University of Debrecen

Faculty of Engineering

Vehicle Engineering MSc Program

Alternative propulsion vehicle production Specialization

2026

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DEAN'S WELCOME

Welcome to UD's Faculty of Engineering!

The Faculty of Engineering of the University of Debrecen has become an outstanding centre of education and research in the Eastern Hungarian region. Following the footsteps of our predecessors, the academic and administrative staff of the Faculty work hand in hand to make our training programmes and researches meet both national and international standards.

The Faculty of Engineering is one of Hungary's most significant institutions of higher-education, and its 3000 students make it a dominant faculty of the University of Debrecen which - having the most international students, offering the most academic programmes among Hungarian universities and having been classified as a research university, the highest of qualifications - is officially listed among the best universities in the country.

We welcome the most outstanding and inquisitive students of the region with an enthusiastic and professional team of academics and researchers, and a set of laboratories unique in the country. We consciously aspire to develop the quality of education and research further, based on a close cooperation between the Faculty and the industry. Our students enter many prestigious competitions and they are becoming increasingly successful and acclaimed, while our instructors are working on a growing number of national and international projects of basic and applied research.

The Faculty bridges the gap between theory and practice and provides a high-quality theoretical background merged into practice-oriented training based on industrial relations. We do our best to maintain the high prestige of the engineering diplomas awarded by the University of Debrecen and to make sure that the knowledge and achievements of students who graduate from our Faculty continue to be recognised in the labour market.

All things considered, you are kindly advised to read this bulletin which hopefully reflects our endeavours appropriately and provides all the information you need to know about your chosen training programme. We are looking forward to supporting the personal and professional growth of our future engineers.

With the best of wishes for the years to come,

Géza Husi

Dean

HISTORY OF THE UNIVERSITY

The history of Debrecen's higher education dates back to the 16th century. The Calvinist Reformed College, established in 1538, played a central role in education, teaching in the native language and spreading Hungarian culture in the region as well as in the whole country. The College was a sound base for the Hungarian Royal University, founded in 1912. Apart from the three academic faculties (arts, law, theology) a new faculty, the Faculty of Medicine was established, and the University soon became one of the regional citadels of Hungarian higher education. Today, University of Debrecen is classified as "University of National Excellence" and offers the highest number of academic programs in the country, therefore it is considered to be one of the best universities in Hungary. Its reputation is the result of its quality training, research activities and the numerous training programs in different fields of science and engineering in English. With 14 faculties and a student body of almost 30.000, out of which about 3700 are international students, the University of Debrecen is one of the largest higher education institutions in Hungary.

The history of the Faculty of Engineering dates back to 1965, when the Technical College was established. In 1972 it was renamed Ybl Miklós Polytechnic and in 1995 it became part of Kossuth Lajos University. In 2000 the Faculty of Engineering became part of the integrated University of Debrecen.

In 2005 the Bologna System was introduced which supports the competitiveness of qualifications received at the University of Debrecen against universities all over Europe.

The Faculty of Engineering is practice-oriented and develops skills required for the current needs of the national and international labour market. The teaching staff is involved in numerous domestic and international research and design projects. The recently-opened new building wing with its ultra-modern design hosts several lecture halls, seminar rooms and laboratories equipped with the latest technology. Our students are provided with practical knowledge, training and field practice from numerous prestigious domestic and multi-national industry partners. The internship periods are excellent opportunities for students to experience how theory is put into practice at the most renowned industry representatives and become more successful in the labour market of this highly competitive sector. Students learn how to work in the working environment of multi-national companies and adapt to challenges easily. After graduation they will be able to work at a strategic decision-making level, giving priority to efficiency and engineering ethics.

The Faculty of Engineering offers a great variety of BSc, MSc courses and post-graduate training courses tailored to the needs of the rapidly changing world of engineering and focusing on European and international trends. In 2011 the Faculty of Engineering launched engineering trainings in English. In order to optimize the quality of training, the Faculty continuously strives to expand the number of industrial and educational partners at home and abroad.

The Faculty of Engineering has been a pioneer in the introduction of Quality Management System at faculty level to measure and evaluate the efficiency of its education and

teaching staff in order to improve the quality of education and training from the feedback received.

The Faculty of Engineering has a vivid student life. There is a film club waiting for movie buffs and the door of the Faculty library is always open. The library is not only the host to the latest technical books, exhibitions and tea afternoons with invited speakers, but students can also purchase theatre and concert tickets from the librarians. The Borsos József Dormitory is also a hub of activities for students.

The increasing number of international students brings cultural and ethnic diversity to the faculty.

Our aim is to aid students to become efficient members of the labour market and enrich the world of engineering in Hungary and abroad with their knowledge and expertise.

ADMINISTRATION UNITS FOR INTERNATIONAL PROGRAMMES

COORDINATING CENTER FOR INTERNATIONAL EDUCATION

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Admission Officer (for scholarship students)	Ms. Lilla Almási-Fónai Ms. Annamária Rácz
Administrative Assistant (for fee paying students)	Ms. Enikő Réka Balogh Ms. Arife Katalin Davarci Mr. Ádám Losonczi
Administrative Assistant (for scholarship students)	Mr. Norbert Tanki

The Coordinating Centre for International Education supports the international degree programmes of the University of Debrecen by providing new students with information on admissions and entrance examinations. Its promotional and administrative responsibilities include enrolment, study contracts, modifying student status or degree programmes, and activating student status at the beginning of the academic year. Furthermore, the Centre manages the modification of students' personal data, provides certificates for the Immigration Office (for residence permits), issues student status letters and transcripts of records, handles health insurance contracts and cards, and assists students with the visa application process.

STUDENT ADMINISTRATION CENTER (HAK)

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The Student Administration Center (HÁK) at the University of Debrecen is the main hub for managing students' official academic and administrative matters. It handles essential tasks such as issuing permanent and temporary student cards, Unipass cards, managing Neptun-related administration, and supporting students with procedures like scholarship administration, and graduation paperwork (pre-degree certificates).

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Dean's Representative for Foreign Affairs	Mr. Zsolt Tiba PhD tiba@eng.unideb.hu

The International Office has been functioning since 2014 in order to ensure the smooth running of the international degree courses. The office is responsible for student administration (full-time students, full-time transfer students, visiting/Erasmus students), providing certificates for students, considering and accepting requests, solving problems related to course registration, giving information **about internship, final exam, thesis, etc.**

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Department of Civil Engineering
Department of Electrical Engineering and Mechatronics
Department of Engineering Management and Enterprise
Department of Environmental Engineering
Department of Mechanical Engineering
Department of Vehicles Engineering

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Academic Calendar
Faculty of Engineering

2026/2027

FALL SEMESTER	
Joint Opening Ceremony for the Academic Year	September 6, 2026
Registration week	August 31-September 6, 2026
Exam weeks for exam courses scheduled for the 1st semester of the academic year 2026/2027	August 31-September 11, 2026
“Orientation Day” event	September 15, 2026
“MSc Open Day” event	October 6, 2026
“Autonomous Machines and Intelligent Robotics Applications 2026” conference	October 13, 2026 – October 14, 2026
“Innovation Forum on Digital Design and Manufacturing 2026” exhibition	October 14, 2026
“Professional exhibition and ISCAME – International Scientific Conference on Advance in Mechanical Engineering” – organized by Department of Mechanical Engineering	November 5, 2026 – November 6, 2026
Scientific Students’ Associations Conference (TDK)	November 21, 2026
“Taste the World – International Desserts and Traditions” event	December 8, 2026
“Open Day and Parent-Teacher Meeting” event	January 20, 2027
“Engineering Graduates’ Ball" event	January 29, 2027
For non-graduating students	
Study period	September 14–December 18, 2026 (14 weeks)
Drawing week 1 – for completing semester design tasks	October 19–22, 2026
Drawing week 2 – for completing and improving assignments except for final-semester subjects	December 7–11, 2026
Exam period	December 14, 2026–January 29, 2027 (7 weeks)

For graduating students	
Study period	September 7–November 6, 2026 (9 weeks)
Drawing week 1 – for completing semester design tasks	October 19–22, 2026
Exam period	November 9–December 11, 2026 (5 weeks)
Thesis submission deadline	Based on departmental decision, on at most the 14th day counting back from the final exam.
Final exam (state exam) period	Based on departmental decision, at least once between December 14-18, 2026 or January 4-22, 2027.
SPRING SEMESTER	
Registration week	February 1–7, 2027
"Industry Day in Debrecen" event	March 17, 2027
"Professional Days and Exhibition in the Field of Building Services" organized by the Department of Building Services and Building Engineering	March 18–19, 2027
"New Trends and Challenges in Management – Management of Global Business Processes"– conference by Department of Engineering Management and Enterprise	March 18, 2027
"6th Environment, Health, Safety (EHS) International Symposium 2027 / ISEHS 2027" - organized by the Department of Environmental Engineering	March 18, 2027
For non-graduating students	
Study period	February 8–May 14, 2027 (14 weeks)
Drawing week 1 – for completing semester design tasks	March 16–19, 2027
Drawing week 2 – for completing and improving assignments except for final-semester subjects	May 10–14, 2027
Exam period	May 18–July 2, 2027 (7 weeks)
For graduating students	

Study period	February 8–April 9, 2027 (9 weeks)
Drawing week 1 – for completing semester design tasks	March 16–19, 2027
Exam period	April 12–May 14, 2027 (5 weeks)
Thesis submission deadline	Based on departmental decision, on at most the 14th day counting back from the final exam.
Final exam (state exam) period	Based on departmental decision, at least once between May 18 and June 11, 2027.
Closing ceremony of the academic year, graduation ceremony	Based on the faculty's decision, between 17 June and 4 July 2027.

THE VEHICLE ENGINEERING MASTER PROGRAM

INFORMATION ABOUT THE PROGRAM

Name of master's program:	Vehicle Engineering Master Program
Specializations available:	Alternative propulsion vehicle production
Field, branch:	Engineering, automotive, vehicle engineering
Level:	MSc
Qualification:	Vehicle Engineer
Mode of attendance:	Full-time
Faculty:	Faculty of Engineering
Program coordinator:	Dr József Menyhárt, Associate Professor
Person in charge of the specialization:	*Alternative-powertrain Vehicle Production Specialisation:* Department of Vehicle Engineering Dr József Menyhárt, Associate Professor
Program length:	4 semesters
Credits total:	120 (thesis: 30, optional subjects: 6)

Aim of the graduate program and professional competencies

The aim of the training programme is to train vehicle engineers who, with a high level of knowledge in the fields of vehicles and mobile machinery, IT and economic management, are able to develop, design, manufacture and research the processes involved in the development, design, and production of rail, road, agricultural, water and air vehicles, construction and material handling machinery. They are capable of operating, diagnosing, maintaining and repairing these vehicles and machines, as well as the transport systems and machinery systems they comprise, in a safe way, taking into account environmental protection and energy management requirements. The training program also prepares students to pursue their studies at doctoral level.

Professional competencies to be acquired

A vehicle engineer's

a) knowledge

He/She

- understands and applies the general and specific principles, rules, relations, procedures of mathematics, natural and social sciences necessary to work in the engineering field.
- has a comprehensive knowledge of global social and economic processes.
- understands and applies a wide range of theories, contexts and terminology in the field of vehicles and mobile machinery.
- knows and understands the basic facts and limits of the knowledge and the system of activities related to the technical field and the expected directions of development and improvement in automotive engineering.
- has a detailed knowledge and understanding of knowledge acquisition and data collection methods, their ethical limitations and problem-solving techniques in the field of engineering.
- knows and understands the terminology, specifications and aspects of vehicle technology related to the field of vehicles and mobile machinery and other fields of particular importance for the practice of the profession (i.e. transport, logistics, management, environmental protection, quality assurance, information technology, legal, economic, health and safety, occupational health and safety, fire protection, safety).
- knows and understands information and communication technologies for transport and logistics processes using vehicles and mobile machinery.
- knows and understands the methodology and tools for the design and research of vehicles and mobile machinery.
- knows measurement techniques and measurement theory for research purposes in the field of vehicles and mobile machinery.
- knows and understands the tools and methods of computer modelling and simulation in the field of vehicles and mobile machinery.
- knows a wide range of problem-solving techniques for research or academic work.
- knows organisational tools and methods related to management and the legislation required for professional practice.
- knows and understands the specific methods and technologies of the chosen specialisation.

b) abilities

He/she can

- apply the acquired general and specific principles, rules, contexts and procedures of mathematics, and natural and social sciences in solving problems in the field of engineering.
- apply the theories and related terminology in an innovative way when solving problems in a given field of engineering.

- test and analyse methods used in the field of vehicles and mobile machinery, evaluate and document test results.
- process, organise, analyse and draw conclusions from information collected during the implementation of vehicle and mobile machinery systems and processes.
- recognise the interrelations and mechanisms of vehicles and mobile machinery and the constituent processes of these systems, and to evaluate and manage them using the systems approach.
- contribute creatively to the solution of research and development tasks in the field of vehicles and mobile machinery.
- add original ideas to the knowledge base in the field.
- apply integrated knowledge in the fields of transport, mobile machinery, process theory, industrial production processes, electronics and information technology.
- design complex systems globally based on a systems thinking, process-oriented approach.
- apply and develop procedures, models and information technologies used in the design, implementation and operation of vehicles and mobile machinery.
- perform quality assurance, metrology and process control tasks in vehicle and mobile machinery systems.
- carry out condition assessments and, based on these assessments and proposals, develop, plan, organise and manage complex vehicle and mobile machinery systems at a higher level.
- plan and manage the complex use of technical, economic, environmental and human resources.
- perform, after sufficient experience, managerial duties.
- publish and negotiate in his/her mother tongue and at least one foreign language in his/her field of specialisation.

c) attitude

He/She

- is open and receptive to learning about, adopting and authentically communicating professional, technological development and innovation in the field of vehicles and mobile machinery.
- embraces the professional and ethical values associated with the technical discipline.
- strives to respect and enforce ethical principles of work and organisational culture and quality requirements.
- is committed to sustainability, environmental awareness, health protection and energy efficiency.
- strives to carry out his/her work in a complex approach with a systems- and process-oriented mindset.
- strives to improve both their own knowledge and that of their staff through continuous self- and peer-learning.
- strives to acquire a broad and comprehensive literacy.

d) autonomy and responsibility

He/She

- takes the initiative and independently select and apply relevant problem-solving methods in solving professional tasks.
- takes his/her decisions independently, in a prudent manner, in consultation with other disciplines (in particular law, economics, energy and environmental safety), and assumes full responsibility.
- demonstrate a responsible attitude towards sustainability, health and environmental protection.
- takes into account and applies the principles of EHS, quality control, consumer protection, product liability, equal access, occupational health and safety, as well as technical, economic and legal regulations and basic engineering ethics when making a decision.
- takes responsibility for the actions and work of his/her employees and for the processes under his/her control.

COMPLETION OF THE ACADEMIC PROGRAM

Credit System

Majors in the Hungarian Education System have generally been instituted and ruled by the Act of Parliament under the Higher Education Act. The higher education system meets the qualifications of the Bologna Process that defines the qualifications in terms of learning outcomes: statements of what students know and can do on completing their degrees. In describing the cycles, the framework uses the European Credit Transfer and Accumulation System (ECTS).

ECTS was developed as an instrument of improving academic recognition throughout the European Universities by means of effective and general mechanisms. ECTS serves as a model of academic recognition, as it provides greater transparency of study programmes and student achievement. ECTS in no way regulates the content, structure and/or equivalence of study programmes.

Regarding each major, the Higher Education Act prescribes which professional fields define a certain training program. It contains the proportion of the subject groups: natural sciences, economics and humanities, profession-related subjects and differentiated field-specific subjects.

Characteristics of the Master's Program

- The academic disciplines and fields of study that make up the program and lead to professional qualification: - natural sciences: 20–35 credits; - economics and humanities: 10–20 credits; - professional knowledge in automotive engineering: 15–44 credits, of which - simulation and optimization methods: 5–15 credits; - design theory of vehicles and mobile machinery: 5–15 credits; - discipline-specific knowledge: 5–25 credits.

- Taking into account the available specializations, specialized knowledge may be acquired in fields relevant to the needs of the automotive engineering profession, specifically in the areas of simulation and optimization methods, and vehicle and mobile machinery design theory. The minimum credit requirement for these elective courses, including the thesis, is 40 credits.
- Credit points assigned to thesis: 30
- Credits total: 120

During the program students have to complete a total amount of 120 credit points. It means approximately 30 credits pro semester. The curriculum contains the list of subjects (with credit points) and the recommended order of completing subjects which takes into account the prerequisite(s) of each subject. You can find the recommended list of subjects in chapter "Guideline".

Guideline (List of Subjects/Semesters)

The total number of credit points (120) of the training program can be obtained by completing the subjects of the curriculum. There is a certain degree of freedom in the order students can complete the subjects. However, it is recommended that the suggested order be followed because some subjects can only be taken after the completion of the prerequisite subject(s), and/or can be the prerequisites for other subjects.

The list of subjects to complete in the semesters according to the model curriculum of Vehicle Engineering MSc programme **Alternative Propulsion Vehicle Production specialization**

Spring start

1st semester	2nd semester
Application of Differential Equations /Mathematics IV	Application of Stochastic Systems /Mathematics V
Solid State/Semiconductor Physics	Applied Dynamics
Production Management and Production Planning	Vehicle Manufacturing, Environmental Toxicology and Life Cycle Analysis
Quality Assurance in Automotive Manufacturing Processes	Robotics and Vehicle Manufacturing
Internet of Things – Systems and Technologies	Pneumatic and Hydraulic Components for Production Systems
Electrical Measurement and Signal Processing	Electric Drives
Car Body Production and Technologies	Optional Subject I.
Non-fossil Energy Sources	
3rd semester	**4th semester**
Assembly and Production Automation	6 Sigma and Lean Philosophy
Automotive Safety	Project work II.
Material Handling and AGV Systems	Optional Subject II.
Project work I.	MSc Diploma Thesis II.
MSc Diploma Thesis I	
Internship	

Autumn start

1st semester	2nd semester
Application of Stochastic Systems /Mathematics V	Application of Differential Equations /Mathematics IV
Applied Dynamics	Solid State/Semiconductor Physics
Vehicle Manufacturing, Environmental Toxicology and Life Cycle Analysis	Production Management and Production Planning
Robotics and Vehicle Manufacturing	Quality Assurance in Automotive Manufacturing Processes
Pneumatic and Hydraulic Components for Production Systems	Internet of Things – Systems and Technologies
Electric Drives	Electrical Measurement and Signal Processing
Optional Subject I.	Car Body Production and Technologies
	Non-fossil Energy Sources
3rd semester	**4th semester**
6 Sigma and Lean Philosophy	Assembly and Production Automation
Project work II.	Automotive Safety
Optional Subject II.	Material Handling and AGV Systems
MSc Diploma Thesis II.	Project work I.
	MSc Diploma Thesis I
	Internship

For those who hold a previously awarded degree, the minimum requirements for admission to the master's degree program are:

For those who hold a previously awarded degree, —with the exception of those holding a bachelor's degree in automotive engineering as described —the minimum number of credits required for admission to the master's degree program is 70 credits in the following areas: - 20 credits in the field of basic natural sciences (mathematics, chemistry and materials science, mechanics, thermodynamics and fluid mechanics, electrical engineering); - 10 credits in the field of economics and humanities (economics and management, environmental protection, quality assurance, occupational safety, social

sciences); - subject-specific knowledge (structure and operation of vehicles and mobile machinery, transportation systems, logistics systems, industrial transport systems, computer science, technical drawing, vehicle and drive components, structural materials and technologies used in vehicle manufacturing, repair, and maintenance, thermal and fluid power systems in vehicles, control engineering, vehicle dynamics and drive technology, transportation studies) 40 credits. Admission to the master's program requires that the student have earned at least 40 credits in the listed fields based on their undergraduate studies. Any credits missing from the master's program must be earned in accordance with the academic and examination regulations of the institution of higher education. The minimum number of credits required for admission to the master's program from the bachelor's program in Vehicle Operations Engineering is 60 credits in the following areas: - natural sciences (mathematics, physics, fluid mechanics) 10 credits; - economics and humanities: 2 credits; - subject-specific knowledge (structure and operation of vehicles and mobile machinery, transportation systems, logistics systems, industrial transport systems, computer science, technical drawing, vehicle and drive components, structural materials and technologies used in vehicle manufacturing, repair, and maintenance, thermal and fluid power systems in vehicles, control engineering, vehicle dynamics and drive technology, transportation studies) 48 credits. A prerequisite for obtaining the master's degree is that the 60 credits in the listed subject areas must be earned concurrently with the master's degree program, within two semesters of admission, in accordance with the provisions of the higher education institution's academic and examination regulations.

Work and Fire Safety Course

According to the Rules and Regulations of the University of Debrecen, students must complete the online course for work and fire safety. Registration for the course and its completion are necessary for graduation. For MSc students the course is only necessary if their BSc diploma has not been awarded by the University of Debrecen.

Registration in the Neptun system by the subject: MUNKAVEDELEM

Students have to watch/read an online material to get the signature on Neptun for the completion of the course. The link of the online course is available on the website of the Faculty.

Internship

Students have to complete a 4-week internship in the summer following the third semester in case of February intake and after the second semester in case of a September intake, after earning a minimum of 40 credits. The internship must be completed at a company (or, in exceptional individual cases, at the department) through work that aligns with the program's educational objectives and is related to the courses taught. During the internship, students must familiarize themselves with the company's operations, main processes, organizational structure, and organizational culture.

Credits assigned: 0

Completion of internship

The internship is considered valid if the student submits a certificate with the workplace supervisor's official signature confirming the time spent and the work performed, and has submitted a report the topic of which is selected by them with the assistance of their supervisor(s). The report can only contain publicly available data on the company, or information previously approved by the company.

Physical Education

According to the Rules and Regulations of the University of Debrecen, students must complete Physical Education course at least in one semester during his/her Master's

training. Our University offers a wide range of facilities to complete them. Further information is available from the Sport Centre of the University, its website: http://sportsci.unideb.hu.

Optional Courses

According to the Rules and Regulations of the University of Debrecen, students must complete elective courses during their MSc studies. These elective courses are opened by the Departments at the Faculty of Engineering at the beginning of the actual semester. The list of such subjects for a given semester is to be found under “Current Students” >” Useful Information about your Study” >” Optional subjects” on the Faculty’s website.

Students can also select optional courses offered by other faculties of University of Debrecen to complete.

In the Vehicle Engineering MSc program, one must gain at least 6 credits by completing elective subjects.

Pre-degree Certification

A pre-degree certificate is issued by the Faculty after completion of the master’s (MSc) program. The pre-degree certificate can be issued if a student has successfully completed the study and exam requirements as set out in the curriculum, the requirements relating to Physical Education as set out in Section 10 in Rules and Regulations, internship (mandatory) – with the exception of thesis preparing – and gained the necessary credit points (120). The pre-degree certificate verifies (without any mention of assessment or grades) that the student has fulfilled all the necessary study and exam requirements defined in the curriculum and the requirements for Physical Education. Students who obtained the pre-degree certificate can submit the thesis and take the final exam.

Thesis

A Thesis is the creative elaboration of a professional task (scientific, engineering, design, development, research or research development) in a written form. By solving the task, the student relies on his/her studies using national and international literature under the guidance of an internal and external supervisor (referee). By writing and successfully

defending a thesis, students of the Vehicle Engineering Master program prove that they are able to apply the acquired knowledge in practice, to summarize the work done and its results in a professional way, to solve the tasks related to their topic creatively, and to complete individual professional work.

Students in the master program must write a thesis as a prerequisite of the final exam. Requirements regarding the content of the thesis, the general aspects of evaluation and the number of credits assigned to it are defined based on the requirements of the program. In case of the Vehicle Engineering Master Program, the number of credits assigned to the thesis is 30.

Thesis topics are announced by the departments no later than the end of the fourth week of the study period of the last but one semester. Students may also offer a topic for the thesis, which the competent head of department may accept or reject. The conditions on the acceptance of a SSS (Student Scientific Society) paper as a degree thesis are defined by the Faculty. SSS papers are supposed to meet the requirements of a thesis both in form and content. Furthermore, it is necessary that the committee of the Pre-SSS make suggestions on the SSS papers to be accepted as theses.

Formal requirements of thesis shall be designated by the Department of Vehicle Engineering and must be announced in writing together with other thesis-related assignments.

The preparation of a thesis shall be overseen by an internal supervisor approved by the department, and may be assisted by an external supervisor (also approved by the department).

The thesis submission deadline is defined in the academic calendar of the Faculty (issued by the Vice-Rector for Education) or, failing that, it is 12 a.m. on the 14th day before the first day of the final exam. The thesis can be submitted only if both the internal and the external supervisors approve. It is evaluated by an independent external reviewer, and the Head of the Department of Vehicle Engineering makes a suggestion to the final examination board on its classification based on a five-grade scale.

If the reviewer evaluates the thesis firmly as fail, the student may not take the final exam and must create a new thesis. Students must be informed about it. Conditions on resubmitting the thesis are designated by the head of the relevant educational unit responsible for the major or specialization.

Final exam

After receiving the pre-degree certificate, students conclude their studies by taking the final exam of Environmental Engineering master program. The final exam shall test and assess the knowledge, skills and abilities requisite to the award of the degree, whereby

students shall also prove their ability to apply the acquired knowledge in practice. The conditions for taking the final exam and the parts of the final exam itself shall be defined in the requirements for the training program (see entry 'Completion of studies').

The final exam shall be taken in front of a board in the examination period following the award of the pre-degree certificate. If a candidate does not pass the final exam until the termination of his/her student status, that student can sit for the final exam any time after the termination of his/her student status according to the provisions regarding the final exam, effective at the time of taking the final exam.

The Final exam consists of 2 parts:

1. Oral exam – An oral exam consisting of questions on the subject matter related to the thesis topic, as well as questions selected from core professional material and specialized professional topics.
2. Thesis defence – A presentation of the thesis, followed by responses to questions and comments regarding it.

The exam may begin only if the thesis is deemed eligible for the final exam based on the unequivocal opinion of the examiner and the Department. All voting members of the final examination committee evaluate the components of the final examination using a five-point grading scale, and the final results are determined by a vote in a closed session after the last candidate has completed their examination; the results are then announced by a member of the final examination committee. The candidate receives a grade from the final examination committee for the oral examination and the thesis defence. Minutes are taken of the final examination.

The degree classification is calculated using the following formula:

$$\text{Degree classification} = 0.5xA + 0.25xB + 0.25xC$$

where
A: Grade for the thesis defence
B: Grade for the oral exam
C: Cumulative weighted grade point average for the entire course of study
Based on the calculated average score, the degree is graded as follows:
Outstanding 4.81–5.00, Excellent 4.51–4.80, Good 3.51–4.50, Satisfactory 2.51–3.50, Pass 2.00–2.50

Retaking a failed final exam

If any part of the final exam is evaluated as fail, according to the existing rules of the university, it can be retaken. The retake of the final exam may be attempted in the following examination period at the earliest. If a thesis is evaluated unanimously as fail, the student may not take the final exam and shall write another thesis. The final exam can be retaken twice per each subject.

Final exam board

The members of the final examination board shall be delegated and commissioned with the consent of the Faculty Council by the dean of the faculty. They are selected from among the acknowledged internal and external experts of the professional field. Traditionally, a chairperson and, in case of his/her absence or indisposition, a vice-chair shall be commissioned. The final examination board shall have a minimum of two members apart from the chairperson and as many questioners as needed. At least one of the members of the board shall be a university or college professor. The length of the appointment of membership in the final exam board shall be one year. The division of students to individual commissioned final exam boards shall be announced by the Department of Vehicles Engineering.

COURSE DESCRIPTIONS FOR VEHICLE ENGINEERING MSC

The order of subject follows the subject list in the model curriculum above.

Subject group "Basic Natural Sciences"

Mathematics IV

Code: MK5MAT1A04VX23-EN

ECTS Credit Points: 4

Evaluation: mid-semester grade

Number of teaching hours/week (lecture + practice): 2+2

Topics:

Survey of differential and integral calculus. Interpolation. Regression. Non-parametric regression models. Taylor polynomials. Trigonometric system, trigonometric polynomials, Fourier series. Optimization problems. Optimization with differentiation. Gradient-based optimization methods. Derivative-free optimization methods. Integral transforms. Exponential system, Fourier transform, discrete Fourier transform. Spectrum. Applications in signal analysis and vibration diagnostics. Laplace transform. Differential equations, initial value problem, boundary value problem. Direction field. Euler method, Runge-Kutta method. Autonomous systems, phase plane. Some non-linear type differential equations. Linear differential equations. Method of variation of parameters and undetermined coefficients. Solution with Laplace transform. System of linear differential equations. System of linear differential equations with constant coefficients. Matrix functions. Linear and non-linear autonomous systems. Stability. Main types of partial differential equations. Examples. Variational principle. Analytical and numerical solution methods.

Literature:

Compulsory:

- Greenberg, M. D., Advanced Engineering Mathematics, New Jersey, Prentice Hall, 1998.
- Kreyszig, Advanced engineering mathematics, John Wiley & Sons Inc., 2011.
- Chapra, S. C., Numerical Methods for Engineers, Mc Graw Hill, 2006.

Recommended:

- Polyanin, A.D., Manzhirov, A.V., Handbook of Mathematics for Engineers and Scientists, Chapman & Hall, 2007.
- Logan, J. D., Applied Partial differential equations, New York, Springer, 2004.
- Dyke, P., An Introduction to Laplace Transforms and Fourier Series, Springer, 2014.

Schedule

1st week Registration week	
2nd week: **Lecture:** Survey of differential and integral calculus. **Practice:** Applications of differential and integral calculus.	3rd week: **Lecture:** Interpolation. Regression. Taylor polynomials, Taylor series. **Practice:** Interpolation. Regression. Taylor polynomials, Taylor series.
4th week: **Lecture:** Trigonometric polynomials, trigonometric system, Fourier series. Complex functions, exponential system. Complex Fourier series. Applications in signal processing. **Practice:** Trigonometric system, exponential system. Fourier series.	5th week: **Lecture:** Optimization problems. Optimization with differentiation. Gradient-based optimization methods. **Practice:** Optimization with differentiation.
6th week: **Lecture:** Derivative-free optimization methods. **Practice:** Derivative-free optimization methods.	7th week: **Lecture:** Integral transforms. Exponential system, Fourier transform, discrete Fourier transform. Spectrum. Applications in signal analysis and vibration diagnostics. Laplace transform. **Practice:** Fourier transform. Laplace transform.
8th week: 1st drawing week	
9th week: **Lecture:** Differential equations, initial value problem, boundary value problem. Direction field. Euler method, Runge-Kutta method. **Practice:** Euler method, Runge-Kutta method.	10th week: **Lecture:** Autonomous systems, phase plane. Some non-linear type differential equations. **Practice:** Some non-linear type differential equations.
11th week: **Lecture:** Linear differential equations. Method of variation of parameters and undetermined coefficients. Solution with Laplace transform.	12th week: **Lecture:** System of linear differential equations. System of linear differential equations with constant coefficients. Matrix functions.

Practice: Method of variation of parameters and undetermined coefficients. Solution with Laplace transform.	**Practice:** System of linear differential equations with constant coefficients.
13th week:	**14th week:**
Lecture: Linear and non-linear autonomous systems. Stability.	**Lecture:** Main types of partial differential equations. Examples. Variational principle. Analytical and numerical solution methods.
Practice: Stability of autonomous systems.	**Practice:** Main types of partial differential equations.
15th week: 2nd drawing week	

Requirements

A, for a signature:

Attendance at **lectures** is recommended, but not compulsory.

Participation at **practice classes** is compulsory. A student must attend the practice classes and may not miss more than three times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. A student can't make up any practice with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Missed practice classes should be made up for at a later date, to be discussed with the tutor. Active participation is evaluated by the teacher in every class. If a student's behaviour or conduct doesn't meet the requirements of active participation, the teacher may evaluate his/her participation as an absence because of the lack of active participation in class.

During the semester there are two tests: the mid-term test in the 8th week and the end-term test in the 15th week. Students have to sit for the tests.

B, for grade:

The course ends in an **end-term grade**, it is based on the total scores of the mid-term and the end-term tests.

The minimum requirement for the mid-term and end-term tests is 60%. Based on the score of the tests, the grade is given according to the following table:

Score	Grade
0-59%	fail (1)
60-69%	pass (2)
70-79%	satisfactory (3)
80-89%	good (4)

90-100% excellent (5)

If the score of tests is below 60%, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

Solid State/Semiconductor Physics

Code: MK5SZFFR04VX23-EN

ECTS Credit Points: 4

Evaluation: exam

Number of teaching hours/week (lecture + practice): 2+2

Topics:

Modelling theory at conceptual level and detailed level; Control theory for vehicle motion, Automotive networking fundamentals and technologies: Bus systems; Automotive sensors: principles and technologies and sensor types; Automotive actuators: Electric actuators and Hydraulic Actuators; Electronic transmission modelling and control; HVAC system and control for passenger comfort and battery thermal management; Fault Diagnostics of mechanical and electrical vehicle components.

Literature:

Required: -

Recommended:

- Prof. Dr.-Ing. Konrad Reif (ed) "Automotive Mechatronics" Springer, 2015, ISBN 978-3-658-03974-5
- Rolf Isermann "automotive Control", Springer, 2021, ISBN: 9783642394393
- Martin Meywerk, "Vehicle Dynamics", Wiley, 2015, ISBN: 9781118971352

Schedule

1st week Registration week	
2nd week:	3rd week:
Lecture: Modelling theory I. conceptual level. Vehicle and components. Modelling on Electrical, mechanical and hydraulic domain.	**Lecture:** Modelling theory I. detailed level. Vehicle and components. Modelling on Electrical, mechanical and hydraulic domain. Non-linear effects.
Practice: Modelling practice: conceptual level, linear models of electrical, mechanical and hydraulic components.	**Practice:** Modelling practice: detailed level, non-linear models of electrical, mechanical and hydraulic components.
4th week:	5th week:

Lecture: Control Theory; summary. Open and Closed control loop. Time and Frequency domain. Control performance evaluation.

Practice: Performance evaluation in time and frequency domain, control parameter tune. Vehicle motion control.

6th week:

Lecture: Bus systems: Requirements for vehicles; classification for vehicles; Application for vehicles. Coupling of different networks.

Practice: Vehicle bus system examples: CAN bus; LIN bus; Wireless protocols: Bluetooth and WiFi; Diagnostic interfaces

Lecture: Automotive networking. OSI ISO Layer model. Requirements for vehicle networking. Classification of networking and topologies.

Practice: **Networking** technologies. Application examples, vehicle and passenger requirement.

7th week:

Lecture: Automotive sensors. Fundamental principles; automotive applications; core features of vehicle sensors.

Practice: Sensor measurement principles: position and displacement, speed and rpm, acceleration and impact; pressure; force and torque.

8th week: 1st drawing week

9th week:

Lecture: Automotive sensor types. ICE and electrical traction. Mechanical and electrical variables.

Practice: Sensor application: Engine speed, Hall phase, speed sensor for ICE and transmission, micromechanical yaw-rate sensor, mechanical pressure sensor.

10th week:

Lecture: Electric actuators: operation principles, requirements and environmental conditions.

Practice: Electromechanical actuators, linear and rotational. Electrical machines: AC and DC machines: requirements and technologies.

11th week:

Lecture: Hydraulic actuators. Electrohydraulic actuators. design and requirements. Operation principles and theory.

Practice: Actuator types, operating concept and technologies. Non-linear effects. Modelling and simulation.

12th week:

Lecture: Electric transmission modelling and control. Drivetrain management, Transmission types and components.

Practice: Transmission modelling and control logic development. Shift logic and vehicle dynamics. Fuel consumption and drive cycles.

13th week:

Lecture: HVAC system and control. Components, working gases, environmental requirements and regulations.

Practice: Passenger comfort and battery thermal management. Component and control technologies.

14th week:

Lecture: Fault diagnostics: theory, technologies for mechanical and electrical components.

Practice: OBD, On-Board Diagnostics, failure codes. Manufacturer specific maintenance and inspection methods.

15th week: 2nd drawing week

Requirements

A, for a signature:

Attending practices is compulsory. Attendance at lectures is recommended. Students have to attend practice classes and may not miss more than three practice classes during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Students cannot make up any practice class with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certification needs to be presented. Missed practice classes have to be made up for at a later date previously discussed with the tutor.

B, for a grade:

The course ends in a written end-term test.

The minimum requirement of the end-term test is 50%. The grade is given according to the following (score/grade): 0-49 = fail (1); 50-69 = pass (2); 70-79 = satisfactory (3); 80-89 = good (4); 90-100 = excellent (5). If the score of the test is below 50, students can retake that test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

Mathematics V

Code: MK5MAT2A04VX23-EN

ECTS Credit Points: 4

Evaluation: mid-semester grade

Number of teaching hours/week (lecture + practice): 2+2

Topics:

The series of lectures are based on the topics of engineering statistics. It reviews the concepts and methods used in stochastic modelling of technical systems and processes. Sample spaces and events. Axioms of probability. Conditional probability. Multiplication and total probability rules. Independence. Discrete and continuous random variables, probability distribution, density function. Numerical characteristics of random variables. Limit theorems. Joint probability distributions. Correlation, independence. Descriptive statistics. Point and interval estimation. Confidence interval. Hypothesis testing (probability, mean, standard deviation), normality test, ANOVA. Regression analysis. System reliability. Time series. Markov chain. Statistical process control. Statistical tools in 6σ process improvement.

Literature:

Required:

- Montgomery, D. C., Runger, G. C., Applied Statistics and Probability for Engineers, John Wiley & Sons Inc., 2003
- Soong, T. T., Fundamentals of probability and statistics for engineers, John Wiley & Sons, Inc., 2004

Recommended:

- DeCoursey, W. J., Statistics and Probability for Engineering Applications With Microsoft® Excel, Newnes, 2003
- Allen, T. T., Introduction to Engineering Statistics and Six Sigma, Springer, 2006
- Pham, Hoang (Ed.), Springer Handbook of Engineering Statistics, Springer, 2006, ISBN 978-1-85233-806-0
- NIST/SEMATECH e-Handbook of Statistical Methods, http://www.itl.nist.gov/div898/handbook/
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Schedule

1st week Registration week	
2nd week: **Lecture:** Sample spaces and events. Axioms of probability. Conditional probability. Multiplication and total probability rules. Independence. **Practice:** Calculation of probability.	**3rd week:** **Lecture:** Discrete and continuous random variables, probability distribution, density function. **Practice:** Random variables.
4th week: **Lecture:** Numerical characteristics of random variables. Limit theorems. **Practice:** Random variables.	**5th week:** **Lecture:** Joint probability distributions. **Practice:** Joint probability distributions.
6th week: **Lecture:** Correlation, independence. **Practice:** Correlation, independence.	**7th week:** **Lecture:** Descriptive statistics. **Practice:** Descriptive statistics.
8th week: 1st drawing week	
9th week: **Lecture:** Point and interval estimation. Confidence interval. **Practice:** Point and interval estimation. Confidence interval.	**10th week:** **Lecture:** Hypothesis testing (probability, mean, standard deviation), normality test, ANOVA.

	Practice: Hypothesis testing (probability, mean, standard deviation), normality test, ANOVA.
11th week:	**12th week:**
Lecture: Regression analysis.	**Lecture:** System reliability.
Practice: Regression analysis.	**Practice:** System reliability.
13th week:	**14th week:**
Lecture: Time series. Markov chain.	**Lecture:** Statistical process control. Statistical tools in 6σ process improvement.
Practice: Time series. Markov chain.	**Practice:** Statistical process control. Statistical tools in 6σ process improvement.
15th week: 2nd drawing week	

Requirements

A, for a signature:

Attendance at **lectures** is recommended, but not compulsory.

Participation at **practice classes** is compulsory. A student must attend the practice classes and may not miss more than three times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. A student can't make up any practice with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Missed practice classes should be made up for at a later date, to be discussed with the tutor. Active participation is evaluated by the teacher in every class. If a student's behaviour or conduct doesn't meet the requirements of active participation, the teacher may evaluate his/her participation as an absence because of the lack of active participation in class.

During the semester there are two tests: the mid-term test in the 8th week and the end-term test in the 15th week. Students have to sit for the tests.

B, for grade:

The course ends in an **end-term grade**, it is based on the total scores of the mid-term and the end-term tests.

The minimum requirement for the mid-term and end-term tests is 60%. Based on the score of the tests, the grade is given according to the following table:

Score	Grade
0-59%	fail (1)

60-69%	pass (2)
70-79%	satisfactory (3)
80-89%	good (4)
90-100%	excellent (5)

If the score of tests is below 60%, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

Applied Dynamics

Code: MK5ADING05GX17-EN

ECTS Credit Points: 5

Evaluation: exam

Number of teaching hours/week (lecture + practice): 2+3

Topics:

Classification of dynamic systems, their characteristic properties (linearity, time invariance, stability, etc.). Comparison and use of Newtonian, Lagrangian and Hamiltonian mechanics to generate the equations of motion. Time domain analysis of linear dynamic systems. Typical input functions. Application of the impulse response function theorem and the convolution theorem. Investigating the effect of stochastic excitation. Complex frequency domain analysis of linear dynamic systems. Laplace transform and its application. The transfer function and its properties. Frequency domain analysis of linear dynamic systems. The Fourier transform and its application. Properties of the frequency transfer function and its relationship with the transfer function. Numerical analysis of linear and nonlinear dynamic systems. The Runge-Kutta methods. Analysis of nonlinear systems using the phase plane method. Description of spatial mechanisms, elements, structure, characteristic properties. Kinematic analysis of spatial mechanisms. Direct and inverse kinematic problems. Dynamic analysis of spatial mechanisms. Direct and inverse dynamics problems. Distributed parameter systems. Longitudinal and torsional oscillations of homogeneous, prismatic bars. Bending oscillations of homogeneous, prismatic beams

Literature:

S. Graham Kelly: *Mechanical Vibrations: Theory and Applications*, Cengage Learning, 2012.

Leonard Meirovitch: *Fundamentals of Vibrations*, McGraw-Hill Higher Education, 2001.

William T. Thomson and Marie Dillon Dahleh: *Theory of Vibration with Applications*, Prentice-Hall Inc., 1998.

Schedule

1st week Registration week	
2nd week: **Lecture:** Classification of dynamic systems, their characteristic properties (linearity, time invariance, stability, etc.). **Practice:** An overview of the mathematical topics (linear algebra, differential equations, etc.) necessary for learning the subject.	**3rd week:** **Lecture:** Comparison and use of Newtonian, Lagrangian and Hamiltonian mechanics to generate the equations of motion. **Practice:** Creation of the equation of motion of linear and nonlinear systems.
4th week: **Lecture:** Time domain analysis of linear dynamic systems. Typical input functions. Application of the impulse response function theorem and the convolution theorem. Investigating the effect of stochastic excitation. **Practice:** Practical examples of time domain analysis of linear dynamic systems.	**5th week:** **Lecture:** Complex frequency domain analysis of linear dynamic systems. Laplace transform and its application. The transfer function and its properties. **Practice:** Generation and analysis of transfer functions of linear dynamic systems using Matlab.
6th week: **Lecture:** Frequency domain analysis of linear dynamic systems. The Fourier transform and its application. Properties of the frequency response function and its relationship with the transfer function. **Practice:** Generation and analysis of frequency response functions of linear dynamic systems using Matlab.	**7th week:** **Lecture:** Numerical analysis of linear and nonlinear dynamic systems. The Runge-Kutta methods **Practice:** Analysis of linear and nonlinear dynamic systems using Matlab and Simulink.
8th week: 1st drawing week	
9th week: **Lecture:** Analysis of nonlinear systems using the phase plane method. **Practice:** Practical examples of using the phase plane method.	**10th week:** **Lecture:** Description of spatial mechanisms, elements, structure, characteristic properties. **Practice:** Modeling spatial mechanisms using Matlab Simscape Multibody.

11th week: **Lecture:** Kinematic analysis of spatial mechanisms. Direct and inverse kinematic problems. **Practice:** Kinematic analysis of spatial mechanisms using Matlab Simscape Multibody.	12th week: **Lecture:** Dynamic analysis of spatial mechanisms. Direct and inverse dynamics problems. **Practice:** Dynamic analysis of spatial mechanisms using Matlab Simscape Multibody.
13th week: **Lecture:** Distributed parameter systems. Longitudinal and torsional oscillations of homogeneous, prismatic bars. **Practice:** Practical examples related to longitudinal and torsional oscillations of homogeneous, prismatic bars.	14th week: **Lecture:** Distributed parameter systems. Bending oscillations of homogeneous, prismatic beams. **Practice:** Practical examples related to bending oscillations of homogeneous, prismatic beams.
15th week: 2nd drawing week	

Requirements

A, for a signature:

Attending practices is compulsory. Attendance at lectures is recommended. Students have to attend practice classes and may not miss more than three practice classes during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Students cannot make up any practice class with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certification needs to be presented. Missed practice classes have to be made up for at a later date previously discussed with the tutor.

B, for a grade:

The course ends in a written end-term test.

The minimum requirement of the end-term test is 50%. The grade is given according to the following (score/grade): 0-49 = fail (1); 50-69 = pass (2); 70-79 = satisfactory (3); 80-89 = good (4); 90-100 = excellent (5). If the score of the test is below 50, students can retake that test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

Environmental Toxicology and Life Cycle Analysis

Code: MK5JGKEJ04JX24-EN

ECTS Credit Points: 4

Evaluation: exam

Further courses are built on it: -

Number of teaching hours/week (lecture + practice): 2+2

Topics:

Within the framework of environmental toxicology and life cycle analysis of vehicle manufacturing, students will learn the principles and practice of environmental toxicology, and the safety, environmental protection and energy management requirements of vehicles and machines, their transport systems and machinery. Related topics will include basic EHS knowledge and environmental pollution associated with vehicle manufacturing.

In the management and processing of hazardous waste associated with vehicle manufacturing, particular emphasis will be placed on the harmful effects of automotive oils and how to reduce them, the environmental impact of working oils, the impact of oil spills and environmental damage, and fuel storage and environmental protection.

In relation to life-cycle analysis, the topic will cover basic recycling knowledge and the basics, specifications and practical tools for carrying out life-cycle analyses, ecological and carbon footprint calculations for a complete vehicle production cycle.

Literature:

Required:

1. Aly Ibrahem, Nils Sjöqvist: Life Cycle Assessment in the Automotive Industry, DEGREE PROJECT IN MECHANICAL ENGINEERING, SECOND CYCLE, Stockholm, Sweden 2021.
2. Bupe Mwanza: Introduction to Recycling, In book: Recent Developments in Plastic Recycling, DOI: 10.1007/978-981-16-3627-1_1, October 2021.
3. Fuels Institute: Life Cycle Analysis Comparison, ELECTRIC AND INTERNAL COMBUSTION ENGINE VEHICLES, January 2022.

Recommended:

1. Troy R. Hawkins et al.: Comparative Environmental Life Cycle Assessment of Conventional and Electric Vehicles, Journal of Industrial Ecology, DOI: 10.1111/j.1530-9290.2012.00532., February 2013.

Schedule

1st week Registration week	
2nd week: Lecture: Concept, subject and division of toxicology.	3rd week: Lecture: Toxicity tests, toxicant effects, dose-response and concentration-response relationships.

Practice: Impact of chemicals on the environment.	**Practice:** Commonly used test methods.
4th week: **Lecture:** Ecotoxicology and the risk of chemicals. Chemical risks in the automotive industry. **Practice:** The basis for measuring risk.	**5th week:** **Lecture:** Ecotoxic factors in environmental systems. **Practice:** Environmental effects of heavy metals, consequences of heavy metal pollution.
6th week: **Lecture:** Industrial pollutants and their environmental effects. **Practice:** Toxic substances in environmental systems.	**7th week:** **Lecture:** Organic solvents and their toxicity. Hazards of surface treatment agents. **Practice:** The role of EHS practices in vehicle manufacturing.
8th week: 1st drawing week	
9th week: **Lecture:** The concept, purpose, phases and types of life cycle analysis (LCA). **Practice:** Case studies.	**10th week:** **Lecture:** The emergence, evolution and data quality requirements of LCA. **Practice:** Calculation methods related to the topic.
11th week: **Lecture:** The role of LCA in reducing environmental impacts and its applications. **Practice:** Case studies.	**12th week:** **Lecture:** Steps in the LCA process I. **Practice:** Case studies.
13th week: **Lecture:** Steps in the LCA process II. **Practice:** Calculation methods related to the topic.	**14th week:** **Lecture:** Carbon footprint calculation. **Practice:** Presentation of project tasks.
15th week: 2nd drawing week	

Requirements

A, for a signature:

Active participation is requested and evaluated by the teacher in every class. completion of the project task.

B, for a grade:

The course ends in a written exam covering the whole semester material and the students get grade on the base of its result. The minimum requirement for the end-term test is 60%.

The grade for the tests is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of the end-term test is below 60, the student will be allowed to write it again and improve their grades.

Subject group “Economics and Humanities”

Production Management and Production Planning

Code: MK5TMGYM03JX24-EN

ECTS Credit Points: 3

Evaluation: exam

Number of teaching hours/week (lecture + practice): 2+1

Topics:

The aim and objective of the course is to familiarize students with the functioning of value-creating and non-value-creating processes in companies, with particular emphasis on aspects of sustainable development.

The course content covers strategic planning in companies from a production management perspective. Theoretical and practical training, combined with real-world problem-solving, deepens understanding in the following areas: general modelling of production activity management. Activity planning based on available resources – the organization as a system. Characteristics of production types and their analytical comparison. Future planning – forecasting models, decision support methods, and analysis of method errors. Fundamentals of inventory management and application of models, ABC analysis. Material requirements planning procedures – the essence and characteristics of MRP. Capacity calculation methods and the time horizon of production planning tasks. Process management. Production philosophies: Toyota – Lean approach and its methods – waste reduction, mapping value streams. Life cycle philosophies: LCA analysis and impact assessment. Use of LCA analysis software: plan, project – evaluation phases

Literature:

Required:

-W. J. Stevenson: Operations Management, 12th ed. Boston: McGraw-Hill/Irwin, 2014, ISBN 9780077169527

-Arnold, J. R. Tony; Chapman, Stephen N.; Clive, Lloyd M.: Introduction to Materials Management, 8th global ed., New Jersey, Pearson, cop. (2016) ISBN 9781292162355 0131376705

Schedule

1st week Registration week	
2nd week:	3rd week:

Lecture: A comprehensive outline of the installation of a multinational manufacturing factory **Practical**: Case studies, calculation exercises	**Lecture:** Characteristics of production types **Practical**: Case studies, calculation exercises
4th week:	**5th week:**
Lecture: Forecasting models **Practical**: Case studies, calculation exercises	**Lecture:** Analysis of forecasting errors **Practical**: Case studies, computational exercises
6th week:	**7th week:**
Lecture: Inventory management **Practical**: Case studies, calculation exercises	**Lecture:** Capacity analysis **Practical**: Case studies, calculation exercises
8th week: 1st drawing week	
9th week:	**10th week:**
Lecture: Aggregate production planning. Resource and material requirements planning **Practical**: Case studies, calculation exercises	**Lecture:** Process management. Toyota production system. Lean management. **Practical**: Case studies, calculation exercises
11th week:	**12th week:**
Lecture: Process management. Toyota production system. Lean management. **Practical**: Case studies, calculation exercises	**Practice:** Production line modeling, batch, repetitive, and one-piece flow modeling, measurement of production parameters, comparison and discussion of results
13th week:	**14th week:**
Lecture: Fundamentals of life cycle analysis, conceptual approach, categories of environmental impact **Practical**: Analysis of case studies	**Practice:** steps of a new product implementation process with participation of a guest speaker from the automotive industry
15th week: 2nd drawing week	

Requirements

A, signature: Participation in practical sessions in accordance with the TVSZ regulations. Correct completion of assigned individual tasks.

Case studies, calculation exercises

B, Grade:

Performance evaluation, requirements for obtaining a grade: The exam consists of a written and an oral section; a score of 60% is required to pass: 0%-59% failing, 60%-69% passing, 70%-79% average, 80%-89% good, 90%-100% excellent

Quality Assurance in Automotive Manufacturing Processes

Code: MK5JGFMM04JX24-EN

ECTS Credit Points: 4

Evaluation: mid-semester grade

Number of teaching hours/week (lecture + practice): 2+2

Topics:

Within the framework of quality assurance in automotive manufacturing processes, students will learn the requirements of automotive standards, building on their previous knowledge of quality assurance. The course introduces students to the new product manufacturing processes, APQP . General automotive customer requirements and the various capability tests, CP, CPK, PPK calculation are described.

In relation to automotive manufacturing, students will be introduced to the handling of quality assurance complaints and related supplier evaluation. They will become familiar with the parts of the first sample documentation (PPAP) and its structure. They will learn the elements of IATF16949 and VDA 6.3 through practical examples and case studies. Students will master basic auditing concepts and methods. They will gain knowledge of different types of audits (internal audit, supplier and customer audit, layered audit, witnessing audit, etc.) and through practical exercises they will gain proficiency in SPC and MSA calculation exercises.

Literature:

Required: -

Recommended:

- Jeremy Hazel, Scott Gray: The Automotive IATF 16949:2016 Memory Jogger, Goal/QPC, ISBN: 978-1576811894
- IATF 16949 standard
- VDA 6.3 standard

Schedule

1st week Registration week	
2nd week:	3rd week:
Lecture: Introduction to quality assurance in automotive manufacturing, course overview and expectations, role of quality in automotive industry, overview of standards IATF 16949 and VDA 6.3	**Lecture:** Fundamentals of Six Sigma, Six Sigma concept and philosophy, sigma levels and performance interpretation, organizational roles champion master black belt black belt green belt yellow belt

Practice: Case discussion on quality issues in automotive production	**Practice:** Sigma level calculation exercises and interpretation
4th week:	**5th week:**
Lecture: Basic statistics for quality engineering, mean variance standard deviation normal distribution, introduction to process variation	**Lecture:** Measurement systems analysis MSA fundamentals, accuracy precision repeatability reproducibility bias linearity stability
Practice: Statistical calculations and data interpretation	**Practice:** Basic MSA calculations and evaluation of measurement systems
6th week:	**7th week:**
Lecture: Advanced MSA methods, gauge R and R analysis variable and attribute measurement systems, acceptance criteria and interpretation	**Lecture:** Process capability fundamentals, process stability and capability concept, Cp and Cpk indices definition interpretation and limitations
Practice: Gauge R and R calculation and evaluation	**Practice:** Cp and Cpk calculation exercises using sample datasets
8th week: 1st drawing week	
9th week:	**10th week:**
Lecture: Advanced process capability analysis, Pp and Ppk indices long term capability comparison with Cp Cpk, process centering and variation analysis	**Lecture:** Statistical process control SPC fundamentals, purpose of SPC process stability, types of variation common and special causes
Practice: Pp and Ppk calculations and capability evaluation.	**Practice:** Identifying variation types in datasets
11th week:	**12th week:**
Lecture: Control charts for variables, X bar and R charts X bar and S charts, rules for interpretation and out of control signals	**Lecture:** Control charts for attributes, p chart np chart c chart u chart, application in automotive production
Practice: Control chart construction and analysis.	**Practice:** Attribute control chart calculations and interpretation
13th week:	**14th week:**
Lecture: Automotive quality tools and documentation, APQP process overview, PPAP documentation structure and requirements, supplier quality and complaint handling	**Lecture:** Integration and industrial application, role of MSA SPC and capability indices in decision making, linking measurement systems and process capability **Practice:** Final project presentation including capability calculation and SPC analysis
Practice: PPAP element identification and case exercise	
15th week: 2nd drawing week	

Requirements

A, for a signature:

Attending practices is compulsory. Attendance at lectures is recommended. Students have to attend practice classes and may not miss more than three practice classes during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Students cannot make up any practice class with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certification needs to be presented. Missed practice classes have to be made up for at a later date previously discussed with the tutor.

B, for a grade:

The course ends in a written end-term test.

The minimum requirement of the end-term test is 50%. The grade is given according to the following (score/grade): 0-49 = fail (1); 50-69 = pass (2); 70-79 = satisfactory (3); 80-89 = good (4); 90-100 = excellent (5). If the score of the test is below 50, students can retake that test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

6 Sigma and Lean Philosophy

Code: MK5SZLIM05JX24-EN

ECTS Credit Points: 4

Evaluation: mid-semester grade

Number of teaching hours/week (lecture + practice): 2+2

Topics:

During the course, students will learn about the six sigma method and lean principles through case studies. During their studies, they will learn structured problem-solving and process improvement procedures that combine a number of quality (TQM - Total Quality Management) and process improvement tools.

Within the framework of the course, students will work on statistical calculations, the calculation of indicators (standard deviation, standard deviation squared, etc.), problem-solving procedures such as DMAIC (Define, Measure, Analyse, Improve, Control) or PDCA.

Students will be introduced to the six sigma levels of organisation (champion, master black belt, black belt, green belt, yellow belt).

Literature:

Required: -

Recommended:

- Paul Keller: The Six SIGMA Handbook, Sixth Edition: A Complete Guide for Green Belts, Black Belts, and Managers at All Levels, ISBN 9781265143992, McGraw Hill Book CO., 2023.

- James P. Womack, Daniel T. Jones, Daniel Roos: The Machine That Change the World, ISBN 9780743299794, Simon and Schuster, 2011.

Schedule

1st week Registration week	
2nd week: **Lecture:** Course overview, expectations, History of Lean (Toyota Production System) and Six Sigma, Differences and synergies (Lean vs Six Sigma) **Practice:** Case discussion on Lean vs traditional production, identifying waste in everyday processes	3rd week: **Lecture:** Lean principles and value, five Lean principles (value, value stream, flow, pull, perfection), customer value definition **Practice:** Value identification exercises, simple process mapping
4th week: **Lecture:** Types of waste (Muda, Mura, Muri), seven plus one wastes in Lean, waste elimination strategies **Practice:** Waste identification in case studies, Gemba observation simulation	5th week: **Lecture:** Process thinking and flow, process-oriented thinking, flow versus batch production, bottlenecks and constraints **Practice:** Process simulation, bottleneck identification
6th week: **Lecture:** Introduction to Six Sigma, Six Sigma concept and philosophy, sigma levels and performance, organizational roles (champion, master black belt, black belt, green belt, yellow belt) **Practice:** Sigma level calculation exercises, case study on process variation	7th week: **Lecture:** Basic statistics for Six Sigma, mean, variance, standard deviation, normal distribution, process capability basics **Practice:** Statistical calculations and data interpretation
8th week: 1st drawing week	
9th week: **Lecture:** Basic statistics for Six Sigma, mean, variance, standard deviation, normal distribution, process capability basics **Practice:** Statistical calculations and data interpretation	10th week: **Lecture:** DMAIC methodology define and measure phases, problem definition, voice of customer and CTQ, data collection. **Practice:** Problem definition workshop, SIPOC diagram creation
11th week:	12th week: **Lecture:** DMAIC improve phase, improvement techniques, brainstorming

Lecture: DMAIC analyze phase, root cause analysis, tools including fishbone diagram, five whys and Pareto analysis **Practice:** Root cause analysis on case study, Pareto chart creation	and solution selection, introduction to FMEA **Practice:** Generating improvement ideas, simple FMEA exercise
13th week: **Lecture:** DMAIC control phase, control plans, standardization, introduction to control charts. **Practice:** Designing control plans, control chart interpretation	14th week: **Lecture:** ntegration and industry applications, Lean Six Sigma integration, applications in automotive, logistics and services, introduction to digital Lean and Industry 4.0 and 5.0. **Practice:** final project presentations, course summary and reflection
15th week: 2nd drawing week	

Requirements

A, for a signature:

Attending practices is compulsory. Attendance at lectures is recommended. Students have to attend practice classes and may not miss more than three practice classes during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Students cannot make up any practice class with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certification needs to be presented. Missed practice classes have to be made up for at a later date previously discussed with the tutor.

B, for a grade:

The course ends in a written end-term test.

The minimum requirement of the end-term test is 50%. The grade is given according to the following (score/grade): 0-49 = fail (1); 50-69 = pass (2); 70-79 = satisfactory (3); 80-89 = good (4); 90-100 = excellent (5). If the score of the test is below 50, students can retake that test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

Internet of Things – Systems and Technologies

Code: MK5TIRTR06VX23-EN

ECTS Credit Points: 6

Evaluation: mid-semester grade

Number of teaching hours/week (lecture + practice): 2+3

Topics:

The course addresses the rapidly evolving IoT landscape by developing practical technological and software competencies. It covers problem identification, IoT device design and programming, data acquisition and management, visualization, and related business models. Using Raspberry Pi, Arduino, and Packet Tracer environments, students build end-to-end systems integrating sensors, networks, cloud services, and introductory Python-based machine learning for data analysis.

Literature:

Required:

- Towards a definition of the Internet of Things (IoT), IEEE Internet Initiative, white paper, pp 86.
- Hanes David, Networking Technologies, Protocols, and Use Cases for the Internet of Things, Pearson Education (US), 576 pp, ISBN: 1587144565.

Recommended:

- Ammar Rayes, Samer Salam: Internet of Things from Hype to Reality: The Road to Digitization, Springer Nature Switzerland AG, pp 451, ISBN: 3030901572.
- Rolando Herrero: Fundamentals of IoT Communication Technologies (Textbooks in Telecommunication Engineering), pp 559, ISBN 3030700798.

Schedule

1st week Registration week	
2nd week:	**3rd week:**
Lecture: Introduction to the Internet of Things (IoT), its historical evolution, enabling technologies, and application domains. Overview of cyber-physical systems, sensing, connectivity, and the role of IoT in digital transformation.	**Lecture:** StandaFundamental IoT concepts including device ecosystems, embedded systems, and data flow between sensors, gateways, and cloud platforms. Discussion of typical IoT architectures and layered communication models.
Practice: Introduction to cloud-based IoT development environments using Cisco	**Practice:** Hands-on exploration of Packet Tracer IoT components. Students

Packet Tracer. Students explore device simulation, virtual sensors, and basic IoT workflows including device connectivity and data transmission.	configure virtual sensors and actuators, simulate network connectivity, and observe how data is transmitted and visualized in a cloud environment..
4th week:	5th week:
Lecture: Standardization of IoT technologies and communication protocols. Overview of IEEE standards including IEEE 802.15.4 for low-power wireless networks, covering topology, MAC layer operation, and efficient device communication.	Lecture: Industrial trends in IoT development including smart manufacturing, automation, and Industry 4.0. Examination of real-world IoT solutions and emerging industrial platforms for connected devices and data-driven services.
Practice: Design of electronic circuits using virtual design tools. Students simulate sensor circuits and simple embedded systems to understand how physical signals are converted into digital data for IoT processing.	Practice: Introduction to RedBoard and Arduino IDE. Students program basic microcontroller functions using LEDs, photoresistors, and flex sensors, gaining experience with analog input, digital output, and embedded programming.
6th week:	7th week:
Lecture: Architectural perspectives of IoT systems including device layer, edge computing, network layer, and cloud services. Discussion of scalability, interoperability, and distributed processing within IoT ecosystems.	Lecture: Operating characteristics of sensor systems including energy efficiency, real-time constraints, and embedded operating systems for IoT devices. Concepts of resource-constrained computing and low-power design.
Practice: Advanced Arduino device control using servo motors, buzzers, and relays. Students implement actuator control and event-driven programs responding to sensor inputs in simple automation scenarios.	Practice: Simulation of IoT devices and sensors within Packet Tracer. Students configure microcontrollers, simulate environmental sensors, and observe data collection and transmission processes in virtual IoT networks.
8th week: 1st drawing week	
9th week:	10th week:
Lecture: Addressing mechanisms for IoT devices including IPv6 addressing, Electronic Product Codes (EPC), and identification schemes for billions of connected devices within large-scale distributed networks.	Lecture: Programmability of IoT devices focusing on embedded software frameworks, firmware updates, and communication protocols enabling device-to-device and device-to-cloud interaction in large distributed systems.

Practice: Exploration of single-board computers (SBC) in IoT applications. Students implement smart-home scenarios including device monitoring, sensor integration, and actuator control within a simulated environment.

11th week:

Lecture: Software Defined Networking (SDN) concepts in IoT infrastructures. Examination of programmable networking, dynamic traffic control, and network management approaches supporting large-scale IoT deployments.

Practice: Simulation of smart city and smart grid applications. Students analyze interconnected systems including traffic management, energy monitoring, and distributed sensing networks.

13th week:

Lecture: Introduction to the Web of Things (WoT), enabling web-based interaction with IoT devices using standardized APIs and web technologies for interoperability across heterogeneous platforms.

Practice: Application of machine learning methods to IoT datasets. Students implement linear regression, decision tree classification, and anomaly detection for monitoring Internet traffic and sensor measurements.

Practice: Development of a connected factory scenario using Packet Tracer. Students implement industrial IoT communication and explore methods for securing cloud services and protecting IoT data flows.

12th week:

Lecture: Network Function Virtualization (NFV) in IoT systems. Discussion of virtualized network services, scalable infrastructure, and flexible deployment of communication and security functions in IoT architectures.

Practice: Introduction to Python-based data analytics using Jupyter Notebook. Students perform basic data exploration, visualization, and processing of IoT sensor datasets.

14th week:

Lecture: IoT-aware process modeling and integration of IoT data into business workflows. Exploration of process automation and digital transformation supported by real-time IoT data streams. Integration of IoT technologies with 5G communication networks. Discussion of ultra-low latency, massive device connectivity, and emerging IoT services enabled by next-generation mobile infrastructure.

Practice: Advanced visualization techniques for IoT datasets. Students analyze network performance metrics and evaluate Internet speed compliance through graphical and statistical data representation. Implementation of computer vision applications in IoT systems. Students perform camera control, change detection, and smile detection using artificial intelligence and image processing techniques.

15th week: 2nd drawing week

Requirements

A, for a signature:

Attending practices is compulsory. Attendance at lectures is recommended. Students have to attend practice classes and may not miss more than three practice classes during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Students cannot make up any practice class with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certification needs to be presented. Missed practice classes have to be made up for at a later date previously discussed with the tutor.

B, for a grade:

The course ends in a written end-term test.

The minimum requirement of the end-term test is 50%. The grade is given according to the following (score/grade): 0-49 = fail (1); 50-69 = pass (2); 70-79 = satisfactory (3); 80-89 = good (4); 90-100 = excellent (5). If the score of the test is below 50, students can retake that test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

Electrical Measurement and Signal Processing

Code: MK5MEJER04LX17-EN

ECTS Credit Points: 4

Evaluation: exam

Number of teaching hours/week (lecture + practice): 2+2

Topics:

Industry 4.0 are typical trends, the current and expected trends of development. System engineering: Basic concepts, classification of systems. Bond graphs in electrical engineering. Sensors in manufacturing automation and other industrial applications. Physical engineering practice is the most important measurement of physical quantities: temperature measurement, position detection, proximity switches, flow sensors, speed sensors, acceleration sensors. Sensors (sensors) and measuring transducers. The measuring device structure and characteristics. Measurement errors. Measurement methods. Electromechanical and Electronic Instruments. Analogue, Digital Instruments. Microelectronic sensors. Processing of analogue and digital signals of data. The evaluation of the results, error analysis using data acquisition card (DAQ).

Literature:

Required: -

Recommended:

Compulsory:

- Ed. Robert H. Bishop: The Mechatronics Handbook, Section III: Sensors and actuators, CRC Press; 2nd edition 2007, ISBN: 978-0849392573
- Aciatore, David G.: Introduction to mechatronics and measurement systems, Boston, 2007, ISBN:007 125407 2

Schedule

1st week Registration week	
2nd week: **Lecture:** Industry 4.0 trends, current and expected development directions **Practice:** Process simulation exercise	**3rd week:** **Lecture:** Systems engineering: basic concepts, classification of systems **Practice:** Modelling of electrical machines
4th week: **Lecture:** Application of bond graphs in electrical engineering **Practice:** Bond graph applications	**5th week:** **Lecture:** Concept and classification of sensors, physical effects used in sensing, overview of sensor materials and manufacturing technologies **Practice:** Sensor measurement exercises
6th week: **Lecture:** Proximity switches, position sensors and other industrial sensors **Practice:** Sensor measurement exercises	**7th week:** **Lecture:** Flow and temperature sensors overview **Practice:** Sensor measurement exercises
8th week: 1st drawing week	
9th week: **Lecture:** Speed and acceleration sensors overview. **Practice:** Sensor measurement exercises.	**10th week:** **Lecture:** Structure and operation of measurement transducers **Practice:** Measurement of analog and digital transducers
11th week: **Lecture:** Structure and operation of analog and digital measuring instruments **Practice:** Data acquisition using DAQ card	**12th week:** **Lecture:** Measurement system architecture and data acquisition **Practice:** Processing signals provided by DAQ
13th week: **Lecture:** Processing measured data and error analysis **Practice:** Error analysis of DAQ signals	**14th week:** **Lecture:** Summery **Practice:** repeat practice

15th week: 2nd drawing week

Requirements

A, for a signature:

Attendance at lectures is recommended, but not compulsory. Participation at practice classes is compulsory. A student must attend the practice classes and may not miss more than three times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. A student can't make up a practice class with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. Missed practice classes must be made up for at a later date, being discussed with the tutor. Active participation is evaluated by the teacher in every class. If student's behaviour or conduct doesn't meet the requirements of active participation, the teacher may evaluate his/her participation as absence because of the lack of active participation in class. During the semester there are one test: the end-term test in the 15th week. Students have to sit for these tests.

B, for grade:

At the end of the course an oral exam must be taken. Based on the average of the grades of the reports and the test results, the mid-semester grade is calculated as an average of them: - the average grade of the twelve reports (30 %) - the grade of the tests (20 %) - the oral exam (50 %) The minimum requirement for end-term test is 60%. Based on the score of the test separately, the grade for the test is given according to the following table: Score Grade 0-59 fail (1) 60-69 pass (2) 70-79 satisfactory (3) 80-89 good (4) 90-100 excellent (5)

Robotics and Vehicle Manufacturing

Course Code: MK5RTJGJ04JX24-EN

Credit Points: 4

Evaluation: exam

Number of Lessons/Week (theory + practice): 2 + 3

Prerequisite: -

Topics:

Adaptive control of multi-axis robot manipulators. Application of methods for robot coordinate system positioning. Configurations of robot manipulators and working of TTT, RTT, RRT, RRR structures. Positioning of robot units in the workspace. Perform direct and inverse kinematic calculations. Effector orientation and robot calibrations. Robot path planning in tool, world, base and wrist coordinate systems. Application of Denavit-Hartenberg transformation matrix. Recursive kinematic models of robot units. Design and testing of computational dynamics models of robot manipulators. Decentralized PD robot

control in virtual space. Overview of automotive robots and programming languages. Fundamentals of production planning. Application of shop floor simulations to model mechanical components and assemblies. Design and integration of manufacturing processes in a simulation environment. Definition of sequences of operations. Vehicle component manufacturing characteristics and design of simulation models (gearbox, engine, chassis, etc.). Assemblability analysis and optimisation of the manufacturing process. Presentation and process analysis of vehicle manufacturing and assembly systems.

Literature:

Required:

- Robotics: Modelling, Planning and Control (Advanced Textbooks in Control and Signal Processing)by Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, 2009.
- The Automotive Body Manufacturing Systems and Processes by Mohammed A. Omar, 2011.

Recommended:

- Automotive Manufacturing Processes, By G.K. Awari, V.S. Kumbhar, R.B. Tirpude, S.W. Rajurkar, 2023
- Recent Advances in Manufacturing, Automation, Design and Energy Technologies: Proceedings from ICoFT by Sendhil Kumar Natarajan, Rajiv Prakash, K. Sankaranarayanasamy, 2020.

Schedule

1. Registration Week	
2. week: **Theory:** A general overview of robotics. Definition and classification of robot units. **Practice:** Introduction to industrial robots I.	**3. week:** **Theory:** Configurations of robot manipulators and the working of TTT, RTT, RRT, RRR structures. **Practice:** Introduction to industrial robots II.
4. week: **Theory:** Perform direct and inverse kinematics calculations. Effector orientation and robot calibrations. **Practice:** Application of the Denavit-Hartenberg transformation matrix. Recursive kinematic models of robot units.	**5. week:** **Theory:** Perform robot path planning in tool, world, base and wrist coordinate systems. **Practice:** Programming methods for industrial robots.
6. week:	**7. week:**

Theory: Design and testing of computational dynamics models for robot manipulators. **Practice:** Decentralized PD robot control in virtual space.	**Theory:** Overview of robots and programming languages used in the automotive industry. **Practice:** Basics of production planning.
8. week: 1st drawing week	
9. week: **Theory:** Using factory simulations to model machinery components and assemblies. **Practice:** Design and integration of manufacturing processes in a simulation environment.	10. week: **Theory:** Vehicle component manufacturing characteristics and design of simulation models (gearbox, engine, chassis, etc.) **Practice:** Definition of sequences of operations.
11. week: **Theory:** Component fit testing and manufacturing process optimization. **Practice:** Virtual vehicle production process design I.	12. week: **Theory:** Presentation and process analysis of automotive manufacturing and assembly systems. **Practice:** Virtual vehicle manufacturing process design II.
13. week: **Theory:** 3D CAD modelling of automotive components and integration into simulation environment **Practice:** Virtual vehicle manufacturing process design III.	14. week: **Theory:** Optimizing of 3D CAD models **Practice:** Virtual vehicle manufacturing process design IV.
15. week: 1nd drawing week	

Requirements

A, Signature:

Participation in exercises according to the rules of the TVSZ. Correctly solving the assigned homework and submitting it on time.

B, Grade:

Performance assessment, the condition for obtaining a mark, the average of the tasks submitted.

Subject group “Vehicle and mobile machine design theory”

Car Body Production and Technologies

Course Code: MK5RTJGJ04JX24-EN

Credit Points: 3

Evaluation: exam

Number of Lessons/Week (theory + practice): 2 + 1

Topics:

The course provides comprehensive knowledge of vehicle body structure manufacturing processes, from sheet metal forming to complex assembly and surface treatment technologies. The curriculum is based on press shop processes, where students learn the principles of cold forming and the hot stamping (press hardening) processes used for high-strength steels. The process planning phase places particular emphasis on the robotization of manufacturing cells, where multi-axis industrial manipulators perform the assembly. A central element of the course is welding simulation, which enables the trajectory optimization of resistance spot welding electrodes and laser heads, collision detection, and the preliminary calculation of heat-affected zones and deformations. Students also master the simulation of painting processes, which is one of the most complex virtual tasks in modern automotive manufacturing. This includes coordinating robot arm movements with atomizer parameters, predicting coating thickness uniformity, and modeling air bubble formation and fluid dynamic effects during E-coat (cathodic dip painting/KTL) processes. Digital validation within a production line simulation environment is an integral part of the curriculum. This approach ensures that complex welding sequences, adhesive application cycles, and painting phases are synchronized, minimizing cycle times and scrap rates.

Literature:

Required:

- Robotics: Modelling, Planning and Control (Advanced Textbooks in Control and Signal Processing)by Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, 2009.
- The Automotive Body Manufacturing Systems and Processes by Mohammed A. Omar, 2011.
- Altan, T. & Tekkaya, A. E. (2012): Sheet Metal Forming: Processes and Applications. ASM International. ISBN: 978-1615038428.

Recommended:

- Automotive Manufacturing Processes, By G.K. Awari, V.S. Kumbhar, R.B. Tirpude, S.W. Rajurkar, 2023

- Recent Advances in Manufacturing, Automation, Design and Energy Technologies: Proceedings from ICoFT by Sendhil Kumar Natarajan, Rajiv Prakash, K. Sankaranarayanasamy, 2020.

Schedule

1. Registration Week	
2. week: **Theory:** Overview of the car body manufacturing process I. **Practice:** Introduction to industrial robots I.	3. week: **Theory:** Overview of the car body manufacturing process II. **Practice:** Introduction to basic press shop operations and tools (cutting, bending, deep drawing) II.
4. week: **Theory:** Cold forming and hot stamping (press hardening). **Practice:** Determination of forming technology parameters.	5. week: **Theory:** The phenomenon and compensation of elastic springback. **Practice:** Investigation of forming limit diagrams (FLD).
6. week: **Theory:** Automated joining technologies: Theory of resistance spot welding, laser welding, and structural bonding I. **Practice:** Configuration of multi-axis robots for body welding tasks.	7. week: **Theory:** Automated joining technologies: Theory of resistance spot welding, laser welding, and structural bonding II. **Practice:** Selection of welding guns and end-effectors.
8. week: 1st drawing week	
9. week: **Theory:** Fundamentals of production line simulations in car body manufacturing. **Practice:** Welding trajectory planning and collision detection in a simulation software environment I.	10. week: **Theory:** Digital Twin concepts in manufacturing. **Practice:** Welding trajectory planning and collision detection in a simulation software environment II.
11. week: **Theory:** Surface treatment technologies: E-coat (KTL) and sealing processes. **Practice:** Virtual manufacturing cell design: robot placement, fixture design, and workspace analysis I.	12. week: **Theory:** Automation and simulation models of the painting process. **Practice:** Virtual manufacturing cell design: robot placement, fixture design, and workspace analysis II.
13. week:	14. week:

Theory: Future trends: Giga-casting (large-scale castings) and modularity. Cycle time analysis and bottleneck management I. **Practice:** Running the complete virtual body assembly line, synchronization of logistics routes (AGVs) and robots I.	**Theory:** Future trends: Giga-casting (large-scale castings) and modularity. Cycle time analysis and bottleneck management II. **Practice:** Running the complete virtual body assembly line, synchronization of logistics routes (AGVs) and robots II.
15. week: 1nd drawing week	

Requirements

A, Signature:

Participation in exercises according to the rules of the TVSZ. Correctly solving the assigned homework and submitting it on time.

B, Grade:

Performance assessment, the condition for obtaining a mark, the average of the tasks submitted.

Pneumatic and Hydraulic Components for Production Systems

Course Code: MK5TRPHJ03JA24-EN

Credit Points: 3

Evaluation: exam

Number of Lessons/Week (theory + practice): 2 + 1

Topics:

Production and preparation of compressed air. Application of pneumatic actuators and control elements. Application of directional control valves, shut-off and flow control elements. Pneumatic implementation of basic logic functions, counters and timers. Application and implementation of the standard symbol system for pneumatic elements and connections. Use of the FluidSIM-P program. Generation of hydraulic energy, hydraulic energy converters and their operation. Basic physical concepts and basic hydraulic calculations, power and efficiency. Application of hydraulic actuators and control elements. Directional valves, shut-off and flow control elements, pressure regulators, spool and seat elements. Element technology measurements and measuring circuits. Application of pipeline sections, hoses, oil filters. Application and implementation of the standard symbol system for hydraulic elements and connections. Use of the FluidSIM-H program. Assembly of pneumatic and hydraulic systems.

Literature:

Required:

- Festo Didactic P111
- Festo Didactic H511

Recommended:

• Dr. Tibor Hantos, Antal Barak, Lajos Nagy, Gábor Simon: Fundamentals of Hydraulics, University of Miskolc HEFOP 2007.

Schedule

1st week Registration	
2nd week: **Theory:** Introduction to pneumatics, basic concepts, laws, tools needed to produce air of the appropriate quantity and quality **Practice:** Getting to know the user interface of the FluidSim program, simulating direct connections and installing them on test benches	3rd week: **Theory:** Options for modifying the speed/rpm of pneumatic actuators, cylinders, linear drives, air motors, turning units, and working units **Practice:** Modifying the speed of cylinders in a simulation and assembly environment
4th week: **Theory:** Constructional structure, types, marking system of pneumatic valves **Practice:** Indirect switching tasks, taking into account safety requirements in a simulation and assembly environment	5th week: **Theory:** Pneumatic timers and counters **Practice:** Implementing time-dependent control tasks in simulation and assembly environments
6th week: **Theory:** Purpose and solution of sequential control tasks, interpretation of path-step diagrams and short descriptions **Practice:** Solving sequential control tasks in simulation and assembly environments	7th week: **Theory:** Sequential control tasks in the case of blocking signals, theory of cascade and step chain controls **Practice:** Solving complex sequential control tasks with cascade, step module, step chain solutions in simulation and assembly environments
8th week: 1st drawing week	
9th week: **Theory:** Introduction to hydraulics, advantages and disadvantages, basic laws, relationships **Practice:** Symbols used in hydraulics, direct control of mobile hydraulic systems in a simulation environment, assembly of basic connections, calculation of transmission ratios of hydraulic systems	10th week: **Theory:** Laws related to power and efficiency used in hydraulics, cavitation phenomena **Practice:** mobile hydraulics logic control tasks, calculation tasks related to power and losses

11th week:	12th week:
Theory: Construction, marking system, types of hydraulic valves	Theory: Function and types of pressure regulators used in hydraulics
Practice: Speed/rev modification with split flow in simulation and assembly environment	Practice: Pressure-dependent controls in hydraulics, installation tasks with pressure regulators
13th week:	14th week:
Theory: Construction of oil quality equipment (filters, cooling, heating equipment) and tank structure	Theory: Construction of pumps and actuators
Practice: Sequential control tasks for hydraulic systems	Practice: Complex sequential control tasks related to mobile hydraulics
15th week: 2nd drawing week	

Requirements

A, signature:

The condition for signing is participation in the exercises. The maximum number of absences allowed is three, in case of more absences the signature will be refused. Lateness (regardless of its extent) is considered an absence. The administration of absences is done by signing the attendance sheet.

B, grade:

During the semester, students must write two closed-door papers. (One on pneumatics and one on hydraulics.) The paper consists of three parts: theory, simulation task and assembly task. At least satisfactory completion of all three modules is required for a successful paper. The final grade is determined based on the total score of the two papers. To successfully complete the subject, both papers must be completed at least satisfactorily. Make-up and correction are possible according to the relevant rules of the study and examination regulations.

Assembly and Production Automation

Course Code: MK5SZGAJ03JA24-EN

Credit Points: 3

Evaluation: mid-semester grade

Number of Lessons/Week (theory + practice): 0 + 2

Topics:

Learning the properties of electropneumatic and electrohydraulic systems and their elements, preparing the corresponding circuit diagrams, physically implementing electropneumatic and electrohydraulic control tasks on test benches. Learning the basics of proportional hydraulics and examining control options with PLC.

Literature:

Required:

- FESTO-Basics of electropneumatics
- EP211 - FESTO-Basics of electrohydraulics - EH622

Recommended:

- Dr.Bodzás Sándor, Dr. Tóth János – Assembly automation
- Balpataki A.,Bécsi T.,Károly J. – Vehicle hydraulics and pneumatics

Schedule

1st week: Registration	
2nd week: Theory: Basic concepts of electropneumatics, control concepts Practice: Direct EP connections in simulation and assembly environments	3rd week: Theory: Construction of an electrical power supply, learning about the types of sensors, types of time relays, advantages of a PLC-controlled EP system Practice: Indirect connections in a simulation and assembly environment
4th week: Theory: Structural design, types, properties, and applications of EP valves Practice: Indirect controls using sensors	5th week: Theory: EP development and optimization opportunities, the issue of damage caused by electrical networks Practice: Time-dependent EP control tasks in simulation and assembly environments
6th week: Theory: Types of documentation required for the installation and operation of an EP system Practice: Sequential control tasks	7th week: Theory: Modern wiring solutions in the EP system, advantages of using bus systems, basics of proportional pneumatics Practice: Complex sequential control tasks, switching circuits
8th week: 1st drawing week	
9th week:	10th week: Theory: Design solutions for EH valves

Theory: Repetition of hydraulic system characteristics, electrohydraulic control options **Practice:** direct and indirect control of basic EH connections, their simulation in FluidSim ® program	**Practice:** Sequential control tasks in EH systems
11th week:	**12th week:**
Theory: Mobile and installed electrohydraulic solutions **Practice:** Time-dependent controls	**Theory:** Development opportunities in electrohydraulics **Practice:** Installation of electrohydraulic systems
13th week:	**14th week:**
Theory: Monitoring and maintenance of electrohydraulic systems **Practice:** Complex sequential control within a circuit	**Theory:** Basic concepts of proportional hydraulics **Practice:** Control tasks related to proportional hydraulics
15th week: 2nd drawing week	

Requirements:

A, signature:

The condition for signing is participation in the exercises. The maximum number of absences allowed is three, in case of more absences the signature will be refused. Lateness (regardless of its extent) is considered an absence. The administration of absences is done by signing the attendance sheet.

B, grade:

During the semester, students must write two closed-door papers. (One on electropneumatics and one on electrohydraulics.) The paper consists of three parts: theory, simulation task and assembly task. At least satisfactory completion of all three modules is required for a successful paper. The final grade is determined based on the total score of the two papers. To successfully complete the subject, both papers must be completed at least satisfactorily. Make-up and correction are possible according to the relevant rules of the study and examination regulations.

Automotive Safety

Course Code: MK5JIBTJ03JA24-EN
Credit Points: 3

Evaluation: exam

Number of Lessons/Week (theory + practice): 2 + 1

Topics:

Structure, function and development possibilities of active and passive safety systems used in vehicles. Basic concepts of traffic safety. Types of collisions and crash tests. Passenger protection solutions (belts, belt tensioners, distance control systems, stability control systems)

Literature:

Required

- Lévai Zsolt – Traffic safety,2019
- Seiffert, Ulrich – Automotive safety handook, 2003

Recommended:

• Vehicle driving dynamics: forces acting on the vehicle, steering, braking, testing methods, road safety / Ádám Zomotor

Schedule:

1st week: Registration	
2nd week: **Theory:** Basic concepts related to traffic safety, distinction between active and passive safety **Practice:** Calculation tasks regarding braking distance and following distance	**3rd week:** **Theory:** Types of collisions, typical technical and personal injuries **Practice:** Calculation tasks regarding the extent of personal injury
4th week: **Theory:** Passive safety systems, body structure **Practice:** Forward and backward calculations, EES, vector method	**5th week:** **Theory:** Types of fracture tests, qualification method **Practice:** Analysis of body creases and damage
6th week: **Theory:** Passive safety of trucks **Practice:** Testing underrun protection systems	**7th week:** **Theory:** Modern body construction **Practice:** Calculation of impact energy absorption
8th week: 1st drawing week	
Week 9: **Theory:** Active safety concepts **Practice:** Active safety systems in practice	**10th week:** **Theory:** Seat belts and belt tensioners **Practice:** Structural testing of belts and belt tensioners

11th week: **Theory:** Airbag Structure **Practice:** Airbag Structure	12th week: **Theory:** Adaptive cruise control, lane keeping systems **Practice:** Calibration of adaptive cruise control systems
13th week: **Theory:** Safety technology of X-by wire systems, stabilizers **Practice:** Calculation of overloads	14th week: **Theory:** Emergency brake assistants, roll-back prevention systems **Practice:** Braking process examination
15th week: 2nd drawing week	

Requirements

A, signature:

The condition for signing is to attend practical classes and complete the assignments on time and correctly. The number of permitted absences is three. Lateness (regardless of its extent) is considered an absence.

B, grade:

The subject must be concluded with a successful oral examination.

Material Handling and AGV Systems

Course Code: MK5AAGVJ03JA24-EN
Credit Points: 3

Evaluation: exam

Number of Lessons/Week (theory + practice): 2 + 1

Topics:

Introduction to material handling systems and logistics automation. Classification of material handling equipment. Fundamentals of Automated Guided Vehicles (AGVs): types, kinematics, navigation systems, and control strategies. Sensors and perception systems in AGVs. Path planning and obstacle avoidance. Integration of AGVs into smart factories and Industry 4.0 environments. Simulation and optimization of AGV systems.

Literature:

Required: -

Recommended:

- J. Bartholdi, Warehouse & Distribution Science

- R. Siegwart, I. Nourbakhsh, Introduction to Autonomous Mobile Robots, MIT Press
- Ullrich, G., 2024. Automated Guided Vehicle Systems. SpringerLink. https://doi.org/10.1007-978-3-662-44814-4
- Springer Handbook of Robotics, 2016. SpringerLink. https://doi.org/10.1007-978-3-319-32552-1

Schedule

1st week: Registration

2nd week:

Lecture: Introduction to material handling systems, including their role in modern manufacturing, warehousing, and logistics chains. Discussion of system objectives such as efficiency, cost reduction, and safety. Overview of material flow types (continuous, discrete, unit load) and classification of handling equipment (conveyors, cranes, forklifts, AGVs).

Practice: Case studies of industrial material handling systems.

3rd week:

Lecture: Comprehensive overview of Automated Guided Vehicles (AGVs), including historical development and evolution toward Autonomous Mobile Robots (AMRs). Detailed classification of AGVs (tow vehicles, unit load carriers, pallet trucks, forklift AGVs, hybrid systems). Analysis of application domains such as manufacturing lines, warehouses, and hospitals. Comparison between AGVs and AMRs in terms of flexibility and intelligence.

Practice: Identification and comparison of AGV types in industrial scenarios.

4th week:

Lecture: AGV kinematics and motion modeling, including differential drive, skid-steer, and omnidirectional platforms. Mathematical representation of robot motion, coordinate transformations, and velocity control. Discussion of constraints such as nonholonomic systems and their implications for control design. Introduction to basic control strategies for trajectory tracking.

Practice: Modeling and simulation of AGV motion.

5th week:

Lecture: Navigation techniques for AGVs, ranging from traditional fixed-path methods (magnetic tape, inductive wires, QR codes) to advanced methods such as laser guidance and vision-based navigation. Introduction to SLAM (Simultaneous Localization and Mapping) and its importance for autonomous navigation in dynamic environments.

Practice: Implementation of basic navigation algorithms.

6th week:

Lecture: Sensor technologies used in AGVs, including LiDAR, ultrasonic sensors, encoders, IMUs, and cameras. Principles of sensor operation, data acquisition, and noise characteristics. Introduction to sensor fusion techniques for improving localization and

7th week:

Lecture: Path planning algorithms for AGVs, including classical graph-based methods (Dijkstra, A*), sampling-based approaches, and real-time adaptive planning. Discussion of static vs dynamic environments, cost functions, and optimality.

perception accuracy (e.g., Kalman filtering concepts). **Practice:** Sensor data acquisition and interpretation.	**Practice:** Implementation of path planning algorithms.
8th week: 1st drawing week	
Week 9: **Lecture:** Obstacle detection and avoidance strategies, including reactive (local) and deliberative (global) approaches. Use of sensor data for real-time decision-making. Introduction to algorithms such as potential fields, dynamic window approach (DWA), and velocity obstacles. Handling dynamic obstacles and safety-critical scenarios. **Practice:** Simulation of obstacle avoidance techniques.	**10th week:** **Lecture:** Advanced multi-AGV coordination and fleet intelligence. Modeling AGV fleets as multi-agent systems with centralized, decentralized, and hybrid control architectures. In-depth analysis of traffic management using graph-based representations of warehouse layouts. **Practice:** Implementation of multi-AGV coordination scenarios with conflict resolution and traffic control in simulation.
11th week: **Lecture:** Intelligent task allocation and optimization in AGV systems. Application of advanced optimization methods including heuristic and metaheuristic approaches (genetic algorithms, particle swarm optimization), as well as AI-based methods (reinforcement learning for dynamic dispatching). Multi-objective optimization considering energy efficiency, time, and system robustness. Real-time adaptive scheduling under uncertainty and dynamic environments. **Practice:** AGV task allocation and scheduling problems using optimization and AI-based approaches.	**12th week:** **Lecture:** Integration of AGVs into Industry 4.0 and smart factory ecosystems. Communication architectures (ROS2, cloud systems), interoperability, and digital infrastructure. Role of AGVs in cyber-physical systems and data-driven decision-making. **Practice:** ROS-based AGV simulation and control.
13th week: **Lecture:** Safety standards and regulations for AGVs (ISO standards), risk assessment methodologies, and safe human-robot interaction. Ethical considerations and deployment challenges in real environments. Review of industrial applications across sectors. **Practice:** Risk assessment and safety design scenarios.	**14th week:** **Lecture:** Simulation tools and digital twin concepts for AGV systems. Use of platforms such as MATLAB, ROS, and Gazebo for modeling, testing, and validation. Introduction to performance evaluation, system verification, and virtual commissioning. **Practice:** Software-based simulation and analysis.

15th week: 2nd drawing week

Requirements

A, for a signature:

Attending practices is compulsory. Attendance at lectures is recommended. Students have to attend practice classes and may not miss more than three practice classes during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Students cannot make up any practice class with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certification needs to be presented. Missed practice classes have to be made up for at a later date previously discussed with the tutor.

B, for a grade:

The course ends in a written end-term test.

The minimum requirement of the end-term test is 60%. The grade is given according to the following (score/grade): 0-59 = fail (1); 60-69 = pass (2); 70-79 = satisfactory (3); 80-89 = good (4); 90-100 = excellent (5). If the score of the test is below 60, students can retake that test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

Non-fossil Energy Sources

Course Code: MK5NFEFJ03JA24-EN

Credit Points: 3

Evaluation: exam

Number of Lessons/Week (theory + practice): 2 + 0

Topics:

Fossil energy sources: types, limitations, environmental impacts. Non-fossil energy sources in the automotive industry. Electric and hybrid vehicles: HEV, PHEV, FCEV, BEV. Electrochemical fundamentals (energy sources). Battery types: lead-acid, nickel-based, lithium-ion. Experimental batteries: Na-ion, Li-air, Li-S. Lithium-ion batteries: evolution, types (LCO, LMO, NMC, NMCA, LFP, LIP). Battery manufacturing: raw materials → electrodes → cells/modules/packs. Hydrogen vehicles: fuel cell, internal combustion. Biofuels: types, production. Synthetic fuels (e-fuels), e.g., Fischer–Tropsch process. Nuclear energy production: basic principles. Nuclear-powered vehicles

Literature:

Required: -

Recommended:

- Jingshan Li, Shiyu Zhou, Yehui Han (2016): Advances in Battery Manufacturing, Service, and Management Systems, Wiley, Print ISBN:9781119056492
- Detlef Stolten, Remzi C. Samsun, Nancy Garland (2016): Fuel Cells: Data, Facts and Figures, Wiley-VCH Verlag GmbH & Co. KGaA., Print ISBN:9783527332403
- Chris Mi, M. Abul Masrur: (2017): Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd., Print ISBN:9781118970560

Schedule

1st week Registration week	
2nd week:	3rd week:
Lecture: Carbon cycle, greenhouse effect, global climate change. Fossil energy carriers Practice: -	Lecture: Fossil energy carriers in the transportation and its limitations: efficiency, CO2 emission, emission of exhaust gases, finite availability Practice: -
4th week:	5th week:

Lecture: Electrochemical background of batteries. Fundamental concepts of batteries **Practice:** -	**Lecture:** Major battery types in transportation: lead-acid, nickel-based, lithium-ion batteries **Practice:** -
6th week: **Lecture:** Development, structure, and manufacturing of lithium-ion batteries **Practice:** -	**7th week:** **Lecture:** Electric and hybrid vehicles: HEV, PHEV, FCEV, BEV **Practice:** -
8th week: 1st drawing week	
9th week: **Lecture:** Hydrogen vehicles: fuel cell, internal combustion. **Practice:** -	**10th week:** **Lecture:** Biofuels: types (bioethanol, biodiesel, biogas), production. Advantages, limitations, and sustainability **Practice:** -
11th week: **Lecture:** E-fuels: synthetic liquid and gaseous fuels. Efficiency and costs **Practice:** -	**12th week:** **Lecture:** Electrification and biofuels and e-fuels in aviation. SAF (Sustainable Aviation Fuel). Electric and hybrid aircraft **Practice:** -
13th week: **Lecture:** Nuclear energy production and nuclear-powered vehicles. History and applications of nuclear propulsion **Practice:** -	**14th week:** **Lecture:** Student presentations **Practice:** -
15th week: 2nd drawing week	

Requirements

A, for a signature:

Attendance at lectures is optional, but recommended. A student presentation is to given on an assigned topic.

B, for a grade:

Assessment is carried out through an oral exam, based on designated topics, using a five-grade scale.

Electric Drives

Course Code: MK5NFEFJ03JA24-EN

Credit Points: 4

Evaluation: exam

Number of Lessons/Week (theory + practice): 2 + 3

Topics:

Modelling theory at conceptual level and detailed level; Control theory for electrical drives. Control theory, open and closed loop, controller performance definition and evaluation. Electrical machines: theory, direct current machines, alternative current (rotating field machines) machines: Induction, PMSM, SRM, SyRM. Inverters: theory of DC to AC conversion, PWM, topology. VSD: Variable Speed Drives: topology, components and control. Battery: theory, components and technology. BEV and hybrid traction: modelling and components.

Literature:

Required: -

Recommended:

- Ali Emadi, "Advanced Electric Drive Vehicles", CRC Press, 2015, ISBN 978-1-4665-9770-9
- John G. Hayes, „Electric Powertrain", Wiley, 2018, ISBN 978-1-1190-6366-7
- Mehrdad Ehsani et al. "Modern Electric, Hybrid Electric and Fuel Cell Vehicles", 3rd ed., 2018, ISBN 978-1-4987-6177-2

Schedule

1st week Registration week	
2nd week:	3rd week:
Lecture: Modelling theory I. conceptual level. Electric drives and components. Modelling on electrical, mechanical and hydraulic domain.	**Lecture:** Modelling theory II. detailed level. Electric drive and components. Modelling on Electrical, mechanical and hydraulic domain. Non-linear effects.
Practice: Modelling practice: conceptual level, linear models of electrical, mechanical and hydraulic components.	**Practice:** Modelling practice: detailed level, non-linear models of electrical, mechanical and hydraulic components.
4th week:	4th week:
Lecture: Control Theory; summary. Open and closed control loop. Time domain modelling. Control performance evaluation.	**Lecture:** Control Theory; summary. Open and closed control loop. Frequency domain modelling. Control performance evaluation.
Practice: Performance evaluation in time domain, control parameter tune. Electric drive motion control.	**Practice:** Performance evaluation in frequency domain, control parameter tune. Electric drive motion control.
6th week:	7th week:

Lecture: Electrical machines: construction and theory. Steady-state and dynamical characteristics. **Practice:** Excitation, armature. Electrical power conversion. Construction and properties.	**Lecture:** Rotating field machines. Theory: generation of a rotating field: magnetic field. Induced voltage (electromagnetic force). **Practice:** Induction machine: construction and properties, synchronous machine: construction and properties.
8th week: 1st drawing week	
9th week: **Lecture:** Power electronic components: diode, thyristor, IGBT, MosFET **Practice:** Modelling of electronic components, rectifiers (AC-to-DC converters).	10th week: **Lecture:** Inverters: theory, single phase inverter, three-phase, six step inverter topology. **Practice:** voltage Source Inverter, Current Source Inverter, PWM inverter
11th week: **Lecture:** Battery modelling: battery components, cell types and modelling. **Practice:** Battery cell modelling, cell connection schematics.	12th week: **Lecture:** BEV: Battery Electrical Vehicles, modelling, steady state and dynamic models. **Practice:** BEV components and modelling: battery, inverter and electrical machine.
13th week: **Lecture:** Series and parallel hybrid vehicles, modelling, steady state and dynamic models. **Practice:** Series and parallel hybrid vehicles components and modelling: ICE, transmission, battery, inverter and electrical machine.	14th week: **Lecture:** Electromagnetic theory, electromagnetic compatibility: emission and immunity. **Practice:** Practical methods to reduce emission and improve against external electromagnetic interference.
15th week: 2nd drawing week	

Requirements

A, for a signature:

Attending practices is compulsory. Attendance at lectures is recommended. Students have to attend practice classes and may not miss more than three practice classes during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Students cannot make up any practice class with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certification needs to be presented. Missed practice classes have to be made up for at a later date previously discussed with the tutor.

B, for a grade:

The course ends in a written end-term test.

The minimum requirement of the end-term test is 50%. The grade is given according to the following (score/grade): 0-49 = fail (1); 50-69 = pass (2); 70-79 = satisfactory (3); 80-89 = good (4); 90-100 = excellent (5). If the score of the test is below 50, students can retake that test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

Project work I.

Course Code: MK5VPF1J08JA24-EN
Credit Points: 8

Evaluation: mid-semester grade

Number of Lessons/Week (theory + practice): 5 + 5

Topics:

The purpose of the project work for the student is to work independently in the context of solving a complex engineering task. The project assignment, preferably announced by industrial partners, can be given to a student individually, or even to a group of 2-4 students. In the latter case, they work together on the project, but solve separate tasks independently. The task may also have system and circuit designers, contractors, technological, manufacturability, design, marketing, cost analysis, quality assurance, procurement, application engineering, relationship building, and publication aspects. Continuous consultation with both the university lecturers and the competent specialists of the partner company is ensured. It is possible to carry out the task both in the university laboratories and in the designated areas of the industrial partner. The progress in solving the task is jointly evaluated by the instructors and the industrial partner, and possible changes and changes in direction are suggested. At the end of the semester, the student presents the individual results of the project work in a conference-like presentation, the evaluation is also attended by instructors and industrial partners. The results produced in the framework of the project work and which reach the standard of the MSc studies can be incorporated into TDK works and later in the thesis work of the individual participants.

Literature:

Required: -

Recommended: -

Requirements

A, for a signature:

Attending practices is compulsory. Attendance at lectures is recommended. Students have to attend practice classes and may not miss more than three practice classes during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Students cannot make up any practice class with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certification needs to be presented. Missed practice classes have to be made up for at a later date previously discussed with the tutor.

B, for a grade:

The course ends with a project task.

Project Work II.

Course Code: MK5VPF2J08JA24-EN

Credit Points: 8

Evaluation: mid-semester grade

Number of Lessons/Week (theory + practice): 5 + 5

Topics:

The purpose of the project work for the student is to work independently in the context of solving a complex engineering task. The project assignment, preferably announced by industrial partners, can be given to a student individually, or even to a group of 2-4 students. In the latter case, they work together on the project, but solve separate tasks independently. The task may also have system and circuit designers, contractors, technological, manufacturability, design, marketing, cost analysis, quality assurance, procurement, application engineering, relationship building, and publication aspects. Continuous consultation with both the university lecturers and the competent specialists of the partner company is ensured. It is possible to carry out the task both in the university laboratories and in the designated areas of the industrial partner. The progress in solving the task is jointly evaluated by the instructors and the industrial partner, and possible changes and changes in direction are suggested. At the end of the semester, the student presents the individual results of the project work in a conference-like presentation, the evaluation is also attended by instructors and industrial partners. The results produced in the framework of the project work and which reach the standard of the MSc studies can be incorporated into TDK works and later in the thesis work of the individual participants.

Literature:

Required: -

Recommended: -

Requirements

A, for a signature:

Attending practices is compulsory. Attendance at lectures is recommended. Students have to attend practice classes and may not miss more than three practice classes during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Students cannot make up any practice class with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certification needs to be presented. Missed practice classes have to be made up for at a later date previously discussed with the tutor.

B, for a grade:

The course ends in a written end-term test.

The minimum requirement of the end-term test is 50%. The grade is given according to the following (score/grade): 0-49 = fail (1); 50-69 = pass (2); 70-79 = satisfactory (3); 80-89 = good (4); 90-100 = excellent (5). If the score of the test is below 50, students can retake that test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS

DIPLOMA

The diploma shall be issued to the students within thirty days from having successfully passed the final exam at the grandaunt's special request. Otherwise, the diploma shall be awarded to him/her at the graduation ceremony of the Faculty.

The diploma is a public document bearing the coat of arms of the Hungary, certifying that the studies have been successfully completed in the Environmental Engineering master program. The diploma displays the name of the HEI (higher education institution), its institutional identification number, the serial number of diploma, the name and the place and date of birth of its holder, the level of qualification or the degree awarded, the program, the specialization, and its mode of attendance, as well as the place, day, month and year of issue. The diploma shall also contain the signature of the rector (in case of incapacitation the vice-rector), and shall bear the stamp of the University of Debrecen.

At the graduate's special request, a certificate on the completion of studies may be issued. The document does not contain any references to the qualification of the graduate, it merely proves that the he/she has taken a successful final exam. The Faculty shall keep a record of the certificates issued.

The diploma shall be assessed on the basis of the calculation of the grade average as follows:

Outstanding	4,81 – 5,00
Excellent	4,51 – 4,80
Good	3,51 – 4,50
Satisfactory	2,51 – 3,50
Pass	2,00 – 2,50

Diploma with Honours

A degree/diploma with honours shall be issued to a student who receives excellent grade in all the subjects of the final exam, excellent grade for the thesis, the grade average of all their exam and seminar grades is 4. The student did not receive a grade lower than satisfactory (3) during his/her studies.

MODEL CURRICULUM OF VEHICLE ENGINEERING MSC

ALTERNATIVE-POWERTRAIN VEHICLE PRODUCTION SPECIALIZATION

The curriculum of the program is available in excel format on the webpage of the Faculty of Engineering (www.eng.unideb.hu/en)

University of Debrecen **Faculty of Engineering** **Sample** **FULL TIME - Spring start**

Vehicle Engineer (MSc) - Alternative-powertrain vehicle production specialization

Ssz.	Subject group		Subject name		Spring semester				Fall semester				Spring semester				Fall semester				Prereq uisites
					L	P	E	cr	L	P	E	cr	L	P	E	cr	L	P	E	cr	
1	Basics of Natural Sciences		Mathematics IV	MK5MAT1A04VX23-EN	2	2	m	4													
2			Solid State/Semiconductor Physics	MK5SZFFR04VX23-EN	2	2	e	4													
3			Mathematics V	MK5MAT2A04VX23-EN					2	2	m	4									
4			Applied Dynamics	MK5ADING05GX17-EN					2	3	e	5									
5			Vehicle Manufacturing, Environmental Toxicology and Life Cycle Analysis	MK5JGKEJ04JX24-EN					2	2	e	4									
6	Economics and Humanities		Production Management and Production Planning	MK5TMGYM03JX24-EN	2	1	e	3													
7			Quality Assurance in Automotive Manufacturing Processes	MK5JGFMM04JX24-EN	2	2	m	4													
8			6 Sigma and Lean Philosophy	MK5SZLIM05JX24-EN													2	2	m	4	
9	Professional knowledge of vehicle engineering	Simulation and optimisation methods	Internet of Things – Systems and Technologies	MK5TIRTR06VX23-EN	2	3	e	6													
10			Electrical Measurement and Signal Processing	MK5MEJER04LX17-EN	2	2	e	4													
11			Robotics and Vehicle Manufacturing	MK5RTJGJ04JX24-EN					2	3	e	4									
12		Vehicle and mobile machine design theory	Car Body Production and Technologies	MK5KSGTJ03JA24-EN	2	1	e	3													
13			Pneumatic and Hydraulic Components for Production Systems	MK5TRPHJ03JA24-EN					2	1	e	3									
14			Assembly and Production Automation	MK5SZGAJ03JA24-EN									0	2	m	3					
15			Automotive Safety	MK5JIBTJ03JA24-EN									2	1	e	3					
16			Material Handling and AGV Systems	MK5AAGVJ03JA24-EN									2	1	e	3					
17		Specific knowledge	Non-fossil Energy Sources	MK5NFEFJ03JA24-EN	2	0	e	3													
18			Electric Drives	MK5VIHAJ04JA24-EN					2	3	e	4									
19			Project work I.	MK5VPF1J08JA24-EN									5	5	m	8					
20			Project work II.	MK5VPF2J08JA24-EN													5	5	m	8	
21	Optional Subjects		Optional Subject I.								m	3									
22			Optional Subject II.																m	3	
23	Diploma Thesis		MSc Diploma Thesis I	MK5DIP1J10JX24-EN									0	8	m	15					
24			MSc Diploma Thesis II.	MK5DIP2J16JX24-EN													0	16	m	15	
25	Internship		Internship	MK5SZGYJ10JX24-EN									4 weeks								

		L	P	E	C	L	P	E	C	L	P	E	C	L	P	E	C
Total/Semester		16	13		31	12	14		27	9	17		32	7	23		30
Number of exam subjects				5				4				2				0	
Number of mid-semester grade subjects				3				3				3				4	
Number of subjects				8				7				5				4	
Number of teaching hours		29				26				26				30			

Total	
Number of exam subjects	11
Number of mid-semester grade subjects	13
Number of subjects	24
Number of teaching hours	1254
number of optional credits	6
total number of credits	120

University of Debrecen | Faculty of Engineering | Sample | FULL TIME - Autumn start

Vehicle Engineer (MSc) - Alternative-powertrain vehicle production specialization

No.	Subject group		Subject name		Fall semester				Spring semester				Fall semester				Spring semester				Prerequisites
					L	P	E	cr	L	P	E	cr	L	P	E	cr	L	P	E	cr	
1	Basics of Natural Sciences		Application of differential equations (mathematics)	MK5MAT1A04VX23-EN	2	2	m	4													
2			Solid State/Semiconductor Physics	MK5SZFFR04VX23-EN	2	2	e	4													
3			Application of stochastic systems (mathematics)	MK5MAT2A04VX23-EN					2	2	m	4									
4			Applied Dynamics	MK5ADING05GX17-EN					2	3	e	5									
5			Vehicle Manufacturing, Environmental Toxicology and Life Cycle Analysis	MK5JGKEJ04JX24-EN					2	2	e	4									
6	Economics and Humanities		Production Management and Production Planning	MK5TMGYM03JX24-EN	2	1	e	3													
7			Quality Assurance in Automotive Manufacturing Processes	MK5JGFMM04JX24-EN	2	2	m	4													
8			6 Sigma and Lean Philosophy	MK5SZLIM05JX24-EN													2	2	m	4	
9	Professional knowledge of vehicle engineering	Simulation and optimisation methods	Internet of Things – Systems and Technologies	MK5TIRTR06VX23-EN	2	3	e	6													
10			Electrical Measurement and Signal Processing	MK5MEJER04LX17-EN	2	2	e	4													
11			Robotics and Vehicle Manufacturing	MK5RTJGJ04JX24-EN					2	3	e	4									
12		Vehicle and mobile machine design theory	Car Body Production and Technologies	MK5KSGTJ03JA24-EN	2	1	e	3													
13			Pneumatic and Hydraulic Components for Production Systems	MK5TRPHJ03JA24-EN					2	1	e	3									
14			Assembly and Production Automation	MK5SZGAJ03JA24-EN									0	2	m	3					
15			Automotive Safety	MK5JIBTJ03JA24-EN									2	1	e	3					
16			Material Handling and AGV Systems	MK5AAGVJ03JA24-EN									2	1	e	3					
17		Specific knowledge	Non-fossil Energy Sources	MK5NFEFJ03JA24-EN	2	0	e	3													
18			Electric Drives	MK5VIHAJ04JA24-EN					2	3	e	4									
19			Project work I.	MK5VPF1J08JA24-EN									5	5	m	8					
20			Project work II.	MK5VPF2J08JA24-EN													5	5	m	8	
21	Optional Subjects		Optional Subject I.								m	3									
22			Optional Subject II.																m	3	
23	Diploma Thesis		MSc Diploma Thesis I	MK5DIP1J10JX24-EN									0	8	m	15					
24			MSc Diploma Thesis II.	MK5DIP2J16JX24-EN													0	16	m	15	
25	Internship		Internship	MK5SZGYJ10JX24-EN									4 weeks								

		L	P	E	C	L	P	E	C	L	P	E	C	L	P	E	C
Total/Semester		16	13		31	12	14		27	9	17		32	7	23		30
Number of exam subjects				5				4				2				0	
Number of mid-semester grade subjects				3				3				3				4	
Number of subjects				8				7				5				4	
Number of teaching hours		29				26				26				30			

Total	
Number of exam subjects	11
Number of mid-semester grade subjects	13
Number of subjects	24
Number of teaching hours	#####
number of optional credits	6
total number of credits	120