stats: Data and Models*. Pearson<br><br>4. Freedman, Pisani, Purves (2007) *Statistics*. 4th edition. Norton<br><br>Recommended Video Lectures:<br><br>5. Mattuck, Arthur, Haynes Miller, Jeremy Orloff, and John Lewis. *18.03SC Differential Equations,Fall 2011*. (Massachusetts Institute of Technology: MIT OpenCourseWare), http://ocw.mit.edu (Accessed 08 May, 2013). License: Creative Commons BY-NC-SA<br><br>6. Strang, Gilbert. *18.06SC Linear Algebra,Fall 2011*. (Massachusetts Institute of Technology: MIT OpenCourseWare), http://ocw.mit.edu (Accessed 08 May, 2013). License: Creative Commons BY-NC-SA |

## 2002 Numerical Mathematics

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|---|---|---|
| Module name/ Module code: | Numerical Mathematics | 2002 |
| Degree: | Industrial Engineering:<br>Mechanical Engineering:<br>Mechatronic Systems Engineering:<br>Biomaterials Science<br>Electrical and Electronics Engineering | IE 4 2002<br>ME 4 2002<br>MSE 4 2002<br>BMS 4 2002<br>EL 4 2002 |
| Module coordinator: | Prof. Dr. A. Kehrein | |
| Lecturer: | Prof. Dr. A. Kehrein<br>Prof. Dr. M. Krauledat<br>Prof. Dr. A. Struck<br>Dr. T. Camps | |
| Language: | English | |
| Place in curriculum: | Core: IE, ME, MSE<br>Focus Field subject: BMS, EL | |
| Timetabled hours: | Lectures:<br>Exercise: | 3 HPW<br>1 HPW |
| Workload: | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | 2000 Introductory Mathematics<br>2001 Applied Mathematics<br>2011 Programming | |
| Module objectives: | The students learn that use of a computer introduces new mathematical difficulties: not all numbers are representable; there are round off errors and propagation errors. Mathematically equivalent formulas may produce different results on a computer. The students learn how to do computations effectively within the machine limitations.<br><br>The students learn some standard methods of numerical mathematics but, more importantly, that numerical methods must be developed to fit the problem at hand.<br><br>The students become active learners and look for applications of the new methods on their own. They become independent in checking the correctness of their results. | |
| Content: | • Presentation of numbers in a computer: INT and FLOAT; round off errors<br>• Loss of significant digits, error propagation<br>• Interpolation: Lagrange polynomials and splines<br>• Numerical differentiation: use of Taylor approximations, order of a numerical method, truncation error | |

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| | • Numerical integration: midpoint rule, trapezoid rule, Romberg scheme<br>• Fixed-point iteration<br>• Iterative solution of non-linear systems, in particular Newton's Method<br>• Numerical solution of differential equations: forward and backward Euler, Runge-Kutta, difference equations, stability, implicit vs. explicit schemes |
| Assessment: | Written examination |
| Forms of media: | Whiteboard, projector |
| Literature: | 1. Forman S. Acton (2005) *Real Computing Made Real – Preventing Errors in Scientific and Engineering Calculations*. Mineola. Dover Publications. 00/TKX 19´<br><br>2. Cleve Moler (2004) *Numerical Computation with Matlab*, Society for Industrial and Applied Mathematics (pdf available from https://de.mmathworks.com/moler/chapters.html)<br><br>3. Gilbert Strang (2007) *Computational Science and Engineering*. Wellesley. Wellesley-Cambridge Press. 00/TKX 3<br><br>4. Richard Burden and Douglas Faires (2011) *Numerical Analysis*. 9th international edition. Brooks/Cole. 00/TKX 17<br><br>5. Parviz Moin (2010) *Fundamentals of Engineering Numerical Analysis*. 2nd edition. Cambridge. Cambridge University Press. 00/WAT 1<br><br>6. William Press, Saul Teukolsky, William Vetterling, Brian Flannery (2007) *Numerical Recipes – The Art of Scientific Computing*. 3rd edition. Cambridge. Cambridge University Press. (online materials available from http://numerical.recipes) 00/TKX 5 |

## 2008 Static and Strength of Materials

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|---|---|---|
| Module name/Module code: | Statics and Strength of Materials | 2008 |
| Degree: | Biomaterials Science:<br>Electrical and Electronics Engineering:<br>Industrial Engineering:<br>Mechanical Engineering:<br>Mechatronic Systems Engineering: | BMS 3 2008<br>EL 1 2008<br>IE 1 2008<br>ME 1 2008<br>MSE 1 2008 |
| Module coordinator: | Prof. Dr.-Ing. H. Schütte | |
| Lecturer: | Prof. Dr.-Ing. H. Schütte | |
| Language: | English | |
| Place in curriculum: | Core | |
| Timetabled hours: | Lecture:<br>Exercise: | 2 HPW<br>2 HPW |
| Workload: | 90 h attendance<br>60 h preparation and review<br>30 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | School knowledge of Physics and Mathematics | |
| Module objectives: | Students are able to sum and decompose concurrent forces in two dimensions. They are able to calculate moments and combine them in the plane. Building on these skills they can analyse the forces and torques that act on a rigid body in equilibrium conditions. Students are able to determine the centroid of an arbitrary line or area. Based on this knowledge, students are able to analyse planar and multi-piece structures. Furthermore, they are able to determine the forces in the members of a simple truss using the method of joints. They are able to determine the distribution of normal, transversal and bending moments for statically determined beams. Students are able to understand the concept of normal and shear stresses. They know the stress distributions in rods, shafts and beams and are able to calculate the maximum stresses due to the respective loadings. Students apply the knowledge gained in the lectures to regular exercises for solving selected tasks, thereby reinforcing their learning. | |
| Content: | 1. Fundamentals<br>1.1 Definition of force as vector<br>1.2 Newtonian laws<br>1.3 Rigid body<br>1.4 Cutting principle<br><br>2. Forces with a common point of origin<br>2.1 Composition of forces in a plane<br>2.2 Dismantling of forces in a plane<br>2.3 Equilibria in a plane | |

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| | 3. Force systems and equilibrium of the rigid body<br>3.1 Forces in a plane<br>3.2 Torque vector<br><br>4. Median point<br>4.1 Median point and centre of mass of a body<br>4.2 Centroid of an area<br>4.3 Centroid of a line<br><br>5. Bearing reactions<br>5.1 Plain structures<br>5.2 Simple multi-piece structures<br><br>6. Beams<br>6.1 Support reactions for beams<br>6.2 Internal forces in beams<br><br>7. Stresses<br>7.1 Normal and Shear Stresses and their effects<br>7.2 Stress distributions due to axial loading, torque and bending<br>7.3 Maximum stresses due to torque and bending<br>7.4 Failure models |
| Assessment: | Written digital examination<br>Accompanying online course |
| Forms of media: | Webex/Moodle |
| Literature: | 1. Ferdinand Beer, Jr. Johnston, John DeWolf, David Mazurek: Statics and Mechanics of Materials, 2nd edition, ISBN 9780073398167<br><br>2. Lecture Notes |

## 2009 Advanced Strength of Materials

| Module name/ Module code: | Advanced Strength of materials | 2009 |
|---|---|---|
| Degree: | Mechanical Engineering:<br>Mechatronic Systems Engineering: | ME 2 2009<br>MSE 2 2009 |
| Module coordinator: | Prof. Dr, N. H. Østergaard | |
| Lecturer: | Prof. Dr. N. H. Østergaard | |
| Language: | English | |
| Place in curriculum: | Core | |
| Timetabled hours: | Lecture:<br>Exercise: | 2 HPW<br>2 HPW |
| Workload: | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | 2000 Introductory Mathematics<br>2008 Statics and strength of materials | |
| Module objectives: | The students will be on basis of the concepts of static equilibrium and internal forces be taught how to determine stresses and deformations in the most common structural elements with linear elastic constitutive behaviour. | |
| Content: | • Conceptual introduction to 3D statics<br>• Introduction to the general theory of linear elasticity<br>▪ Cauchy's definition of stress<br>▪ The concept of strain<br>▪ Constitutive equations and Hook's law<br>• Normal stresses and deformations in axially loaded members, truss systems<br>• Shear stresses and twist due to torsion of compound circular shafts<br>▪ The polar moment of inertia<br>• Normal and shear stress due to bending of long and slender prismatic beams<br>▪ The flexure formula for bending around one and two axes<br>▪ The second order area moment of inertia<br>▪ The parallel axis theorem<br>• Deflection of long and slender beams<br>▪ The Bernoulli Euler beam theory<br>▪ Application to statically indeterminate problems and calculation of reactions<br>• The transformation equations for states of plane stress and Mohr's circle<br>▪ Failure criteria (Von Mises, Tresca)<br>• Stresses in thin-walled pressure vessels<br>▪ The case of a helical welding in a cylindrical pressure vessel with spherical end caps<br>• Elastic buckling of beam-columns (Euler buckling) | |

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| | • Introduction to matrix methods and finite element analysis |
| Assessment: | Written examination |
| Forms of media: | Whiteboard (PowerPoint, Projector, demonstration in the lecture) |
| Literature: | 1. Primary teaching material:<br>• Introduction to strength of materials, lecture notes and problems by NH Østergaard (will be uploaded to Moodle at the beginning of the course)<br><br>2. Recommended text book:<br>• Mechanics of materials (Global Ed.), McGraw-Hill Beer, Johnston, DeWolf, Mazurek<br><br>Recommended secondary literature:<br><br>3. Vector Mechanics for Engineers: Statics (Global Ed.), McGraw-Hill<br><br>4. Statics (SI Ed.), Wiley & Sons, Meriam & Kraige<br><br>5. Mechanics of Materials (SI Ed.),Cengage Learning, Gere |

## 2010 Dynamics

| Module name/Module Code: | Dynamics 2010 |
|---|---|
| Degree: | Industrial Engineering: IE 3 2010<br>Mechanical Engineering: ME 3 2010<br>Mechatronic Systems Engineering: MSE 3 2010 |
| Module coordinator: | Prof. Dr. N. H. Østergaard |
| Lecturer: | Prof. Dr. N. H. Østergaard |
| Language: | English |
| Place in curriculum: | Core |
| Timetabled hours: | Lecture: 2 HPW<br>Exercise: 2 HPW |
| Workload: | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation |
| Credits: | 5 |
| Recommended prerequisites: | 2001 Applied Mathematics<br>2008 Statics and Strength of Materials |
| Module objectives: | The students will be taught the basic kinematics and kinetics for plane motions of particles, systems of particles and rigid bodies required for development and engineering analysis of mechanical systems. The course content will be based on Newtonian mechanics with focus on the link between kinematic properties and force. After having completed the dynamics course, students can independently formulate equations of motion and are familiar with the solution procedures. |
| Content: | • Particle kinematics<br>▪ Cartesian coordinates (recti- and curvilinear motions, rotating motion, ballistics)<br>▪ Polar coordinates and curvi-linear frames<br>▪ The concepts of relative motion and kinematic constrains<br>• Particle dynamics, Newton's 2nd law in cartesian coordinates<br>▪ Free-body diagrams and kinetic diagrams<br>▪ mass-wire-pulley problems<br>▪ Coulomb friction<br>• The linear and angular momentums and their properties<br>▪ Motion under a central force (for example satellites)<br>▪ Application to a system of particles<br>▪ The rocket equation (Tsiolkovsky)<br>• Free and forced vibrations of damped and undamped single degree of freedom systems<br>▪ Mass-spring-damper systems<br>▪ The mathematical pendulum<br>• Kinematics of rigid bodies |

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| | ▪ Application of relative motion for formulation of kinematic constrains<br>• Dynamics of rigid bodies<br>▪ Euler's law of motion and moment equilibriums around arbitrary points in the plane<br>▪ Rolling and slipping<br>▪ Gears and sliding bar problems<br>▪ Reciprocating mechanisms<br>• Conceptual introduction to 3D dynamics<br>▪ The Newton-Euler equations and gyro moments<br>• Introduction to computational multibody dynamics |
| Assessment: | Written digital examination |
| Forms of media: | Webex/Moodle |
| Literature: | Primary teaching material:<br>1. Introduction to Dynamics, course slides and problems by NH Østergaard (will be uploaded to Moodle at the beginning of the course)<br><br>Recommended text book:<br><br>2. Beer, Johnston, Cornwell: Vector Mechanics for Engineers: Dynamics (Global Ed.), McGraw-Hill<br><br>Recommended secondary literature:<br><br>3. Meriam and Kraige: Dynamics (SI Ed.), Wiley Publishing, |

## 2011 Programming

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|---|---|---|
| Module name/Module code: | Programming | 2011 |
| Degree: | Biomaterials Science:<br>Electrical and Electronics Engineering:<br>Industrial Engineering:<br>Mechanical Engineering:<br>Mechatronic Systems Engineering: | BMS 1 2011<br>EL 1 2011<br>IE 1 2011<br>ME 1 2011<br>MSE 1 2011 |
| Module coordinator: | Prof. Dr. M. Krauledat | |
| Lecturer: | Prof. Dr. M. Krauledat<br>Prof. Dr. R. Hartanto<br>Dr. T. Camps | |
| Language: | English | |
| Place in curriculum: | Core | |
| Timetabled hours: | Lecture:<br>Practical Training: | 2 HPW<br>2 HPW |
| Workload: | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | | |
| Module objectives: | After successful completion of this module, students are able to<br>• recognize limitations and complexity of computer based operations<br>• Use algorithmic concepts such as recursion<br>• transfer technical problems to program code<br>• implement simple algorithms<br>• analyse results of mathematical calculations using appropriate tools such as graphical plots and numeric computations | |
| Content: | Algorithmic Concepts<br>• Input and Output<br>• Recursion and iteration<br>Program structures using a high-level programming language<br>• Syntax and Semantics<br>• Data Visualization: plotting in MATLAB<br>• MATLAB program structures (m-files): scripts and functions<br>• Basic programming structures: conditional statements, loops<br>• Symbolic determination of derivatives and integrals<br>• Built-in numerical methods<br>• Basic tools for graphical modelling and simulation (e.g. Simulink) | |
| Assessment: | Lecture: Written examination on campus | |

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| | Exercise: Attestation by continuous assessment |
| Forms of media: | Webex/Moodle |
| Literature: | Stormy Attaway (2012). *MATLAB – A Practical Introduction to Programming and Problem Solving*. 2nd edition. Butterworth-Heinemann. |

## 2012 Advanced Programming

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| Module name/Module Code: | Advanced Programming 2012 |
| Degree: | Electrical and Electronics Engineering: EL 2 2012<br>Mechatronic Systems Engineering: MSE 2 2012 |
| Module coordinator: | Prof. Dr. M. Krauledat |
| Lecturer: | Prof. Dr. M. Krauledat,<br>Prof. Dr. R. Hartanto,<br>Prof. Dr. A. Stamm |
| Language: | English |
| Place in curriculum: | Core |
| Timetabled hours: | Lecture: 2 HPW<br>Practical Training: 2 HPW |
| Workload: | 60 h attendance<br>90 h preparation and review |
| Credits: | 5 |
| Recommended prerequisites: | 2011 Programming |
| Module objectives: | After successfully finishing the module, students are able to<br>• develop short programs in C<br>• analyze program code<br>• Use advanced data structures to implement algorithms |
| Content: | Programming<br>• Introduction to Programming in C<br>• Tools for program development<br>• Data types, operators and terms<br>• Input and output<br>• Flow control<br>• Program structures<br>• Functions<br>• References and pointers<br>• Data structures<br>• Searching and Sorting<br>• Strings<br>• Practical programming exercises with C |
| Assessment: | Lecture: Written examination<br>Exercise: Attestation |
| Forms of media: | Whiteboard, PowerPoint, Projector, PC Pools |
| Literature: | 1. King, K.N. (2008) *C Programming – A Modern Approach*. 2nd edition . Norton<br><br>2. Griffiths, David and Griffiths, Dawn (2012) *Head First C.* O'Reilly<br><br>Further Readings: |

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| | 3. Kernighan, Brian W. and Ritchie, Dennis M.: The C Programming Language, 2nd edition, Prentice Hall International, ISBN 978-0131103627, 1988<br>4. M. Sipser, „Introduction to the theory of computation“ (3rd ed.), Cengage Learning 2013<br><br>5. J. G. Brookshear, „Computer Science – an overview“ (11th ed.), Pearson 2012<br><br>Recommended Video Lectures:<br><br>6. Malan, David J.: *CS 50 Introduction to Computer Science I, 2011- 2013*. (Harvard University: OpenCourseWare) http://cs50.tv/2011/fall/ (Accessed 02 Mar, 2014). License: Creative Commons BY-NC-SA |

## 2013 Business Economics and Project Management

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|---|---|
| Module name/Module code: | Business Economics & Project Management 2013 |
| Degree: | Biomaterials Science: BMS 3 2013<br>Electrical and Electronics Engineering: EL 1 2013<br>Mechanical Engineering: ME 1 2013<br>Mechatronic Systems Engineering: MSE 1 2013 |
| Module coordinator: | Prof. Dr. D. Berndsen |
| Lecturer: | Business Economics: Prof. Dr. D. Berndsen<br>Project Management: Prof. Dr.-Ing. D. Untiedt |
| Language: | English |
| Place in curriculum: | Core |
| Timetabled hours: | Lecture: 3 HPW<br>Practical training: 1 HPW |
| Workload: | 60 h attendance<br>45 h preparation and review<br>45 h exam preparation |
| Credits: | 5 |
| Recommended prerequisites: | None |
| Module objectives: | Students acquire a good initial overview and insight into the environment and inner workings of a business organization, focused on manufacturing firms.<br>They understand the basics of different business models and can recognize the strategic rationales for various types of observable business behaviour.<br>More specifically, they know the relevant market and legal environment, stakeholders and typical key objectives of several types of business, with most emphasis on the manufacturing firm.<br>They understand how the performance of such an enterprise can be measured and reported. They know the basic structure and contents of Balance Sheets, Income and Cash Flow Statements. They can make basic evaluations of a business' performance based on information gathered from these statements.<br>Students understand the financing needs of different types of business, and know the most common ways to address them.<br>They can identify the key functions of a business and understand their regular interactions based on the value chain, with particular emphasis on value creation in a manufacturing firm.<br>They also understand the role of project-driven activity in such an enterprise, have a basic knowledge on how different types of project are organized and managed, and which outcomes can be expected. |

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| | They understand basic project-related information and know the fundamentals of select project management techniques. |
| Content: | <u>Business Economics</u><br>• Definition and roles of a business<br>• Market structures, market typology and market influences<br>• Business models (with special emphasis on manufacturing firms)<br>• Business objectives and strategy<br>• Legal environment and legal setups<br>• Financial statements - balance sheet, income statement, statement of cash flow<br>• Additional reporting, codes of conduct and compliance<br>• Overview business functions<br>• Marketing and Sales – brief introduction<br>• Purchasing / Procurement – brief introduction<br>• Logistics – brief introduction<br>• Production / Operations – brief introduction<br>• R&D – brief introduction, the role of data-driven innovation<br>• Human Resources – brief introduction<br>• Finance – key concepts, basics of corporate performance management<br><br><u>Project Management</u><br>• Fundamentals of organizational design<br>• Business decision making and the role of management and leadership<br>• Structure vs. process vs. project<br>• Project stakeholders and project roles<br>• Principles of programme, portfolio, and project management<br>• Project life cycle planning and control<br>• Project governance and basics of risk management<br>• Documenting and managing results<br>• Project management software |
| Assessment: | Business Economics: digital attestation<br>Project Management: continuous assessment and digital attestation |
| Forms of media: | Webex/Moodle |
| Literature: | <u>Business Economics</u><br>1. Nickels, William G. / McHugh, James / McHugh, Susan (2015): Understanding Business. 11th edition, ISBN 978-9814670371, McGraw-Hill<br><br>2. Hughes, Robert / Kapoor, Jack R. / Pride, William M. (2014): Business. EMEA edition. ISBN 978-1473704763, Cengage Learning |

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| | 3. Brealey, Richard A. / Myers, Stewart C. / Allen, Franklin (2016): Principles of Corporate Finance. 12th edition, ISBN 978-1259253331, McGraw-Hill<br><br>4. Osterwalder, Alexander et al. (2014): Value Proposition Design: How to Create Products and Services Customers Want (Strategyzer). ISBN 978-1118968055, Wiley<br>Ries, Eric (2011): The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. ISBN 978-0670921607, Portfolio Penguin<br><br><u>Project Management</u><br>5. Project Management Institute (Ed.) (2013): A Guide to the Project Management Body of Knowledge (PMBOK Guide) (Pmbok#174; Guide), 5th edition, ISBN 978-1935589679, PMI<br><br>6. Berkun, Scott (2008): Making Things Happen. Mastering Project Management. ISBN 978-0596517717, O'Reilly<br>Anderson, David J. (2010): Kanban: Successful Evolutionary Change for Your Technology Business. ISBN 978-0984521401, Blue Hole Press<br><br>7. Additional literature referenced in class<br>(to be updated shortly before new study programme starts) |
| Other self-study materials | • Complete lecture slides provided to students using interactive e-learning system (HSRW Moodle)<br>• Further readings in public domain<br>(e.g. open courseware or wikipedia articles on selected topics)<br>• Sample exams<br>• Catalogue of possible questions for exam preparation |

## 2014 Cross Cultural Management and Creativity

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|---|---|---|
| Module name/Module code: | Cross-Cultural Management and Creativity | 2014 |
| Degree: | Biomaterials Science:<br>Electrical and Electronics Engineering:<br>Industrial Engineering:<br>Mechanical Engineering:<br>Mechatronic Systems Engineering: | BMS 1 2014<br>EL 3 2014<br>IE 2 2014<br>ME 2 2014<br>MSE 5 2014 |
| Module coordinator: | A. Viermann | |
| Lecturer: | A. Viermann<br>D. Ziegler (external lecturer) | |
| Language: | English | |
| Place in curriculum: | Core | |
| Timetabled hours: | Cross-Cultural Management: Lecture & Exercise<br>Creativity: Lecture & Exercise | 3 HPW<br>1 HPW |
| Workload: | 60 h attendance<br>90 h preparation and review and group assignment | |
| Credits: | 5 | |
| Recommended prerequisites: | none | |
| Module objectives: | The aim of this module is to support students to build up cross-cultural competences (cognitive, affective and communicative) and to gain first basic knowledge and abilities to deal with creative processes in individual, team or organisational settings.<br>For this, the students will<br>• develop a deepened understanding of the dangers and potential arising from humans dealing with differences.<br>• reflect on the impact of different dimensions of diversity in business context.<br>• get an understanding of the term and nature of 'CULTURE'<br>• self-reflect and look into effects of dealing with change situations (e.g. culture shock) and reflect on coping strategies.<br>• study different cultural models and get to know different dimensions of culture (e.g. Hofstede). On this basis, reflect and develop an awareness of the student's individual cultural background in contrast to other cultures in respect to values and behaviour. This supports students to become more self-reflective and mindful as well as develop learning strategies for dealing with negative vibes from cultural differences.<br>• experience working within multi-cultural teams and combine theoretical and empirical work while working on topic related projects.<br>• develop awareness of and reflect on the importance of creativity.<br>• be equipped with a repertoire of methods and strategies that support creative processes and know-how to build a supportive | |

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| | work environment and innovative climate in organizations to make best use of creative potentials.<br>• through group work, improve their intercultural collaboration and communication skills as well as presentation abilities. |
| Content: | <u>Cross-Cultural Management:</u><br>• Dealing with differences<br>• Diversity in business environment<br>• Globalisation of markets and economies and the need for cross-cultural competence<br>• Definitions of culture and their key aspects<br>• Culture shock<br>• Cultural models and dimensions of culture<br>• Reflect on the student's individual cultural background in relation to other cultures and on the impact of cultural differences in business environment<br><u>Creativity:</u><br>• Definition of creativity<br>• Impact of creativity on business innovation and the creation of sustainable competitive advantages<br>• Key components of individual creativity and team creativity<br>• Getting to know different classical creativity techniques and new approaches to creativity<br>• Frame conditions for creativity and innovation in organizations |
| Assessment: | Attestation:<br>Group assignments: preparation, submission and oral presentation (40%) and a written assignment (term paper) (60%) |
| Forms of media: | Webex/Moodle |
| Literature: | 1. Hofstede, Geert: Cultures and Organizations, (2010, Mcgraw-Hill)<br>2. Trompenaars, Fons: Riding the Waves of Culture, (2012, Brealey Publishing)<br>3. Lewis, Richard: When cultures collide – Leading across cultures (2006, Brealey Publishing)<br>4. De Bono, Edward: Serious Creativity, (2015, Vermilion // Trade Paperback)<br>5. Keeley, Larry Ten Types Of Innovation, (2013, Wiley)<br>6. Michalko, Michael: Thinkertoys, (2006,Ten Speed Press)<br>7. Wolff, Jurgen: CREATIVITY NOW, (2012, Pearson International)<br>8. Van Aerssen, B. et al: Das Große Handbuch Innovation, (2018, Vahlen)<br>V9. on Oech, Roger: A Kick In The Seat Of The Pants, (1986, Warner Books)<br>10. Supplemental readings, e.g. additional literature, exercises, cases and other learning materials will be provided during class. |

## 2015 Group Project

| Module name/Module code: | Group Project | 2015 |
|---|---|---|
| Degree: | Biomaterials Science:<br>Electrical Engineering:<br>Industrial Engineering:<br>Mechanical Engineering:<br>Mechatronic Systems Engineering: | BMS 5 2015<br>EL 5 2015<br>IE 5 2015<br>ME 5 2015<br>MSE 5 2015 |
| Module coordinator: | Heads of the degree programme | |
| Lecturer: | Prof. Dr.-Ing. D. Untiedt (EL,IE,ME,MSE)<br>Prof. Dr. R. Hartanto (EL,IE,ME,MSE)<br>Prof. Dr.-Ing. T. Brandt (EL,IE,ME,MSE)<br>K. Schacky (EL,IE,ME,MSE)<br>Prof. Dr. N. Shirtcliffe (BMS) | |
| Language: | English | |
| Place in curriculum: | Core | |
| Timetabled hours: | Project: | 1 HPW |
| Workload: | 15 h attendance<br>135 h project workload | |
| Credits: | 5 | |
| Recommended prerequisites: | | |
| Module objectives: | Students work on solutions for a given task in teams (in exceptional cases individually). For this, students create a functional specifications document and calculate project costs and necessary capacities. They present their self-designed concepts to their clients and are able to defend these concepts. Students react constructively to suggestions and criticism and further develop their approaches into a marketable product. They determine implementation and product costs and are able to estimate market potentials. Students contact suppliers and decide on purchase of material and components. Apart from content-related processing, students also master documenting and presenting the results and thereby interact with potential customers. | |
| Content: | Contents are course-specific | |
| Assessment: | Attestation: Continuous Assessment | |
| Forms of media: | Webex/Moodle | |
| Literature: | 1. C. M. Anson and R. A. Schwegler:<br>The Longman Handbook for Writers and Readers, fourth edition, Pearson Education Inc., 2005<br><br>2. G. Pahl, W. Beitz, J. Feldhusen, K.H. Grote:<br>Engineering Design – A Systematic Approach, 3rd ed. 2007 (4. November 2014), Springer, 2014<br><br>3. Selected state-of-the-art papers | |

## 2016 Internship / Semester Abroad

| Module name/Module code: | Internship / Semester Abroad 2016 |
|---|---|
| Degree: | Biomaterials Science: BMS 6 2016<br>Electrical and Electronics Engineering: EL 6 2016<br>Industrial Engineering: IE 6 2016<br>Mechanical Engineering: ME 6 2016<br>Mechatronic Systems Engineering: MSE 6 2016 |
| Module coordinator: | Heads of the degree programme |
| Lecturer: | Professors |
| Language: | English |
| Place in curriculum: | Core |
| Timetabled hours: | None |
| Workload: | 900 h |
| Credits: | 30 |
| Prerequisites: | 90 CP from the curriculum |
| Module objectives: | **Internship Semester:**<br>Student's work in one or more functional units of an enterprise. They will apply their gained knowledge and methods in technical, analytical, and social matters. The students will have to use their theoretical gained knowledge in their respective practical discipline and reflect it afterwards.<br>Students have to use the following key skills:<br>• Interdisciplinary project work<br>• Intercultural skills<br>• Transfer theoretical knowledge into the practical knowledge<br>• Organization and self-management skills<br>• Set priorities and organize work according to priorities<br>• Team oriented work and communication skills<br>• English as international language<br>• Ability to handle changes during task<br>• Work under pressure of time<br><br>The internship can be completed abroad.<br><br>**Semester abroad:**<br>Students can decide to substitute the internship semester with a study abroad semester. Selecting a study abroad semester offers the student to being immersed into a |

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| | different educational system and helps therefore understanding other tertiary systems. Study abroad is further defined as a semester at a university in a country other than their nationality or country of origin.<br><br>The study abroad semester tailors a strengthening of the following key skills:<br>• Deepen and broaden their knowledge of certain subjects (e.g. additional courses)<br>• Gain knowledge of other political, economic, and cultural systems<br>• Widen the cultural background<br>• Increase language capabilities<br>• Widen their social competencies<br>• Interdisciplinary project work<br>• Intercultural skills<br>• Organization and self-management skills<br>• Interdisciplinary team oriented work and communication skills<br>• English as international language<br>• Planning and set-up skills<br><br>Students will increase their intercultural competencies and get an insight into a different culture as well as organization including many administrative tasks. |
| Content: | Internship Semester:<br>The contents of the internship are based on the business activities and the business environment of the company. They are closely coordinated between the company and the university, so that a consistent professional tie is guaranteed to the study.<br><br>Semester Abroad:<br>The contents of the Semester abroad are based on the university programs selected by the student. They are closely coordinated between the sending university and the receiving university, so that a consistent professional tie is guaranteed to the study. |
| Assessment: | Attestation |

## 2017 Bachelor Thesis

| Module name/Module code: | Bachelor Thesis 2017 |
|---|---|
| Degree: | Biomaterials Science: BMS 7 2017<br>Electrical and Electronics Engineering: EL 7 2017<br>Industrial Engineering: IE 7 2017<br>Mechanical Engineering: ME 7 2017<br>Mechatronic Systems Engineering: MSE 7 2017 |
| Module coordinator: | Heads of the degree programme |
| Lecturer: | Supervisor of the bachelor thesis |
| Language: | English |
| Place in curriculum: | Core |
| Timetabled hours: | None |
| Workload: | 360 h |
| Credits: | 12 |
| Prerequisites: | 175 CP in the respective courses |
| Module objectives: | The students<br>• demonstrate their capability to work independently on a subject in alignment with their course of studies, meeting all topical and scientific requirements in a limited period of time<br>• are able to organize their workflow in order to meet the demands of the problems formulated in their theses, as well as to monitor progress and make necessary amendments<br>• are able to document their approach and their results to meet the requirements of a scientific publication |
| Content: | Thesis content depends on the chosen topic and is agreed upon with the supervisor. Documentation is granted by an adequately sized description of the topic/problem, the chosen approach, used methods and results. |
| Assessment: | Written and graded thesis in the range of 15000 to 20000 words (50–70 DIN A4 pages) |

## 2018 Colloquium

| Module name/Module code: | Colloquium 2018 |
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| Degree: | Biomaterials Science: BMS 7 2018<br>Electrical and Electronics Engineering: EL 7 2018<br>Industrial Engineering: IE 7 2018<br>Mechanical Engineering: ME 7 2018<br>Mechatronic Systems Engineering: MSE 7 2018 |
| Module coordinator: | Heads of the degree programme |
| Lecturer: | Supervisor of the Bachelor Thesis |
| Language: | English |
| Place in curriculum: | Core |
| Timetabled hours: | None |
| Workload: | 90 h |
| Credits: | 3 |
| Prerequisites: | 207 CP in the respective courses |
| Module objectives: | The students<br>• are able to defend the results of the Bachelor Thesis<br>• place their work in a suitable context and present their results in a proper form for the audience. They are able to explain their approach and to critically analyse their own results.<br>• are able to analyze questions concerning their thesis and results and answer them suitably. |
| Content: | Content is aligned with the content of the Bachelor Thesis, with an operative focus on discussion of their results, methods and alternatives. |
| Assessment: | Oral examination, graded |
| Forms of media: | Whiteboard, PowerPoint, Projector |
| Literature: | 1. M. Powell: Presenting in English – how to give successful presentations, Heinle Cengage Learning, 2011<br><br>2. S. Krantman: The Resume Writer's Workbook, fourth edition, South-Western Cengage Learning, 2013 |

## 2020 Foreign language

| Module name/Module code: | Foreign language 2020 |
|---|---|
| Degree: | Biomaterials Science: BMS 7 2020<br>Electrical and Electronics Engineering: EL 7 2020<br>Industrial Engineering: IE 7 2020<br>Mechanical Engineering: ME 7 2020<br>Mechatronic Systems Engineering: MSE 7 2020 |
| Module coordinator: | Heads of the degree programme |
| Lecturer: | acc. selected module of the language center |
| Language: | English |
| Place in curriculum: | Elective:<br><br>The choice of the students has to be confirmed by the study program coordinators to avoid clashes with core subjects and to ensure the fitting to the study program. |
| Timetabled hours: | Recommended: 4 HPW |
| Workload: | acc. module description |
| Credits: | 5 |
| Recommended prerequisites: | none |
| Module objectives | At the beginning of the course the students define a language level to be achieved based on the existing language skills in the chosen language. This happens together with the responsible teacher. The expected improvement of the language skills has to be defined in a learning agreement.<br><br>For international students this language should be German, for German students any other language offered by the language center of the university can be selected.<br><br>After completion of the module the students should be able to communicate better in an additional foreign language. They are able to prepare documents required for applications in Germany or abroad. |
| Content: | acc. module description of the selected module of the language center |
| Assessment: | acc. module description of the selected module of the language center |
| Forms of media: | acc. module description of the selected module of the language center |
| Literature: | acc. module description of the selected module of the language center |

## 2021 Module from any other study course HSRW

| Module name/Module code: | Module from any other Bachelor study course HSRW 2021 |
|---|---|
| Degree: | Biomaterials Science: BMS 7 2021<br>Electrical and Electronics Engineering: EL 7 2021<br>Industrial Engineering: IE 7 2021<br>Mechanical Engineering: ME 7 2021<br>Mechatronic Systems Engineering: MSE 7 2021 |
| Module coordinator: | Heads of the degree programme |
| Lecturer: | acc. selected module |
| Language: | German or English |
| Place in curriculum: | Elective:<br><br>The choice of the students has to be confirmed by the study program coordinators to avoid clashes with core subjects and to ensure the fitting to the study program. |
| Timetabled hours: | Recommended: 4 HPW |
| Workload: | acc. module description |
| Credits: | 5 |
| Recommended prerequisites: | none |
| Module objectives: | acc. module description of the selected module |
| Content: | acc. module description of the selected module |
| Assessment: | acc. module description of the selected module |
| Forms of media: | acc. module description of the selected module |
| Literature: | acc. module description of the selected module |

## 2108 Materials and Testing

| Module name/Module code: | Materials and Testing | 2108 |
|---|---|---|
| Degree: | Industrial Engineering:<br>Mechatronic Systems Engineering: | IE 3 2108<br>MSE 3 2108 |
| Module coordinator: | Prof. Dr. C. Heß | |
| Lecturer: | Prof. Dr.-Ing. R. Sicking | |
| Language: | English | |
| Place in curriculum: | Core | |
| Timetabled hours: | Lecture:<br>Exercise:<br>Practical work: | 2 HPW<br>1 HPW<br>1 HPW |
| | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | | |
| Module objectives: | Students are able to<br>• describe crystal structures and different classes of metals and ceramics<br>• explain, with basic knowledge about alloy systems, phase transformations, strength increase mechanisms as well as mechanical and technological properties of metals<br>• identify and describe basic structures of polymers<br>• perform different testing and analysis methods for materials characterization<br>• describe the relationship between microstructure and macroscopic properties of polymers, ceramics, glass and metals<br>• select appropriate materials with regard to their engineering application | |
| Content: | • Introduction into atomic structure and structure of single and polycrystals, lattice structures, lattice defects, alloying systems and stress-strain diagrams<br>• Strength increase mechanisms (cold forming/plastic deformation, solid solution, grain fining, precipitates) and phase transformations<br>• Mechanical load, fracture, corrosion<br>• Equilibrium: component / phase / microstructure, 2-component-system / equilibrium diagrams, lever rule<br>• Classification of polymers<br>• Polymer states, description of polymer chain structure, chain configurations, crosslinking and branching<br>• Structural changes by temperature, glass transition<br>• Structure-Property relationship in polymers and metals<br>• Microstructure and properties of ceramics and glass | |

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| | • Introduction to important testing methods (hardness, impact test, tensile test, microscopic techniques, ultrasonic inspection, surface roughness)<br>• Overview of main manufacturing processing routes<br>• In addition, specific application examples are discussed |
| Assessment: | Lecture: Written Exam on campus<br>Laboratory: Reports |
| Forms of media: | Webex/Moodle, - |
| Literature: | M. F. Ashby, D. R. Jones<br>Engineering Materials 2 – An Introduction to Microstructures, Processing and Design, 3rd ed., ISBN-13 978-0-7506-6381-6, 2006<br><br>C. B. Carter, M.G. Norton<br>Ceramic Materials – Science and Engineering, 2. ed., ISBN 978-1-4614-3522-8, Springer Verlag, 2013<br><br>Further Reading:<br><br>E. Hornbogen, G. Eggeler, E. Werner<br>Werkstoffe: Aufbau und Eigenschaften von Keramik-, Metall-, Polymer- und Verbundwerkstoffen (Materials: Structure and Features of Ceramic, Polymeric and Composite Materials), 9th completely rev. ed., ISBN 978-3540718574, Springer, 2008<br><br>M. F. Ashby, D. R. H. Jones<br>Engineering Materials 1 - An Introduction to Properties, Applications and Design, 4th ed., ISBN 978-0-08-096665-6, Elsevier, 2012<br><br>George M. Crankovic<br>Metals Handbook: Materials Characterization, 9th ed., ISBN 978-0871700162, ASM Intl., 1989<br><br>G. W. Ehrenstein<br>Polymerwerkstoffe – Struktur – Eigenschaften – Anwendungen, 3. ed., ISBN 978-3-446-42283-4, Carl Hanser Verlag, 2011<br><br>E. Saldivar-Guerra, E. Vivaldo-Lima<br>Handbook of Polymer Synthesis, Characterization and Processing, 1. ed., ISBN 978-0-470-63032-7, Wiley, 2013<br><br>Jean Louis Halary, Francoise Laupretre, and Lucien Monnerie<br>Polymer Materials: Macroscopic Properties and Molecular Interpretations, 1. ed., ISBN 978-0470616192, Wiley & Sons., 2011 |

## 2303 Digital Electronics

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|---|---|
| Module name/Module code: | Digital Electronics 2303 |
| Degree: | Electrical and Electronics Engineering EL 2 2303<br>Mechatronic Systems Engineering MSE 4 2303 |
| Module coordinator: | Prof. Dr. R. Hartanto |
| Lecturer: | Prof. Dr. R. Hartanto |
| Language: | English |
| Place in curriculum: | Core: EL<br>Focus Field Subject: MSE |
| Timetabled hours: | Lecture: 2 HPW<br>Exercise: 1 HPW<br>Practical Training: 1 HPW |
| Workload: | 90 h attendance<br>30 h preparation and review<br>30 h exam preparation |
| Credits: | 5 |
| Recommended prerequisites: | 2301 Electrical Engineering I |
| Module objectives: | After successful completion of this module, students able to<br>• perform binary arithmetic<br>• create circuits to add and subtract binary numbers using logic gates and the theorems of Boolean algebra<br>• aided by Karnaugh maps, they can create logic functions according to requirements and assemble them in specific links<br>• simplify or represent digital circuits using equivalent logic gates<br>• create typical combinational circuits and storage circuits for technical applications<br>• analyse VHDL program<br>• create and design digital circuits using FPGA with VHDL<br>• recognize the typical characteristics of digital circuits which use TTL and CMOS circuit techniques |
| Content: | • The numeric system in binary representation<br>• Digital addition and subtraction<br>• Logic gates and switching algebra<br>• Karnaugh maps<br>• Technical realisation of digital circuits<br>• TTL and CMOS<br>• Combinational circuits<br>• Asynchronous and synchronous circuit engineering<br>• Storage circuits<br>• FPGA programming using VHDL |
| Assessment: | Lecture: Written examination |

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| | Exercise: Attestation |
| Forms of media: | Whiteboard, PowerPoint, Projector, Laboratory experiments |
| Literature: | 1. T. Floyd: Digital Fundamentals, a systems approach, Pearson, 2012<br><br>Further Readings:<br><br>2. Klaus Fricke: Digitaltechnik (Digital Technology), Vieweg+ Teubner, 2009<br><br>3. Jan M. Rabaey, Digital Integrated Circuits, Prentice Hall, 2002<br><br>4. Ronald J. Tocci: Digital Systems: Principles and Applications, Prentice Hall, 2010<br><br>5. John F. Wakerly: Digital Design: Principles and Practices, Addison Wesley, 2006 |

## 2304 Analog Electronics

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|---|---|---|
| Module name/Module code: | Analog Electronics | 2304 |
| Degree: | Electrical and Electronics Engineering:<br>Mechatronic Systems Engineering: | EL 2 2304<br>MSE 2 2304 |
| Module coordinator: | Prof. Dr.-Ing. G. Gehnen | |
| Lecturer: | Prof. Dr.-Ing. G. Gehnen | |
| Language: | English | |
| Place in curriculum: | Core | |
| Timetabled hours: | Lecture:<br>Exercise:<br>Practical Training: | 2 HPW<br>1 HPW<br>1 HPW |
| Workload: | 60 h attendance<br>50 h preparation and review<br>40 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | 2301 Electrical Engineering I | |
| Module objectives: | Students know the fundamental conduction mechanisms in semiconductors and the effects that occur by connecting different types of semiconductors. Based on this, they can describe the functional principle of diodes and transistors. They master the basic circuits of diodes and transistors and are able to calculate the proportions of current and voltage using curves and empirical formulae. They are able to design and to analyse circuits containing operational amplifiers. They know the frequency behaviour of semiconductor components and operational amplifiers and are therefore able to make corresponding assessments for practical application. Based on this knowledge, students are able to estimate the frequency behaviour of circuits as well as to apply the related effects specifically for the operation of oscillating circuits. | |
| Content: | • Semiconductors: Structure and conduction mechanisms<br>• Doping of semiconductors<br>• p-n junction and diodes<br>• Applications of diodes<br>• Special forms of diodes: Z-diodes, Schottky-diodes, LEDs<br>• Bipolar transistors, fundamentals and characteristics<br>• Basic transistor circuits<br>• Field effect transistors<br>• Fundamentals of operational amplifiers<br>• Op amp circuits<br>• Frequency-dependent behaviour: Oscillators, timers, and filters | |

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| | • Voltage conversion with linear control systems and clocked circuits |
| Assessment: | Attestation within the scope of laboratory;<br>Written examination |
| Forms of media: | Whiteboard, PowerPoint, Projector, Simulation programs, demonstration during lecture, laboratory equipment |
| Literature: | 1. R. L. Boylestad, L. Nashelsky: Electronic Devices and Circuit Theory, 10th edition, Pearson, 2009<br>2. Horowitz, Hill: The Art of Electronics 3rd edition, Cambridge University Press; 2015<br>Further Readings:<br>3. M. Rashid: Microelectronic Circuits, 2nd edition, Cengage Learning, 2011<br>4. Tietze, Schenk: Halbleiterschaltungstechnik (Semiconductor circuit Technology), Springer Verlag, 2009<br>5. Course materials from the lecturers<br>6. Laboratory documents and exercises from the lecturers |

## 2305 Fundamentals of Electrical Engineering

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| Module name/Module code: | Fundamentals of Electrical Engineering | 2305 |
| Degree: | Industrial Engineering:<br>Mechanical Engineering:<br>Mechatronic Systems Engineering: | IE 3 2305<br>ME 3 2305<br>MSE 1 2305 |
| Module coordinator: | Prof. Dr.-Ing. G. Gehnen | |
| Lecturer: | Prof. Dr.-Ing. G. Gehnen | |
| Language: | English | |
| Place in curriculum: | Core | |
| Timetabled hours: | Lecture:<br>Exercise:<br>Practical work: | 2 HPW<br>1 HPW<br>1 HPW |
| Workload: | 60 h attendance<br>50 h preparation and review<br>40 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | School knowledge of Physics and Mathematics | |
| Module objectives: | Students are able to apply the fundamental laws of Electrical Engineering.<br>They are able to analyze networks of passive linear components as well as to calculate currents and potentials in these networks.<br>They are able to calculate transient processes in capacitors and inductances by means of ordinary differential equations.<br>Additionally, they have knowledge of Alternating Currents insofar as they are able to perform simple calculations of currents, potentials and impedances with complex numbers. They are able to understand poly-phase systems.<br>In doing so they are able to label and to estimate frequency-dependent behavior of a circuit.<br><br>They know the dangers originating from electric current.<br><br>The learned abilities are trained in the exercise and attested in accompanying tutorials and in the laboratory. | |
| Content: | • General introduction to Electrical Engineering, historical backgrounds<br>• Electrostatics: atoms, electrons and charge<br>• Coulomb‘s law<br>• Current as charge movement<br>• Electric potential and voltage<br>• Resistors, Ohm’s law | |

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| | • Electric safety<br>• Series and parallel circuit of resistors<br>• Kirchhoff's laws<br>• Mesh Analysis<br>• Electric power and energy<br>• Superposition principle<br>• Thevenin's theorem, alternative sources<br>• Fundamentals of capacitors<br>• Transient processes at capacitors<br>• Induction law<br>• Inductivities and their relation to capacitors<br>• Transient processes at inductivities<br>• Fundamentals of alternating currents engineering<br>• Calculating with complex numbers in alternating currents engineering, basics of phasor diagrams<br>• Root mean squares and peak values<br>• Calculation of impedance and admittance<br>• Networks in complex notation, application of phasor diagrams<br>• Energy and power in alternating current networks<br>• Polyphase systems<br>• Frequency-dependent behaviour |
| Assessment: | Attestation within the scope of laboratory;<br>Written examination |
| Forms of media: | Webex/Moodle |
| Literature: | 1. R.L. Boylestad: Introductory Circuit Analysis, 12th Edition, Pearson, 2010<br><br>2. T.L. Floyd D.M. Buchla, Electronics Fundamentals, 8th Edition, Person, 2010<br><br>3. G. Hagmann: Grundlagen der Elektrotechnik, 15. Auflage, AULA Verlag, 2011<br><br>4. G. Hagmann: Aufgabensammlung zu den Grundlagen der Elektrotechnik, 14. Auflage, AULA Verlag, 2010<br><br>5. Course materials from the lecturer<br><br>6. Laboratory documents and Exercises from the lecturer |

## 2306 Microcontroller

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|---|---|---|
| Module name/Module Code: | Microcontrollers | 2306 |
| Degree: | Electrical and Electronics Engineering:<br>Mechatronic Systems Engineering: | EL 3 2306<br>MSE 3 2306 |
| Module coordinator: | Prof. Dr.-Ing. I. Volosyak | |
| Lecturer: | Prof. Dr.-Ing. I. Volosyak | |
| Language: | English | |
| Place in curriculum: | Core subject | |
| Timetabled hours: | Lectures:<br>Practical Training: | 2 HPW<br>2 HPW |
| Workload: | 60 h attendance<br>50 h preparation and review<br>40 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | 2011 Programming<br>2012 Advanced Programming<br>2301 Electrical Engineering I<br>2302 Electrical Engineering II<br>2303 Digital Electronics | |
| Module objectives: | Based on data types bit and byte, students master the typical data representation in microcontrollers. They can label the elements of a microcontroller according to Harvard architecture and show the procedural structures for command processing. They are able to write microcontroller instructions using addressing schemes and the set of commands.<br>They can control data input and output and they know the essential development tools for creating programs for microcontrollers (C programming language). | |
| Content: | • Data representation in bits and bytes<br>• Princeton and Harvard architecture<br>• CPU components<br>• Instruction coding and addressing<br>• Data storage<br>• Input and output systems<br>• Development tools | |
| Assessment: | Attestation within the scope of laboratory (T),<br>Written examination (P) | |
| Forms of media: | Webex/Moodle, Laboratory experiments on campus | |
| Literature: | 1. E. Williams: Make: AVR Programming, O'Reilly and Associates, 2014. Also available as online resource: http://www.digibib.net/permalink/1383/FHBRHW-x/HBZ:HT019887239 | |

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| | 2. T. Floyd: Digital Fundamentals, a systems approach, Pearson, 2012<br><br>3. S. Barret: Embedded Systems Design with the Atmel AVR Microcontroller, Morgan & Claypool Publishers, 2009<br><br>Further reading:<br>4. J. Sanchez: Microcontroller Programming [The Microchip PIC], CRC Press, 2007<br><br>5. Klaus Fricke: Digitaltechnik (Digital Technology), Vieweg+ Teubner, 2009<br><br>6. Jan M. Rabaey, Digital Integrated Circuits, Prentice Hall, 2002<br><br>7. Ronald J. Tocci: Digital Systems: Principles and Applications, Prentice Hall, 2010<br><br>8. John F. Wakerly: Digital Design: Principles and Practices, Addison Wesley, 2006<br><br>9. Ioan Susnea, Marian Mitescu: Microcontrollers in Practice, Springer, 2006<br><br>10. N. Senthil Kumar, M. Saravanan, S. Jeevananthan: Microprocessors and Microcontrollers, Oxford University Press, 2011 |

## 2308 Signal Transmission

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|---|---|---|
| Module name/Module code: | Signal Transmission | 2308 |
| Degree: | Electrical and Electronics Engineering:<br>Mechatronic Systems Engineering: | EL 3 2308<br>MSE 5 2308 |
| Module coordinator: | NN | |
| Lecturer: | NN | |
| Language: | English | |
| Place in curriculum: | Core (EL), Focus Field Subject (MSE) | |
| Timetabled hours: | Lecture:<br>Exercise:<br>Practical Training: | 2 HPW<br>1 HPW<br>1 HPW |
| Workload: | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | 2000 Introductory Mathematics<br>2001 Applied Mathematics<br>2304 Analog Electronics<br>2301 Electrical Engineering I<br>2301 Electrical Engineering II | |
| Module objectives: | After finishing this module, students master the differences between continuous and discrete-time signals.<br>Students understand the time- and frequency domain of signals and their essential applications in communications engineering. They know the characteristics of linear time-invariant systems for continuous and discrete signals. The common transformations needed for calculating communication transmissions are comprehensively mastered by the students. | |
| Content: | • Fundamentals of continuous and discrete signals and systems<br>• Sampling theorem<br>• Fourier transforms and their applications<br>• Laplace transforms<br>• Linear time-invariant systems<br>• Z-transformation<br>• Applications in communication systems<br>• Terminology of information theory: entropy, redundancy, decision content<br>• Basics of source coding, channel coding and modulation | |
| Test/examination results: | Written examination and Lab Reports | |
| Forms of media: | Whiteboard, PowerPoint, Projector | |
| Literature: | 1. Alan Oppenheim, Alan Willsky, with Hamid: Signals and Systems, 2. Ed., Pearson International, 2014 | |

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| | 2. Robert G. Gallager: Principles of Digital Communication, Cambridge University Press, 2008<br><br>Further Readings:<br><br>3. Christoph Arndt: Information Measures: Information and its Description in Science and Engineering, Springer, 2003<br><br>4. Wolfgang Frohberg, Horst Kolloschie, Helmut Löffler: Taschenbuch der Nachrichtentechnik (Pocket book of Communications Engineering), Carl Hanser Verlag, 2008<br><br>5. Christoph Arndt: Information Measures: Information and its Description in Science and Engineering, Springer, 2003<br><br>6. Charles Phillips, John Parr, Eve Riskin: Signals, Systems, and Transforms, Pearson International, 2008<br><br>7. Yuriy Shmaliy: Continuous-Time Signals, Springer, 2006 John G. Proakis: Digital Communications, McGraw-Hill, 2000<br><br>8. Martin Werner: Information und Codierung: Fundamentals und Anwendungen (Information and Coding: Fundamentals and Applications), Vieweg und Teubner, 2008 |

## 2309 Object-oriented Programming

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|---|---|---|
| Module name/Module code: | Object Oriented Programming | 2309 |
| Degree: | Electrical and Electronics Engineering:<br>Mechatronic Systems Engineering: | EL 3 2309<br>MSE 5 2309 |
| Module coordinator: | Prof. Dr. M. Krauledat | |
| Lecturer: | Prof. Dr. R.Hartanto | |
| Language: | English | |
| Place in curriculum: | Core: EL<br>Focus Field Subject: MSE | |
| Timetabled hours: | Lecture:<br>Practical Training: | 2 HPW<br>2 HPW |
| Workload: | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | 2012 Advanced Programming | |
| Module objectives: | After successfully finishing the module, students are able to<br>• develop small programs with object-oriented design<br>• analyze program code that has been created in an object-oriented manner<br>• transfer technical problems into an object-oriented design and to describe them in UML | |
| Content: | Programming<br>• Introductory Programming<br>• Introduction to the concept of object-oriented programming<br>• Program development tools<br>• Control flow and control structures<br>• Pointer and references<br>• Functions in OOP<br>• Classes<br>• Interfaces<br>• Inheritance<br>• Polymorphism<br>• Abstract data types (ADT)<br>• Enumerations and Collections<br>• Input, output and streams<br>• Name ranges and visibility<br>• Object-oriented analysis<br>• Object-oriented design, UML<br>• Design Patterns<br>• Treatment of errors and exceptions<br>• Applications on different operating systems (such as Windows or *nix) | |

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| | • Examples and practical programming exercises by means of a concrete object-oriented programming language (such as: C++, JAVA, Python) |
| Assessment: | Graded: Continuous assessment (10%: homework or quizzes) and written or oral examination (90%) |
| Forms of media: | Webex/Moodle |
| Literature: | 1. D. Flanagan : Java in a Nutshell: A Desktop Quick Reference, O'Reilly, 2005, ISBN: 978-0596007737<br><br>2. S. Oualline: Practical C++ Programming, O'Reilly, 2003, ISBN: 978-0596004194<br><br>3. D. Boles, C. Boles: Objektorientierte Programmierung spielend gelernt, Vieweg&Teubner, 2. Auflage, 2010<br><br>4. Y.D. Liang: Introduction to Java Programming and Data Structures 10 or 11 ed, Pearson, 2019. |

## 2311 Embedded Systems

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| Module name / Module code: | Embedded Systems 2311 |
| Degree: | Electrical and Electronics Engineering: EL 4 2311<br>Mechatronic Systems Engineering: MSE 4 2311 |
| Module coordinator: | Prof. Dr. A. Stamm |
| Lecturer: | Prof. Dr. A. Stamm |
| Language: | English |
| Place in curriculum: | Core |
| Timetabled hours: | Lecture: 2 HPW<br>Practical Training: 2 HPW |
| Workload: | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation |
| Credits: | 5 |
| Recommended prerequisites: | 2306 Microcontroller<br>2309 Object oriented Programming |
| Module objectives: | Students have a broad knowledge of embedded systems for which the boundary conditions of limited resources and hardware dependencies are valid. In particular, they know the processes of modern embedded systems development. They are able to differentiate embedded systems from cyber-physical systems.<br>Students should be able to name different motivations and the importance of embedded systems in nowadays technology and life of humans. They are able to conceptual understand the hardware development process of embedded. They are able to apply a typical design flow during embedded system development. This will include model definitions, requirements for a model, models of computation, models of communications, and combined models.<br><br>Students understand concepts for testing embedded software. They are able to write software for embedded systems including the practical implementation and testing of that software on an embedded system. This includes cros/compiling of C Programs.<br><br>Students are able to specify suitable embedded systems for a given task, to create a suitable software concept for this and to select necessary tools and test environments. They act in a methodical and structured manner in this regard, and use professional tools. Students who have finished this module successfully understand how embedded systems are integrated in an overall system. |
| Content: | • Characteristics of Embedded Systems<br>• Architecture of Embedded Systems |

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| | • Challenges during the design phase of Embedded Systems<br>• Real time behaviour, soft and hard real time<br>• Design flow<br>• Specifications & Modeling (CFSM, StateCharts, Petri nets)<br>• Event based languages<br>• Von-Neumann model<br>• Comparison of different models<br>• Modeling levels<br>• Embedded Systems Hardware<br>• Embedded Systems Software<br>• Evaluation and Validation<br><br>• Program implementation: booting, cross-compiling, linking, loading, remote debugging<br>• Hardware abstraction<br>• Failure safety |
| Assessment: | Written examination |
| Forms of media: | Whiteboard, PowerPoint, Projector, Laboratory experiments |
| Literature: | 1. P. Marwedel: Embedded System Design, Springer, 2011<br><br>2. Qing Li, Caroline Yao: Real-Time Concepts for Embedded Systems. CMP Books, 2003.<br><br>Further Readings:<br><br>3. A. Forrai: Embedded Control System Design [A model driven approach], Springer, 2013<br><br>4. Frank Vahid and Tony Givargis: Embedded System Design: A Unified Hardware/Software Introduction. John Wiley & Sons, 2002<br><br>5. Arnold S. Berger: Embedded Systems Design. CMP Books, 2001. |

## 2314 Practical Electronics

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|---|---|---|
| Module name / Module code: | Practical Electronics | 2314 |
| Degree: | Electrical and Electronics Engineering:<br>Mechatronic Systems Engineering: | EL 5 2314<br>MSE 5 2314 |
| Module coordinator: | Prof. Dr. A. Stamm | |
| Lecturer: | Prof. Dr. A. Stamm | |
| Language: | English | |
| Place in curriculum: | Core: EL<br>Focus Field Subject: MSE | |
| Timetabled hours: | Lecture:<br>Exercise:<br>Practical Training: | 2 HPW<br>1HPW<br>1 HPW |
| Workload: | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | 2306 Microcontroller | |
| Module objectives: | Students will be able to design electronic circuits and implement these as printed circuit boards. It involves PCB design, system and component specification, and design principles including noise reduction, transducers, ergonomics, power supplies, and design for testability. Students are required to complete a practical PCB design and a paper system design as part of their assessment. | |
| Content: | <u>Lecture:</u><br>• Introduction to circuit design principles<br>• Op-amps<br>• Rectifiers<br>• Resistors, capacitors, inductors<br>• Transformers<br>• PCB design and fabrication<br>• Sensors and transducers<br>• Identifying noise sources and reduction<br><br><u>Project:</u><br>• Students will be meeting their group members outside of lectures and labs to discuss and decide on a project<br>• Each group of students will be required to propose their project and their circuit to the whole class with oral feedback given by the teaching team (10 minutes)<br>• Students have to prepare a presentation and a written report which will be part of the assessment<br>• Students will present the outcomes in class (15 minutes) | |

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| | • <br> Labs: <br> • Students will be required to attend the labs and design the desired circuit using a PCB Design software <br> • Software training will be provided in class <br> • Implementation of the developed PCB <br> • Assembly of electronic components on the PCB <br> • Development of software for project related tasks (if necessary) <br> • Presentation of a working prototype |
| Assessment: | Continuous assessment (graded) |
| Forms of media: | Webex/Moodle, Laboratory experiments digital and on campus |
| Literature: | Notes supplied during lecture and labs<br>Peter Wilson and Tim Williams, *The circuit designer's companion*, Elsevier, 2004 |

## 2510 Technology and Innovation Management

| Module name/Module code: | Technology and Innovation Management 2510 |
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| Degree: | Electrical and Electronics Engineering: EL 7 2510<br>Industrial Engineering: IE 7 2510<br>Mechanical Engineering: ME 7 2510<br>Mechatronic Systems Engineering: MSE 7 2510 |
| Module coordinator: | Prof. Dr.-Ing. D. Untiedt |
| Lecturer: | Prof. Dr.-Ing. D. Untiedt |
| Language: | English |
| Place in curriculum: | Core |
| Timetabled hours: | Lecture: 2 HPW<br>Practical Training: 2 HPW |
| Workload: | 45 h attendance<br>75 h preparation and review<br>30 h exam preparation |
| Credits: | 5 |
| Recommended prerequisites: | - |
| Module objectives: | Students know the essential terms, methods and tools of technology and innovation management. They are able to arrange technologies and to evaluate these using suitable methods. They are aware of the importance of technologies for businesses and society. They know the methods and tools of technology forecasting, planning and evaluation and are able to apply these to practical problem cases. Students know the importance of innovations for businesses. They are acquainted with the relationships between innovation process, stakeholders and the internal and external business environments. They are able to apply suitable methods and instruments of innovation management in an objective-oriented manner in everyday operation. For this, a clear understanding is gained of the innovation process, its success factors and its management and controlling instruments. After completing the module, students should be able to create technology portfolios and to apply roadmaps. Furthermore they should have basic knowledge in the areas of projections and scenarios. In particular they are able to evaluate technological innovations with regard to chances and risks. |
| Content: | Technology and Life cycle management<br>• Fundamentals of Technology management<br>• Scope of duties of Technology management<br>• Technology forecasting<br>• Technology planning<br>• Protection of intellectual property<br>• Technology evaluation<br>• Formulation of Technology strategies<br>Innovation management |

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| | • Basics concepts of Innovation management<br>• Innovation processes and structures<br>• Innovation strategies<br>• Methods of Innovation management<br>• Generating ideas and creativity<br>• Open Innovation |
| Assessment: | Written Attestation |
| Forms of media: | Webex/Moodle |
| Literature: | Technology management<br>1. Schuh, G.; Klappert, S.: Technologiemanagement (Technology Management). Springer, 2010<br>Betz, F.: Managing Technological Innovation – Competitive Advantage from Change. 3rd edition, John Wiley & Sons, 2011<br><br>Innovation management<br>1. Trott, P.: Innovation Management and new product development. 4th edition. Pearson Education Ltd., 2008<br>Schuh, G. (Hrsg.): Innovationsmanagement. Handbuch Produktion und Management 3. Zweite, vollständig neu bearbeitete und erweiterte Auflage, Springer, 2012<br><br>Further Readings:<br><br>2. Burgelmann, R.: Strategic Management of Technology and Innovation. 5th revised edition, McGraw-Hill Higher Education, 2008<br><br>3. Arnold, H.; Erner, M.; Möckel, P.; Schläffer, Chr. (Eds.): Applied Technology and Innovation Management. Springer, 2010<br><br>4. Narayanan, V. K.; Colarelli O'Connor, G. (Eds.): Encyclopedia of Technology and Innovation Management. 1st edition, John Wiley & Sons, 2010 |

## 2512 Entrepreneurship

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|---|---|---|
| Module name/Module code: | Entrepreneurship | 2512 |
| Degree | Biomaterials Science:<br>Electrical and Electronics Engineering:<br>Industrial Engineering:<br>Mechanical Engineering:<br>Mechatronic Systems Engineering: | BMS 7 2512<br>EL 7 2512<br>IE 7 2512<br>ME 7 2512<br>MSE 7 2512 |
| Module coordinator: | Prof. Dr.-Ing. D. Untiedt | |
| Lecturer: | Prof. Dr.-Ing. D. Untiedt | |
| Language: | English | |
| Place in curriculum: | Core | |
| Timetabled hours: | Project: | 2 HPW |
| Workload: | 30 h attendance<br>20 h preparation and review<br>10 h exam preparation | |
| Credits: | 2 | |
| Recommended prerequisites: | 2013 Business Economics and Project Management" or 2503 Internal Accounting | |
| Module objectives: | Entrepreneurial thinking and acting of the students will be trained specifically with regard to the main responsibilities of business establishment. After finishing the module, they are able to analyse and evaluate markets, market developments, customer values and competitive advantages. They show fundamental knowledge of generating business plans in which the business concept always remains the focal point. | |
| Content: | • Theoretical basics<br>• Legal forms<br>• Business plan creation | |
| Assessment: | Attestation: Continuous Assessment | |
| Forms of media: | Webex/Moodle | |
| Literature: | 1. Barringer, B. R.; Ireland, D.: Entrepreneurship – Successfully Launching New Ventures, 4th edition, Prentice Hall, 2012.<br><br>Further Readings:<br><br>2. Lambing, P. A.; Kuehl, Ch. R.: Entrepreneurship. 4th edition, Prentice Hall, 2007<br><br>3. Bygrave, W. D.; Zacharakis, A.: Entrepreneurship. Wiley, 2008 | |

## 2701 Engineering Drawing and Design

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|---|---|---|
| Module name/Module code: | Engineering Drawing and Design | 2701 |
| Degree: | Industrial Engineering:<br>Mechanical Engineering:<br>Mechatronic Systems Engineering: | IE 2 2701<br>ME 2 2701<br>MSE 2 2701 |
| Module coordinator: | Prof. Dr.-Ing. S. Danjou | |
| Lecturer: | Prof. Dr.-Ing. S. Danjou | |
| Language: | English | |
| Place in curriculum: | Core | |
| Timetabled hours: | Lecture:<br>Exercise:<br>Practical Training: | 2 HPW<br>1 HPW<br>1 HPW |
| Workload: | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation | |
| Credits: | 5 | |
| Prerequisites: | none | |
| Module objectives: | After successfully concluding the module, students should be able to sketch ideas in two and three dimensions. Furthermore, the students know the structure on a design process in engineering<br><br>They are able to draw and read technical drawings for various projection methods. They are able to produce drawings for given components independently,<br>to define the necessary views and sections, to prepare the drawing for an intended purpose and to compile the necessary parts lists.<br><br>Students prove their learning progress with independently produced technical drawings. They learn to use checklists to ensure drawings according to international standards. They competently document what they have learned according to valid referencing rules.<br><br>Students get to know the organizational and contentual structure of a development project and its building blocks. They understand the need for a structured approach and define requirements for product development and utilization of the product. | |
| Content: | • General introduction to Product Development<br>• Design process acc. VDI 2221<br>• Conceptual design, embodiment design and detailed design<br>• Importance of Technical Drawing<br>• Standardization: DIN, EN, ISO<br>• Layout and lettering | |

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| | • Application of lines, line groups and line widths<br>• Orthographic projection<br>• Axonometric projection<br>• Sectional and auxiliary views<br>• Application-oriented dimensioning<br>• Dimensional tolerancing<br>• ISO system of fits: shaft-based / hole-based<br>• Geometric tolerancing<br>• Definition of surface properties (surface textures)<br>• Drawing types: working drawings, assembly drawings, variant drawings, electronic drawings, piping drawings, welding drawings<br>• Introduction to electronic drawings: representation of electric/electronic components, draughting of circuit diagrams<br>• Parts lists: types and representation<br>• Graphic representation of standardized fastening devices (threads, bolts, screws, washers, circlips, keys)<br>• Representation of common machine elements (roller bearings, springs, pins)<br>• Introduction to 3D CAD modelling |
| Assessment: | Attestation within the scope of laboratory and written examination (graded) |
| Forms of media: | Whiteboard, PowerPoint, projector, demonstration in the lecture, practical training |
| Literature: | Colin H. Simmons, Dennis E Maguire, Neil Phelps: Manual of Engineering Drawing – Technical Product Specification and Documentation to British and International Standards, 3rd edition, Elsevier/Newnes, 2006<br><br>Cecil Jensen, Jay D. Helsel, Dennis R. Short: Engineering Drawing & Design, 7th revised edition, McGraw-Hill Higher Education, 2007<br><br>U. Fischer: Mechanical and Metal Trades Handbook, 3rd Edition, Europa-Lehrmittel, 2013<br><br>G. Pahl, W. Beitz, J. Feldhusen, K.H. Grote: Engineering Design – A Systematic Approach, 3rd ed. 2007 (4. November 2014), Springer, 2014<br><br>Further reading:<br>Gary R. Bertoline: Fundamentals of Graphics Communication, 6th ed., McGraw-Hill, 2010<br><br>Hans Hoischen, Andreas Fritz: Technisches Zeichnen – Grundlagen, Normen, Beispiele, Darstellende Geometrie (*Technical Drawing – Fundamentals, standards, examples, descriptive geometry*), 35th revised and updated edition, Cornelsen-Verlag, 2016 |

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| | Course materials from the lecturer<br>Exercises from the lecturer |

## 2705 Engineering Design

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| Module name/Module code: | Engineering Design | 2705 |
| Degree: | Industrial Engineering:<br>Mechatronic Systems Engineering: | IE 5 2705<br>MSE 3 2705 |
| Module coordinator: | Prof. Dr.-Ing. P. Kisters | |
| Lecturer: | Prof. Dr.-Ing. P. Kisters<br><br>K. Schacky | |
| Language: | English | |
| Place in curriculum: | Core | |
| Timetabled hours: | Lecture:<br>Exercise: | 2 HPW<br>2 HPW |
| Workload: | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation | |
| Credits: | 5 | |
| Prerequisites: | 2701 Engineering Drawing and Design | |
| Module objectives: | After successfully finishing the module, students are able to transfer physical principles to the calculations of components. They recognise fluxes and disturbances of those and present constructive improvement measures. Students know essential design rules and apply them to the designing of components. They conduct design calculations of simple machine elements and are finally able to select and design them under consideration of the aspects of reliability, material use and cost. They are able to calculate potentials relating to component strains and to evaluate them compared to given component key figures. | |
| Content: | • Introduction to strength calculation of real components<br>• Material characteristics, elastic and plastic deformation, yield strength, fracture strength<br>• Equivalent stress concepts and theories for calculation of machine elements<br>• Definition of limit and long life fatigue strength, influence of stress cycles on component lifespan<br>• Influence of design on component strains, notch effects and frame influence<br>• Dimensioning and calculation of elastic springs under torsional stressing<br>• Design of springs and spring systems<br>• Systematic arrangement of component joints<br>• Dimensioning and designing of bolt joints<br>• Dimensioning and designing of compression joints with divided and slotted hub | |

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| | • Theoretical fundamentals of threads, selection and application limits of screwed joints<br>• Designing and calculating of screwed joints under consideration of different load conditions<br>• Welding techniques and applications as well as weldability<br>• Representation of various verification concepts<br>• Design, calculation and structural limits of welding joints<br>• Design of roller bearings<br>• Roller bearing calculation under consideration of operating conditions (temperature, lubrication) and combined axial/radial strain |
| Assessment: | Written examination |
| Forms of media: | Webex/Moodle |
| Literature: | Richard G. Budynas:<br>Shigley's Mechanical Engineering Design, Student international edition, 10th revised edition, ISBN 978-9814595285, McGraw-Hill College, 2009<br><br>Robert L. Mott:<br>Machine Elements in Mechanical Design, 4th edition, ISBN 978-0130618856, Prentice Hall, 2003<br><br>Course materials from the lecturer<br>Exercises from the lecturer<br><br>Further Reading:<br><br>Roloff/Matek:<br>Maschinenelemente: Normung, Berechnung, Gestaltung (Machine Elements: Standardization, Calculation, Design), 22nd revised and expanded edition, ISBN 978-3658090814, Vieweg Teubner, 2011)<br><br>Decker:<br>Maschinenelemente: Funktion, Gestaltung und Berechnung (Machine Elements: Function, Design and Calculation), 19th updated edition, ISBN 978-3446438569, Carl Hanser Verlag, 2011 |

## 2706 Manufacturing Technology

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|---|---|---|
| Module name/ Module code:: | Manufacturing Technology | 2706 |
| Degree: | Industrial Engineering:<br>Mechanical Engineering:<br>Mechatronic Systems Engineering: | IE 2 2706<br>ME 4 2706<br>MSE 2 2706 |
| Module coordinator: | Prof. Dr.-Ing. A. Klein | |
| Lecturer: | External lecturer | |
| Language: | English | |
| Place in curriculum: | Core | |
| Timetabled hours: | Lecture:<br>Exercise: | 3 HPW<br>1 HPW |
| Workload: | 60 h attendance<br>45 h preparation and review (3 h per week)<br>45 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | none | |
| Module objectives: | Students have a good overview about many manufacturing technologies and know the basic advantages and disadvantages of the technologies.<br>They know the most important process parameters of most technologies and have an understanding of the challenge to find good process parameters to achieve a good total utility of the process with oftentimes-conflicting goals.<br>Furthermore, they have a good basic knowledge about the types of machines used for the manufacturing technologies. They understand the quality requirements of machine tools and other related pieces of production equipment and metrology equipment needed for quality assurance.<br>Additionally, they know the basic functions of CAM tools (computer aided manufacturing) and its role in industrial manufacturing (and the CAD/CAM chain). | |
| Content: | Manufacturing technologies<br>(structure similar to DIN 8580)<br>• Definition of value creation and disambiguation against other forms of production (such as chemical processing, agricultural production (farming etc.), assembly, food and beverage production)<br>• Primary forming (casting (sand casting, injection moulding etc.), powder pressing (with subsequent sintering), additive manufacturing (stereo lithography, SLM (selective laser melting) and SLS (selective laser sintering), FDM/FFF (fused deposition modelling/ fused filament fabrication)), three dimensional printing))<br>• Deforming (cold deforming, warm deforming, sheet metal forming, bulk deforming, true strain, strain hardening, tool and die making and repair) | |

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| | • Disaggregation (turning, milling (including gear hobbing and 5 axis milling), drilling, broaching, tapping, sawing, grinding, honing, lapping, cutting tool materials, cutting tool wear, cutting tool coatings, dry and wet cutting, burr creation and deburring, unwanted collateral effects (e.g. grinding burn and white layers), process disturbances (e.g. chatter (basics only))<br>EDM (electrical discharge machining), ECM (electro chemical machining))<br>• Joining (welding, soldering, glueing)<br>(basics only, redundancy to metallic materials to be avoided)<br>• Coating (PVD, CVD, electro plating)<br>(basics only)<br>• Change of material properties (heat treatment processes and heat distortions as collateral effects)<br>(basics only)<br><br>Manufacturing equipment and software (basics only):<br>• Machine tool types<br>• Important properties and quality characteristics of machine tools<br>• Important components in machine tools<br>• CNC technology<br>• Related equipment: tools, workholding (clamping systems), metrology equipment, CAM systems<br><br>Quality assurance (not quality management):<br>• Destructive and non-destructive testing<br>• Sample testing and 100% testing<br>• First part qualification<br>• Batch effects<br>• Metrology equipment (basics only)<br><br>Eventually:<br>• Job profiles for people with manufacturing expertise<br>• Basics of technology development<br>(and purpose of DoE (design of experiments)) |
| Assessment: | Written examination |
| Forms of media: | projector, Power point with notes (electronic pen in ppt slides during lecture), whiteboard |
| Literature: | Kalpakjian & Schmid:<br>Manufacturing Processes for Engineering Materials, 5th edition, ISBN 978-0132272711, Prentice Hall<br><br>Lecture slides provided to students<br><br>Further reading / self-study material:<br>• virtual laboratory (videos, HSRW own production) |

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| | • youtube videos of many manufacturing technologies<br>• Further readings in public domain<br>(e.g. open courseware or wikipedia articles on selected topics)<br>• Question catalogue for exam preparation |

## 2708 Thermodynamics

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|---|---|---|
| Module name/Module code: | Thermodynamics | 2708 |
| Degree: | Industrial Engineering:<br>Mechanical Engineering:<br>Mechatronic Systems Engineering: | IE 5 2708<br>ME 3 2708<br>MSE 3 2708 |
| Module coordinator: | Prof. Dr.-Ing. J. Gebel | |
| Lecturer: | Prof. Dr.-Ing. J. Gebel | |
| Language: | English | |
| Place in curriculum: | Core | |
| Timetabled hours: | Lectures:<br>Exercise:<br>Practical Training: | 2 HPW<br>1 HPW<br>1 HPW |
| Workload: | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | 2000 Introductory Mathematics<br>2003 Physics | |
| Module objectives: | Students know the terminology of intensive and extensive state variables (temperature, pressure, specific volume) and are able to apply them correspondingly. They are able to apply the first and second law of thermodynamics for closed and open system. They are able to solve thermodynamic problems by applying enthalpy and entropy correctly. They are able to analyse thermodynamic cycles, i.e. Carnot cycle, Rankine cycle, Stirling cycle, Otto cycle and Diesel cycle. With this knowledge, students are able to analyse gas and vapour power systems such as a steam power plant or a gas turbines and to determine their thermal efficiencies. In the laboratory framework, students learn how to measure temperature and pressure, how a boiling curve can be determined with a Marcet boiler, and how an ideal gas behaves under different conditions. They learn how to operate a steam engine, a hot-air engines, i.e. a Stirling motor, and an air compressor especially with regard to valid safety standards. | |
| Content: | Based on a detailed elaboration of the fundamentals of thermodynamics, the first and second law of thermo-dynamics will be introduced. This offers the requisite knowledge to be able to deal with thermodynamic processes like vapour and gas power systems. In detail, the module contains the following:<br><br>1 General fundamentals<br>1.1 System and control volume<br>1.2 State and state variables<br>1.3 Process and change of state | |

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| | 1.4 Evaluating properties<br><br>2 First law of thermodynamics<br>2.1 Work and heat<br>2.2 Inner energy and enthalpy<br>2.3 Conservation of energy for a control volume<br>2.4 First law for steady-state flow processes<br><br>3 Second law of thermodynamics<br>3.1 Clausius statement and Kelvin statement<br>3.2 Definition of entropy<br>3.3 Reversible and irreversible processes<br><br>3 Gas power systems<br>3.1 Carnot cycle<br>3.2 Otto cycle<br>3.3 Diesel cycle<br><br>4 Vapour power systems<br>4.1 Rankine cycle with superheating and reheating<br>4.2 Gas and steam turbine power plants (‘GuD’) |
| Assessment: | Graded written examination |
| Forms of media: | Moodle |
| Literature: | Michael J. Moran, Howard Shapiro:<br>Fundamentals of Engineering Thermodynamics, SI-Version, ISBN 978-0-470-54019-0<br><br>Further Readings:<br>Robert Balmer:<br>Modern Engineering Thermodynamics, ISBN 978-0-12-374996-3<br><br>Yunus A. Cengel, Michael A. Boles:<br>Thermodynamics An Engineering Approach: 7$^{th}$edition in SI-Units, ISBN 978-007-131111-3<br><br>Claus Borgnakke, Robert E. Sonntag:<br>Fundamentals of Thermodynamics, International Student Version, 7$^{th}$edition, ISBN 978-0-470-17157-8 |

## 2710 Fluid Mechanics

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| Module name/Module code: | Fluid Mechanics | 2710 |
| Degree: | Mechanical Engineering:<br>Industrial Engineering:<br>Mechatronic Systems Engineering: | ME 4 2710<br>IE 4 2710<br>MSE 4 2710 |
| Module coordinator: | Prof. Dr.-Ing. J. Gebel | |
| Lecturer: | Prof. Dr.-Ing. J. Gebel<br>Prof. Dr. N. Ostergaard | |
| Language: | English | |
| Place in curriculum: | Focus Field Subject | |
| Timetabled hours: | Lectures:<br>Exercise:<br>Practical Training: | 2 HPW<br>1 HPW<br>1 HPW |
| Workload: | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | | |
| Module objectives: | On completion of this module the student is able to...<br>– understand the principles of Fluid Mechanics,<br>– identify the importance and role of Fluid Mechanics within the Mechanical Engineering profession,<br>– understand how physical principles such as conservation of mass, momentum, and energy determine fluid behaviour and lead to mathematical descriptions of key features;<br>– understand the advantages and limitations of Fluid Mechanics models, equations and formulae;<br>– use the principles of Fluid Mechanics to solve engineering problems involving such quantities as velocity, pressure, forces (e.g. friction, drag, lift), power requirements, and efficiency.<br>In the laboratory framework, students learn how to measure the pressure losses of a piping system, how to operate a Venturi meter to determine the flow velocity in a tube, how to determine the velocity of fall using Stokes' law, and how to operate a sedimentation basin. | |
| Content: | • Fluid Properties<br>– Density, viscosity, compressibility<br>• Fluids at rest (Hydrostatics)<br>– Pressure in liquids at rest<br>– Stability of submerged and floating objects<br>– Rotating containers<br>• Fluids in motion<br>– Pathlines, streaklines and streamlines<br>– Viscous and inviscid flows<br>– Laminar and turbulent flows | |

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| | • Integral forms of the fundamental laws<br>– Equation of continuity<br>– Energy equation<br>– Bernoulli equation<br>– Momentum equation<br>• Internal flows<br>– Laminar and turbulent flow between plates<br>– Laminar and turbulent flow in a pipe<br>– Hagen-Poiseuille equation<br>• External flows<br>– Flow around immersed bodies<br>– Stokes law<br>– Lift and drag on airfoils<br>• Introduction to Computational Fluid Dynamics CFD |
| Assessment: | Graded written examination |
| Forms of media: | Smartboard/WACOM-Board, PowerPoint, Projector |
| Literature: | Merle C. Potter, David C. Wiggert, Bassem H. Ramadan: Mechanics of fluids. 4th edition, ISBN 978-1-4390-6203-6<br><br>Further Readings:<br><br>K.S.N. Raju: Fluid Mechanics, Heat Transfer, and Mass Transfer. Chemical Engineering Practice. John Wiley & Sons, 2011. ISBN 978-0-470-63774-6<br><br>Pijush K. Kundu, Ira M. Cohen. Fluid Mechanics. Elsevier, 2008. Fourth Edition, ISBN 978-0-12-381-399-2<br><br>Herbert Oertel jr., Sebastian Ruck. Bioströmungsmechanik. Vieweg+Teubner Verlag, 2012. 2. Auflage, ISBN 978-3-8348-1765-5. |

## 2717 Mobile Hydraulics

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| Module name/Module code: | Mobile Hydraulics 2717 |
| Degree: | Mechanical Engineering: ME 5 2717<br>Mechatronic Systems Engineering: MSE 5 2717 |
| Module coordinator: | Prof. Dr.-Ing. Dipl.-Wirt. Ing. R. Schmetz |
| Lecturer: | Prof. Dr.-Ing. Dipl.-Wirt. Ing. R. Schmetz |
| Language: | English |
| Place in curriculum: | Focus Field Subject |
| Timetabled hours: | Lecture: 2 HPW<br>Exercise: 1 HPW<br>Practical Training: 1 HPW |
| Workload: | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation |
| Credits: | 5 |
| Recommended prerequisites: | 2010 Dynamics<br>2305 Fundamentals of Electrical Engineering<br>2711 Drive Systems or<br>2901 Drives and Power Electronics |
| Module objectives: | After completion of the module students are able to<br>• understand the principles of industrial and mobile hydraulic systems and compare them with mechanical, pneumatic, mechatronic and electric drives<br>• read and understand hydraulic circuit diagrams<br>• explain the differences between industrial and mobile hydraulic applications<br>• describe typical applications of mobile hydraulics and explain their advantages and disadvantages<br>• assign the functions to typical mobile hydraulic components, arrange them in mobile hydraulic circuits and conduct simple calculations<br>• use electric actuators and analog closed control loops in industrial and mobile hydraulic applications |
| Content: | Fundamentals of hydraulics, typical applications, advantages and disadvantages, definitions and contexts<br><br>Industrial and mobile hydraulic components: Fluids, pumps, cylinders, motors, valves, orifices, accumulators, filters, containers and sensors<br><br>Industrial Hydraulics<br><br>Mobile hydraulic throttle control systems<br><br>Mobile hydraulic load sensing systems |

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| | Mobile hydraulic load pressure independent flow distribution (LUDV) systems<br><br>Analog closed control loops |
| Assessment: | Written examination |
| Forms of media: | Presentation, Whiteboard, Projector, Practical Demonstrations with Trainings System |
| Literature: | Course materials from the lecturer<br>Exercises from the lecturer<br><br>Further Readings:<br>Project-Manual “Industrial Hydraulics”<br>Publisher: Bosch-Rexroth AG, 2007,<br>Order No. R961003751<br><br>Project-Manual “Mobile Hydraulics - Throttle Control”<br>Publisher: Bosch-Rexroth AG, 2011,<br>Order No. R961005093<br><br>Project-Manual “Mobile Hydraulics - Load Sensing Control”<br>Publisher: Bosch-Rexroth AG, 2011,<br>Order No. R961005146<br><br>Project-Manual “Mobile Hydraulics - LUDV”<br>Publisher: Bosch-Rexroth AG, 2011,<br>Order No. R961005148<br><br>Project-Manual “Analog Position Control Loop”<br>Publisher: Bosch-Rexroth AG, 2011,<br>Order No. R961005092 |

## 2900 Introduction to Engineering

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| Module name/Module code: | Introduction to Engineering 2900 |
| Degree: | Mechatronic Systems Engineering: MSE 1 2900 |
| Module coordinator: | Heads of the degree program |
| Lecturer: | Prof. Dr.-Ing. T. Brandt<br>Prof. Dr.-Ing. H. Schütte<br>Prof. Dr. A. Struck<br>A. Viermann |
| Language: | English |
| Place in curriculum: | Core |
| Timetabled hours: | Descriptive Statistics and Reporting:<br>Lecture: 1HPW<br><br>Basics of Communication and Self-Management:<br>Seminar: 1 HPW<br><br>Introduction to Mechatronic Systems Engineering:<br>Lecture: 1 HPW |
| Workload: | Descriptive Statistics and Reporting:<br>15 h attendance<br>15 h preparation<br><br>Basics of Communication and Self-Management:<br>15 h attendance<br>15 h preparation and self study<br><br>Introduction to Engineering<br>15 h attendance<br>15 h preparation |
| Credits: | 3 |
| Recommended prerequisites: | none |
| Module objectives: | Descriptive Statistics and Reporting:<br>• Students learn to present, summarize, and interpret data in a meaningful way. They learn to present data graphically using standard software packages. The focus lies on enabling the students to handle experimental data in future lab reports.<br><br>Basics of Communication and Self-Management:<br>• Getting to know and apply helpful first basic knowledge, methods and strategies in order to build up skills and capabilities to succeed in studying, communicating and working together with others.<br>• Supporting with adequate exercises and team building elements the team building processes within the study courses in the first semester. On this base, reflect on the |

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| | experiences and proceedings in order to learn from it for other transferable settings in teams and oganizations. |
| Content: | Descriptive Statistics and Reporting:<br>• sample vs. population<br>• grouping data<br>• Median, quartiles, percentiles<br>• Standard units (z-score), bivariate data, scatter plot<br>• Regression – least squares<br>• Report writing<br>• Error propagation<br><br>Basics of Communication and Self-Management:<br>• Communication and Conflict Management<br>• Learning and Self-Management<br>• Dealing with Stress<br>• Working Together |
| Assessment: | Attestation |
| Forms of media: | Webex/Moodle |
| Literature: | Reporting and Descriptive Statistics:<br>Devore, J. (2012). *Probability and Statistics for Engineering and the Sciences* (8th edition Ausg.). Boston: Brooks/Cole.<br><br>Mittal, H. V. (2011). *R Graphs Cookbook.* Brimingham - Mumbai: Packt Publishing<br><br>Basics of Communication and Self-Management:<br>Different literature related to the different topics as well as additional learning material will be provided during class. |

## 2901 Drives and Power Electronics

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| Module name/Module code: | Drives and Power Electronics 2901 |
| Degree: | Electrical and Electronics Engineering: EL 3 2901<br>Mechatronic Systems Engineering: MSE 3 2901 |
| Module coordinator: | Prof. Dr.-Ing. Dipl.-Wirt. Ing. R. Schmetz |
| Lecturer: | Prof. Dr.-Ing. Dipl.-Wirt. Ing. R. Schmetz |
| Language: | English |
| Place in curriculum: | Core |
| Timetabled hours: | Lecture: 2 HPW<br>Exercise: 2 HPW |
| Workload: | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation |
| Credits: | 5 |
| Recommended prerequisites: | 2008 Statics and Strength of Materials<br>2001 Introductory Mathematics<br>2002 Applied Mathematics<br>2301 Electrical Engineering I<br>2302 Electrical Engineering II<br>2304 Analog Electronics |
| Module objectives: | After completion of the module students are able to<br>• perform basic analyses of drivetrains and reduce them to a single equivalent mass inertia<br>• understand the working principles of the most common electric motors and their properties<br>• perform simple calculations and dimensioning tasks regarding electric motors<br>• match the properties of electric motors with the given requirements of drivetrains<br>• describe the most common power semiconductors and their properties and application ranges<br>• perform simple calculations regarding the losses of power semiconductors at operation<br>• understand the fundamentals of electrical energy conversion and inversion and describe the most common energy conversion and inversion circuits<br>• perform simple calculations on rectifiers and buck-, boost- and buckboost-converters<br>• describe different modulation methods for converters and inverters<br>• understand the principle of speed and torque control of electric motors fed by converters and inverters |
| Content: | Objectives and basics of drives and power electronics<br>Electric motors and dimensioning of drives<br>Power semiconductor devices and their losses<br>Energy conversion and inversion circuits<br>Motion control |

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| Assessment: | Written examination |
| Forms of media: | Presentation, Whiteboard, Projector, Practical Demonstrations with Training-Systems |
| Literature: | De Doncker, R.<br>Lecture Notes Power Electronics - Fundamentals, Topologies, Analysis, 4th edition<br>Institut für Stromrichtertechnik und Elektrische Antriebe (ISEA), Aachen, 2013<br>ISBN 978-3-943496-00-0<br><br>Mohan, N., Undeland, T., Robbins, W.<br>Power Electronics<br>3rd edition, John Wiley, 2003,<br>ISBN 978-0-471-22693-2<br><br>Further Readings:<br><br>Automotive Handbook, published by Robert Bosch GmbH, 8th Edition, John Wiley & Sons Ltd., Chichester, 2011<br>ISBN 978-1-119-97556-4<br><br>Hughes, A., Drury, B.<br>Electric motors and drives<br>4th edition, Elsevier, 2013<br>ISBN 978-0-08-099368-3<br><br>Mott, Robert L., Tang, J.<br>Machine Elements in Mechanical Design<br>4th edition in SI-units, Pearson Prentice Hall, 2004,<br>ISBN 978-0-13-197644-3<br><br>Course materials from the lecturer<br><br>Exercises from the lecturer |

## 2902 System Theory and Controls

| Module name/ Module code:: | System Theory and Controls | 2902 |
|---|---|---|
| Degree: | Electrical and Electronics Engineering:<br>Industrial Engineering:<br>Mechanical Engineering:<br>Mechatronic Systems Engineering: | EL 4 2902<br>IE 4 2902<br>ME 4 2902<br>MSE 4 2902 |
| Module coordinator: | Prof. Dr.-Ing. D. Nissing | |
| Lecturer: | Prof. Dr.-Ing. D. Nissing | |
| Language: | English | |
| Place in curriculum: | Core subject | |
| Timetabled hours: | Lectures:<br>Tutorials:<br>Practical Training: | 2 HPW<br>1 HPW<br>1 HPW |
| Workload: | 60 h attendance<br>50 h preparation and review<br>40 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | 2001 Applied Mathematics<br>2008 Static and Strength of Materials (for EL) **or**<br>2010 Dynamics (for IE, ME and SE)<br>2301 Electrical Engineering I (for EL) **or**<br>2305 Fundamentals of Electrical Engineering (for IE, ME and SE) | |
| Module objectives: | After finishing this module, students have fundamental knowledge and abilities for the mathematical description and regulation of technical systems and are able to present these via block wiring diagrams.<br>Furthermore, students are able to analyse and evaluate mathematically described time-continuous single-input/single-output (SISO) control systems by means of system theory knowledge. By doing this, a controller can be designed correspondingly meeting given requirements regarding stationary and dynamic behaviour.<br>Additionally, students gain the ability to deduce requirements for the necessary measurement technique.<br>The control engineering methods learnt this way will be deepened and attested by a tutorial as well as by laboratory work. Here, computer based development tools will be used, particularly Matlab/Simulink, so students are also able to cope with descriptions, calculations and analyses in a practice-oriented manner. | |
| Content: | • Mathematical modelling of technical systems by means of differential equations<br>• System description via block diagrams<br>• Functionality and basic structure of control circuits<br>• Characteristics of control systems<br>– Linear and non-linear systems | |

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| | – Linearization<br>– Systems with concentrated/distributed parameters<br>– Time-variant and time-invariant systems<br>– Causal and non-causal systems<br>• Description of linear continuous systems<br>– Time domain: step response, impulse response, convolution integral<br>– Frequency domain: Laplace transformation, transfer functions<br>• Characteristics of systems<br>– Proportional, integral, derivative and its combinations<br>– Block diagram transformation<br>– Closed-loop transfer function: Reference and disturbance transfer function<br>• Frequency domain characteristics<br>– Nyquist-Plot<br>– Bode-diagram<br>• Stability of linear continuous control systems<br>– Definition of stability and stability condition<br>– Hurwitz criterion/Routh criterion/Nyquist criterion<br>– Gain and phase margin<br>• Design method for linear continuous control systems |
| Assessment: | laboratory, written examination |
| Forms of media: | Whiteboard, PowerPoint, Projector, Computer based Engineering Tools Matlab/Simulink |
| Literature: | Nise, Norman S.: Control Systems Engineering. 2011, John Wiley & Sons. ISBN 978-0-470-64612-0<br><br>Dorf, R. C., R.H. Bishop: Modern Control Systems. 2011, Pearson Education. ISBN 978-0-13-138310-4<br><br>Franklin, G. F., J.D. Powell, A. Emami-Naeini: Feedback Control of Dynamic Systems. 2010, Pearson Education. ISBN 978-0-13-500150-9<br><br>Ogata, K.: Modern Control Engineering. 2010, Pearson Education. ISBN 978-0-13-713337-6 |

## 2903 Controls

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|---|---|---|
| Module name/Module code: | Controls | 2903 |
| Degree: | Electrical and Electronics Engineering:<br>Mechanical Engineering:<br>Mechatronic Systems Engineering: | EL 5 2903<br>ME 5 2903<br>MSE 5 2903 |
| Module coordinator: | Prof. Dr.-Ing. D. Nissing | |
| Lecturer: | Prof. Dr.-Ing. D. Nissing | |
| Language: | English | |
| Place in curriculum: | Electrical Engineering:<br>Mechanical Engineering:<br>Mechatronic Systems Engineering: | Focus Field Subject<br>Core<br>Core |
| Timetabled hours: | Lectures:<br>Tutorials:<br>Practical Training: | 2 HPW<br>1 HPW<br>1 HPW |
| Workload: | 60 h attendance<br>50 h preparation and review<br>40 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | 2902 System Theory and Controls | |
| Module objectives: | After finishing the module, students are able to design, analyse, evaluate and apply enhanced controllers. For this, the knowledge gained in the module “System Theory and Controls” is used and expanded by additional processes and methods. Students will for example be able to describe control systems with multiple inputs and outputs in state space, describe time discrete systems and have the ability to develop programmable logic controllers (PLC). Furthermore, students gain the necessary skills to design and to parameterise linear observers for determining non-measurable properties or those that can only be determined by very elaborate methods. Identifying corresponding structural measures such as controllability and observability are also a part of this.<br>Additionally, students are able to implement the controllers they have designed into digital control systems. Apart from time-discrete controllers, dimensioning and definition of control systems also fall under this aspect.<br>The methods learned this way will be deepened and attested by tutorial as well as by laboratory work. Here, computer based development tools will be used to design a controller upon a model of the plant, particularly Matlab/Simulink and Siemens Step7, so students are also able to cope with descriptions, calculations and analyses in a practice-oriented manner. | |
| Content: | • Programmable logic controllers (PLC)<br>- Hardware and components<br>- Fundamentals of logic | |

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| | - Flip-flops<br>- PLC programming (ladder diagram, instruction list, functional block diagram, flowchart)<br>- Karnaugh-Veitch (KV)-Diagram<br>- Programming timers and counters<br>• State space control<br>- State variable representation (state space model)<br>- Normal forms in state space representation<br>- Stability in state space<br>- Controllability and state space controller<br>- Synthesis of linear control systems in state space<br>• Reconstruction of states via observer techniques<br>• Linear time-discrete systems (digital controlling)<br>- Functioning of digital control systems<br>- z-transformation<br>- Closed-loop feedback sampled-data systems<br>- Stability of time-discrete systems |
| Assessment: | Attestation within the scope of laboratory, written examination |
| Forms of media: | Webex/Moodle |
| Literature: | Nise, Norman S.: Control Systems Engineering. 2011, John Wiley & Sons. ISBN 978-0-470-64612-0<br><br>Dorf, R. C., R.H. Bishop: Modern Control Systems. 2011, Pearson Education. ISBN 978-0-13-138310-4<br><br>Petruzella, Frank D.: Programmable Logic Controllers. 2011, McGraw-Hill. ISBN 978-0-07-351088-0<br><br>Berger, Hans: Automating with SIMATIC S7-1200. 2011, Publicis. ISBN 978-3-89578-356-2 |

## 2904 Modelling and Simulation

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|---|---|---|
| Module name/Module code: | Modelling and Simulation | 2904 |
| Degree: | Industrial Engineering:<br>Mechanical Engineering:<br>Mechatronic Systems Engineering: | IE 5 2904<br>ME 5 2904<br>MSE 4 2904 |
| Module coordinator: | Prof. Dr.-Ing. T. Brandt | |
| Lecturer: | Prof. Dr.-Ing. T. Brandt | |
| Language: | English | |
| Place in curriculum: | Industrial Engineering:<br>Mechanical Engineering:<br>Mechatronic Systems Engineering: | Focus Field subject<br>Core subject<br>Core subject |
| Timetabled hours: | Lectures:<br>Practical Training: | 2 HPW<br>2 HPW |
| Workload: | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | 2010 Dynamics | |
| Module objectives: | After successfully finishing the module, students are able to apply engineering modelling techniques to problems arising in the fields of mechanical and electrical engineering. Besides mechanical or electrical systems this includes also examples like DC-motors that link different technical domains together. The students should be able to select suitable simulation methods for technical systems and to apply them practically e.g. in MATLAB/Simulink. The students are able to identify steady states of dynamic systems and are able to linearize about them in order to create linear state space models. The student is familiar with basic numerical solution methods for differential equations. Finally, students should be able to interpret simulation results correctly and should be able to estimate the reliability of simulation results after completing the module. | |
| Content: | The course covers the fundamental methods of Modelling and Simulation of engineering systems (lecture) and applications (exercise)<br><br>Contents in detail:<br>• Definitions, general concepts<br>• Methods of modelling of engineering systems<br>• Introduction of differential and shortly to differential-algebraic equations<br>• Identification of steady states<br>• Linearization<br>• Constraints of technical systems | |

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| | • Numerical methods for solving linear and non-linear state equations (initial value problems)<br>• Identification of parameters<br>• Application of MATLAB/Simulink |
| Assessment: | Examination (oral or written) |
| Forms of media: | Webex/Moodle |
| Literature: | Klaus Janschek:<br><br>Mechatronic Systems Design: Methods, Models, Concepts, Springer 2012, SBN-13: 978-3642175305<br><br>Further Readings:<br><br>F.E. Cellier:<br>Continuous System Modeling, Springer Verlag, 1991 |

## 2905 FEM

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| Module name/Module code: | Finite Element Analysis 2905 |
| Degree: | Mechanical Engineering: ME 5 2905<br>Mechatronic Systems Engineering: MSE 5 2905 |
| Module coordinator: | Prof. Dr.-Ing. H. Schütte |
| Lecturer: | Prof. Dr.-Ing. H. Schütte |
| Language: | English |
| Place in curriculum: | Focus Field Subject |
| Timetabled hours: | Lecture: 2 HPW<br>Exercise: 2 HPW |
| Workload: | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation |
| Credits: | 5 |
| Recommended prerequisites: | 2002 Numerical Mathematics<br>2106 Metallic Materials and Testing or<br>2108 Materials and Testing |
| Module objectives: | The students are able to decide when and if it is advisable to use the Finite Element Method as the proper numerical tool. They know the theoretical background of the method and are able to build up FEM simulation models. They are able to introduce engineering modelling simplifications to balance effort and accuracy. Using their mechanical and physical background knowledge they can define material properties, boundary conditions and interpret solution results. They can evaluate the proper quality of an FEM discretization (mesh). They know how to approach geometrically and material non-linearities of the models. They interpret results with respect to their accuracy and if these are suitable for the design purpose of the simulation. The students are able to undertake their own analysis and write the corresponding reports and can discuss the results based on presentations. |

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| Content: | Idea of FEM<br>Impact on and position of FEM in the engineering design process<br>• Comparison of advantages and disadvantages of analytical, numerical and especially FEM solutions<br>• Different element types and shape functions<br>• Element and mesh quality<br>• Material models, especially Plasticity<br>• Differences between linear and non-linear models<br>• Examples of non-linear simulations<br>• Simulating contact<br>• Writing reports on calculations and present them<br>• Critical analysis of simulation results<br>• Limitations of FEM Calculations<br>• Design and Optimization of Parts using elastic and elasto-plastic material models |
| Assessment: | written examination (homework assignment) |
| Forms of media: | Webex/Moodle |
| Literature: | H. Lee: Finite Element Simulations With ANSYS Workbench 16, ISBN 978-1585039838 SDC Publication, 2016<br><br>Erdogan Madenci, Ibrahim Guven:<br>The Finite Element Method and Applications in Engineering Using ANSYS, Corrected and 4th printing, ISBN 978-0-387-28289-3, Springer, 2007 |

## 2907 Sensors and Actuator Networks

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|---|---|
| Module name/Module code: | Sensor and Actuator Networks 2907 |
| Degree: | Electrical and Electronics Engineering: EL 5 2907<br>Mechatronic Systems Engineering: MSE 5 2907 |
| Module coordinator: | Prof. Dr. A. Stamm |
| Lecturer: | NN<br>External Lecturer |
| Language: | English |
| Place in curriculum: | Core: MSE<br>Focus Field Subject: EL |
| Timetabled hours: | Sensors and Actuators:<br>Practical: 2 HPW<br>Networks:<br>Lecture: 1 HPW<br>Exercise: 1 HPW |
| Workload: | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation |
| Credits: | 5 |
| Recommended prerequisites: | 2304 Analog Electronics<br>2305 Fundamentals of Electrical Engineering |
| Module objectives: | Students master the principles of different sensors and the further processing into data that is used in mechatronic systems. They are able to show the advantages of intelligent sensors and to judge their application. They are able to compare different effects and select suitable sensors by examples for recording different physical variables. They are able to specify the requirements for actuators in mechatronics. Students master the basic concepts of networks. They are able to classify different methods of data transmission via physical layers and distinguish the related methods of arbitration. Students are able to classify the advantages and disadvantages of different transmission methods and to select suitable bus systems for different cases of application. For this, they have knowledge of marketable bus systems for industrial applications. |
| Content: | Sensors and Actuators<br>• Basic terminology and Parameters of signals<br>• Measurement methods<br>• Basic principles of sensors, e.g. inductive, capacitive and magnetic.<br>• Measuring of different units, e.g. acceleration, distance etc.<br>• Processing of sensor data<br>• Sensor and actuator interfaces<br>• Typical sensors in practical applications<br>• Classification and selection of actuators |

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| | • Piezo sensors and actuators<br>Networks<br>• Basic structure of bus systems/communication interfaces<br>• Master/slave and Multi-master operation<br>• Requirement on bus systems<br>• Terminology of information theory: entropy, redundancy, decision content<br>• Ordinary channel models, channel capacity (Shannon, Nyquist model), influence of disturbances/noise<br>• The ISO/OSI reference model<br>• Placement of interfaces in the ISO/OSI reference model<br>• Physical bit transmission (NRZ/RZ signals, elementary bit coding)<br>• Topologies (ring, star, bus...)<br>• Arbitration process, Medium access control protocols (CSMA-CD, CSMA-CA, TDMA, Token-Ring)<br>• Methods for securing and checking data integrity<br>• Statistical determination of bit error rates<br>• Basic principles of analogue and digital modulation processes<br>• Network and Subnets design<br>• VLSM Addressing<br>• Typical bus systems in industrial automation<br>• CANBUS<br>• Ethernet and TCP/IP/UDP;<br>• Advantages and disadvantages of individual systems |
| Assessment: | Written examination |
| Forms of media: | Webex/Moodle |
| Literature: | Sensors and Actuators:<br>Jon Wilson, Sensor Technology Handbook, Newnes, 2004<br>Jacob Fraden: Handbook of modern Sensors, Springer, 2010<br><br>Jörg Haus: Optical Sensors: Basics and Applications, Wiley-VCH, 2010<br><br>Networks:<br>Wilamowski Bodgan, Bodgan Wilamowski, J. David Irwin, Industrial Communication Systems (The Industrial Electronics Handbook), Crc Pr., 2011<br><br>Tanenbaum, Wetherall, Computer Networks, Pearson, 2014<br><br>Further Readings:<br><br>Jon Wilson: Sensor Technology Handbook, Newnes, 2004<br>Robert H. Bishop: The Mechatronics Handbook - Mechatronic Systems, Sensors and Actuators, CRC Press, 2008 |

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| | Sawomir Tumanski: Principles of Electrical Measurement (Series in Sensors), Inst of Physics Pub, 2006<br><br>Gerhard Schnell, Bernhard Wiedemann, Bussysteme in der Automatisierungs- und Prozesstechnik: Grundlagen, Systeme und Trends der industriellen Kommunikation, (Bus Systems in Automation and Process Engineering: Fundamentals, Systems and Trends of Industrial Communications) Vieweg & Teubner, 2008<br><br>Friedrich Wittgruber, Digitale Schnittstellen und Bussysteme. Einführung für das technische Studium (Studium Technik) (Digital Interfaces and Bus Systems – Introduction to Engineering Studies), Vieweg, 2002<br><br>Richard Zurawski, The Industrial Communication Technology Handbook (The Industrial Information Technology Series), Crc Pr., 2005<br><br>Course materials from the lecturer |

## 2908 Multibody Dynamics

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|---|---|---|
| Module name/Module Code: | Multibody Dynamics | 2908 |
| Degree: | Mechanical Engineering:<br>Mechatronic Systems Engineering: | ME 4 2908<br>MSE 4 2908 |
| Module coordinator: | Prof. Dr.-Ing. T. Brandt | |
| Lecturer: | Prof. Dr.-Ing. T. Brandt | |
| Language: | English | |
| Place in curriculum: | Focus Field Subject | |
| Timetabled hours: | Lectures:<br>Exercises: | 2 HPW<br>2 HPW |
| Workload: | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | 2002 Numerical Mathematics<br>2010 Dynamics<br>2011 Programming | |
| Module objectives: | After successfully finishing the module, students are familiar with the fundamentals of multibody dynamics. They are able to apply basic concepts from linear algebra such as vectors and matrices to mechanical systems. The kinematics of technical joints such as revolute joints can be modelled by algebraic constraints by the student. The student is also able to model the dynamics of constraint multibody dynamic systems based on the method of Newton-Euler. Furthermore, the student is able to develop basic programming code in order to simulate planar multibody dynamic systems and to perform analysis of planar multibody dynamic systems. | |
| Content: | The course focuses on the modelling and numerical simulation of dynamic multibody systems.<br><br>Main subjects are:<br>• Definitions: bodies, joints, and coordinates<br>• Planar kinematics: rotation, translation<br>• Kinematic constraints<br>• Dynamics: Newton-Euler equations<br>• Development of multibody dynamics simulation code<br>• Analysis of multibody dynamic systems | |
| Assessment: | Examination (oral or written) | |
| Forms of media: | Whiteboard, PowerPoint, Projector, in PC exercises: MATLAB/Simulink | |
| Literature: | P. E. Nikravesh: | |

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| | Planar Multibody Dynamics - Formulation, Programming, and Application, CRC press,2008<br><br>Further Readings:<br><br>A.A. Shabana:<br>Dynamics of Multibody Systems, 1998 |

## 2909 Vehicle Technology

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| Module name/Module code: | Vehicle Technology | 2909 |
| Degree: | Mechatronic Systems Engineering: | MSE 4 2909 |
| Module coordinator: | Prof. Dr.-Ing. D. Nissing | |
| Lecturer: | Prof. Dr.-Ing. D. Nissing | |
| Language: | English | |
| Place in curriculum: | Focus Field Subject | |
| Timetabled hours: | Lectures:<br>Exercise:<br>Practical Training: | 2 HPW<br>1 HPW<br>1 HPW |
| Workload: | 45 h attendance<br>65 h preparation and review<br>40 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | 2010 Dynamics<br>2902 System Theory and Controls<br>2904 Modelling and Simulation | |
| Module objectives: | After completing this elective subject, students have knowledge of essential systems and components in vehicles. They are able to describe mathematically the characteristics of components and are able to integrate and analyse these in the overall context for the corresponding tasks of distinguishing features and typical characteristics for vehicles.<br>The knowledge and methods from the modules “System Theory and Controls”, “Dynamics” and “Modelling and Simulation” will be applied to vehicle technology.<br>After completing this course, students have gained the ability to describe vehicle dynamics in all six coordinates (longitudinal, lateral, vertical, pitch, roll and yaw behavior) and have the knowledge as to which components and systems characterise the respective behaviour and how to influence the dynamic behaviour, such as over and under-steering by ESP.<br>The gained knowledge will be deepened by practical tutorials. Here, computer based development tools are used, especially Matlab/Simulink, so students are also able to describe, calculate and analyse the different systems and features in a practical way. | |
| Content: | • Overview<br>– Terminology<br>– Control loop driver – vehicle – environment<br>– Active and passive safety<br>– Coordinate systems<br>• Requirements of driving dynamics of vehicles<br>• Suspension kinematics | |

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| | • Chassis systems and components (tire, axles and suspensions, spring-damper elements)<br>• Vertical dynamics<br>• Longitudinal dynamics<br>  – Driving resistances<br>  – Braking<br>• Lateral dynamics<br>  – Steering kinematics<br>  – Single-track (bicycle) model<br>  – Self-steering: over/under-steering<br>  – Multi-track model<br>• Vehicle control systems<br>  – ABS/ESP<br>  – Semi-active damper<br>  – Overlay of steering moments, steering angles<br>  – Active suspensions<br>• Driver assist functions |
| Assessment: | Examination (oral or written) |
| Forms of media: | Whiteboard, PowerPoint, Projector, Computer based Engineering Tools MATLAB/Simulink, Guest lecturer from the industry (if possible) |
| Literature: | George Rill: Road Vehicle Dynamics. CRC Press. 2012. ISBN 978-1-4398-3898-3.<br><br>Bernd Heißing, Metin Ersoy: Chassis Handbook. Vieweg. 2011. ISBN 978-3-8348-0994-0.<br><br>Further reading:<br><br>Giancarlo Genta: Motor Vehicle Dynamics. World Scientific. 2008. ISBN 978-981-02-2911-5.<br><br>Reza N. Jazar: Vehicle Dynamics. Springer. 2008. ISBN 978-0-387-74243-4.<br><br>H.-H. Braess, U. Seiffert: Vieweg Handbuch der Kraftfahrzeugtechnik (Handbook of Motor Vehicle Engineering). Vieweg. 2007. ISBN 978-3-8348-0222-4. |

## 2910 Robotics

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| Module name/Module code: | Robotics | 2910 |
| Degree: | Mechatronic Systems Engineering: | MSE 5 2910 |
| Module coordinator: | Prof. Dr.-Ing. T. Brandt | |
| Lecturer: | Prof. Dr.-Ing. T. Brandt | |
| Language: | English | |
| Place in curriculum: | Core | |
| Timetabled hours: | Lecture:<br>Exercise: | 2 HPW<br>2 HPW |
| Workload: | 60 h attendance<br>60 h preparation and review<br>30 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | 2010 Dynamics<br>2904 Modelling and Simulation<br>2902 System Theory and Controls<br>2901 Drives and Power Electronics | |
| Module objectives: | Students know mathematical methods for describing position and orientation of robots. They are able to create direct and inverse kinematic and dynamic models of a robot and to simulate corresponding robot motions. They are able to plan complex robot motions and to realize the planned trajectories. Students are particularly aware of different kinds of Human-Machine-Interaction and are able to define the technical components of assistance systems. | |
| Content: | • Description of position and orientation (vectors, angles, matrices, Euler angles)<br>• Kinematics of serial robots (Denavit-Hartenberg-convention, ambiguities, singularities, inverse kinematics), position, speed and acceleration of serial manipulators<br>• Dynamics of robots<br>• Design of robot trajectories<br>• Axis controls<br>• Force-based controls<br>• Human-Machine-Interaction (Haptic communication, visual communication)<br>• Applications | |
| Assessment: | Written examination or oral examination | |
| Forms of media: | Webex/Moodle | |
| Literature: | Mark W. Spong; Seth Hutchinson; Mathukumalli Vidyasagar: Robot Modeling and Control, Wiley & Sons, 2006, ISBN: 978-0471649908<br>John J. Craig: Introduction to Robotics: Mechanics and Control, Pearson Education, 3rd edition, 2009, ISBN-10: | |

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## 2911 Introduction to Scientific Methods in Mechatronics

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| Module name/Module code: | Introduction to Scientific Methods in Mechatronics 2911 |
| Degree: | Mechatronic Systems Engineering: MSE 7 2911 |
| Module Coordinator: | Head of degree program |
| Lecturer: | External lectures |
| Language: | English |
| Part of Curriculum | Elective |
| Timetable hours | Lecture 1 HPW<br>Practical Training 1 HPW |
| Workload | 150 h |
| Credits: | 5 |
| Recommended prerequisites:: | none |
| Module objectives: | The course offers an introduction to the ethics and logic of science as well as to some methods helpful for the investigation of technical questions. Beside methodological aspects the students understand their ethic responsibility as a scientist and reflect their work based on social impacts and scientific rules. The students know scientific misconduct like fabrication, falsification, copyright violation, wrong citation, plagiarism, violation of ethical standards etc. The students are able to get a full overview over their topic and use literature research for this. They repeat the basic principles of scientific procedure and are able to practically implement their knowledge on a scientific question. They are aware of the differences between theory and empiricism as well as between deductive and inductive reasoning. The students reflect their work accordingly. In case experimental validations of phenomena are required they are able to structure their test program using design of experiments. The students evaluate the limits for testing, they define and rate the required simplifications. Research results are analysed statistically and reflected critically in order to evaluate the quality of the results. Finally, the students prepare the results specific to a target groups. |
| Content: | Methodological principles encompass the entire process of the scientific questioning<br>• Science ethics<br>- what is allowed<br>- what shall remain unexplored<br>• Ethical standards in science<br>• Social impacts of science<br>• Analysis of the scientific question<br>• Literature research<br>• Definition state of the art<br>• Introduction to the logic of science<br>• Inductive vs. deductive reasoning |

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| | • Formulation of hypotheses<br>• Verification and falsification of hypotheses<br>• Degree of testability<br>• Simplification and probability<br>• Design of experiments<br>• Numerical and graphical data analysis<br>• Descriptive and analytical statistics<br>• Presentation of data / results<br>• Publication of the results in different forms (report, paper, poster, web pages etc.) |
| Assessment: | Examintation |
| Forms of media: | Board, Power Point, Computer Lab |
| Literature: | Karl R. Popper:<br>The Logic of Scientific Discovery, ISBN 978-0415278447, reprint 2004, Taylor & Francis<br><br>Douglas Montgomery, George Runger:<br>Applied Statistics and Probability for Engineers. SI Version. 5th edition, Wiley, 2011<br><br>Further Readings:<br><br>Geoffrey Vining, Scott Kowalski:<br>Statistical Methods for Engineers. 3rd edition. Brooks/Cole, 2011<br>Douglas Montgomery:<br>Introduction to Statistical Quality Control. 5th edition. Wiley, 2005 |

## 2912 Optical Systems

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|---|---|---|
| Module name/Module code: | Optical Systems | 2912 |
| Degree: | Mechatronic Systems Engineering: | SE 4 2912 |
| Module coordinator: | Prof. Dr. G. Bastian | |
| Lecturer: | Prof. Dr. G. Bastian | |
| Language: | English | |
| Place in curriculum: | Focus Field Subject | |
| Timetabled hours: | Lecture:<br>Exercise:<br>Practical Training | 2 HPW<br>1 HPW<br>1 HPW |
| Workload: | 60 h attendance<br>45 h preparation and review<br>45 h exam preparation | |
| Credits: | 5 | |
| Recommended prerequisites: | 2902 System Theory and Controls | |
| Module objectives: | Students have a general view of optical systems and interaction of optical components. They are able to understand and classify the function of such apparatus as optical microscopes and data storage devices, together with measuring techniques, lithography and laser machining. Students master the design of optical systems with simple examples learnt with numerical aids. | |
| Content: | Aside from fundamentals of propagation of light, refraction and diffraction as well as spectroscopy, the peculiarities and concepts of practical optical systems are discussed and demonstrated by various examples. | |
| Assessment: | Written or oral examination | |
| Forms of media: | Whiteboard, PowerPoint, Projector | |
| Literature: | Course materials from the lecturer<br><br>E. Hecht:<br>Optics (Addison Wesley), 2003, ISBN 0805385663<br><br>G. R. Fowles:<br>Introduction to Modern Optics, Dover Publications, ISBN 0486659577 | |