

**Graduate study program in Mechanical Engineering (Master program)**

List of courses that can be delivered in English including their learning outcomes

**FIRST SEMESTER**

**Selected Topics from Mechanics and Strength**

- Analysing free and forced vibrations in mechanical systems with a single degree of freedom of movement with and without attenuation, explaining the concept of inherent system frequency and resonance.
- Calculate the influence coefficients, slopes and deflections for flat and frame girders using energy methods.
- Calculating the stresses and strains of thick pipes and applying to analysing clamping joints.
- Solving the axisymmetric shell strength problem and applying it in analysing clamping joints.

**Construction Models**

- Recognize the project-based approach in the development of new products.
- Explain the operating principles and characteristics of equipment used in the process and transport industries.
- Perform calculations and develop a conceptual design solution for an engineering task while considering relevant constraints.
- Design an assembly drawing and prepare detailed workshop drawings for a specific engineering task.

**New Engineering Materials**

- Classify new technical and engineering materials based on properties and areas of application.
- Identify and select new engineering materials as a replacement for existing with respect to improved materials.

- Define equilibrium and disequilibrium transformation in steel.
- Analyse the effect of microstructure on properties of steel, metal materials, polymers and composites.
- Evaluate advanced technical materials based on structure, mechanical, tribological and other importance useful properties.

### **Modern Production Technologies**

- Understanding the advantages and weaknesses in using particular types of machining.
- Understanding new possibilities of applying particular machining processes.
- Selecting the optimal manner of machining in regard to workpiece characteristics.
- Compare the procedure for producing the piece with the assistance of a number of technologies.
- Understanding the division of production technologies for adding and removal of material.
- Understanding the sequence of production technologies in machining a certain product.

### **Industrial Design**

- Explain the process in designing industrial products occurring through a series successive phases and select beforehand the optimal solution using a defined methodology.
- Collect and address user requirements for developing a technical system. Compare existing solutions on the market.
- Define requirements for an industrial product and generate an algorithm based upon which the requirements are evaluated and priorities defined.
- Define product specifications from the requirements sheet (ideal, threshold/limit, final).
- Generate a matrix of the conceptual design for the technical system based on non-technical (aesthetic, ergonomic) and technical (technology, materials, price), select the appropriate concept.
- Improve the selected concept in terms of industrial design and preparation for production.

## **Production Economics**

- Recognising the role and importance of management bodies in companies.
- Evaluating the relationship of business decisions in companies and business decisions directed outside the company.
- Determine conditions for demand and supply, as well as evaluating the position of the company on the market.
- Define business strategies, including costs, price, product / service differentiation on the market as well as market conditions according to type of product and market structure.
- Formulating problems in the business sector on the basis of systematic theoretical analysis.
- Proposing optimal business decisions by applying economic, mathematical and statistical concepts.

## **SECOND SEMESTER**

### **Numerical Modelling**

- Defining the fundamental laws of continuum mechanics and understanding differential, variational and integral forms.
- Understanding the fundamental concepts and steps in numerical modelling (preprocessing spatial and temporal discretisation, solving linear equation systems, postprocessing).
- Understanding and applying the finite-difference method, finite-volume method and finite-element method.
- Applying the suitable numerical method depending on the given problem (problems involving heat transmission, problems associated with the theory of elasticity, vibration, fluid dynamic problems).

### **Robotics in Manufacturing**

- Identify and analyse production processes in terms of economic efficiency, productivity and profitability in robotic applications.
- Present their views with reasoning in regards to the issue of the performance of robotic applications in handing materials, manipulation and quality control.

- Organise and redesign production processes in which robots are used and other classical means of processing, as well as maintain them at the required level and reliability and undertake measures for continual improvement.
- Plan preventive measures for maintenance and integrate procedures for the maintenance of robots in the maintenance system at the company level.
- Manage and model robot work and transfer such knowledge to operators.

### **Behaviour of the Materials in Exploitation**

- Assess and identify the basic causes of mechanical parts malfunctioning.
- Classify and describe the procedure for analysing faults in mechanical parts.
- Identify the types of breakages of mechanical parts.
- Determine and elaborate the types of wear mechanisms.
- Differentiate and formulate the consequences of action from continual static and dynamic loads.
- Foresee the wear of a machinery part in use and select the optimal solution for minimising consequences of wear in the use of a mechanical part.

### **Ecological and Energy Industrial Design**

- Estimating the importance and overall scope of designing products and technical systems on the environment and society.
- Establish the connection between ecological and energy criteria, laws and standards with product design.
- Devise ways of raising awareness and advancing the importance of producing sustainable products.
- Valorise the intensity of the relationship between economic development and sustainable production.
- Applying appropriate tools to calculate emissions of harmful substances and energy efficiency for certain products and technical systems.
- Propose ways of reducing emissions of harmful substances and increasing energy efficiency by applying optimal engineering procedures and economic parameters.
- Select optimal solutions based on ecological, energy and economic parameters.

## **Production Safety Management**

- Name and describe the prescribed terminology in the field of occupational health and safety.
- Recognize different types of hazards and risks related to the workplace and the type of work performed in production.
- Identify and determine the causes of hazards based on the list of dangers, harmful factors, and workload.
- Evaluate data related to threats to safe working practices.
- Prepare an action plan for carrying out risk assessment in production.
- Select an appropriate approach to risk assessment.

## **Lean production**

- Identify and analyse production processes in terms of performance by using adequate criteria and measures for the performance of processes, especially in determining value for the customer while recognising the Lean approach.
- Compare and explore good and excellent production processes using the principle of process mapping, tracking process flow, establishing the pull principle and other standard Lean principles in addition to tracking and eliminating waste.
- Create projects for establishing excellent working positions, processes and business systems.
- Devise implementation of the Lean concept in specific business systems.
- Evaluate the performance of production processes, identify places requiring improvements, present and verify the results of the improvements.
- Plan and organise reconstruction plans in particular sectors of the machinery production.
- Devise education programs for the Lean concept, present and implement them at various levels.

## **Documentation in Production of Welded Constructions**

- Identify the symbols and designations of required weld characteristics in technical drawings.
- Determine and prepare the necessary documentation for the production of a specific welded structure.
- Recommend an appropriate approach, perform, and document the certification of a company and welders in accordance with the applicable production standard.

- Recommend an appropriate approach, perform, and document the qualification of a welding procedure in accordance with the applicable production standard.
- Determine tasks and responsibilities in welding coordination, and document and monitor welding production.

### **HVAC Systems**

- Recognize physical parameters, concepts, and characteristics related to heating, cooling, and air-conditioning engineering.
- Describe technical solutions, equipment, and devices used in the practical application of heating, cooling, and air-conditioning systems.
- Distinguish between design and technical solutions for heating, cooling, and air-conditioning systems with respect to indoor comfort microclimatic conditions and technological process parameters.
- Perform thermotechnical, hydrodynamic, and aerodynamic calculations for heating, cooling, and air-conditioning systems.
- Independently or collaboratively analyze individual components and/or complete technical solutions for heating, cooling, and air-conditioning systems.
- Propose appropriate heating, cooling, and air-conditioning equipment and devices in accordance with the selected technical solution.

### **Mechatronics Systems**

- Understand how measurement and control can be used to improve the performance characteristics of a technical system, and analyze, in a specific case (e.g. machine tool position measurement), the limits of applicability.
- Understand how measurement, control, and regulation can be applied to motion, velocity, and position of a mechatronic system.
- Identify and classify typical problems in mechatronic systems.
- Understand how the capabilities and limitations of mechatronic systems influence system sustainability, ease of use, and efficiency.

## **THIRD SEMESTER**

### **Optimization of Constructions**

- Determine the potential for optimizing a structure or one of its structural elements.
- Apply selected optimization methods to basic elements of mechanical engineering structures.
- Evaluate the potential risks associated with the defined objective function.

### **Prototype 3D Modelling**

- Evaluate the advantages and limitations of rapid prototyping methods.
- Compare methods for modeling complex 3D assemblies.
- Select appropriate macros to reduce design and modeling time.
- Recommend a method for adapting scanned objects for 3D printing.
- Justify the use of rapid prototyping methods for manufacturing a structural component.

### **Certification of Products and Systems**

- Analyse the purpose and need for certification of some management systems, as well as select the competent institution for conducting the external assessment (certification).
- Organising management systems in compliance with different international standards and present them to interest parties as well as maintain them at the required level.
- Properly explain the requirements of international, regional and national norms in terms of providing arguments for applications in specific management systems.
- Analyse and review requirements for certification of specific technical products by identifying and evaluating requirements.
- Draft the necessary documented information (technical construction file) and select the suitable institution for testing product conformity.
- Investigate all options in selecting the adequate module, directives and standards for assessing product conformity.

## **Materials and Constructions testing methods**

- Determine and classify methods for the characterization of material microstructure.
- Evaluate material testing methods.
- Determine and apply basic material characterization procedures.
- Qualitatively and quantitatively analyze the microstructure of materials.
- Determine, assess, and evaluate the results of different testing procedures and draw conclusions based on the obtained test results.

## **Modern technologies in Engineering Maintenance**

- Assess the level and type of damage to a machine component, structure, or industrial plant, and make decisions regarding repair or replacement.
- Recommend and prepare the required repair technologies together with the corresponding technical documentation.
- Recommend appropriate repair technologies in the field of surface engineering or manufacture a machine component using modern additive manufacturing technologies for metal products.
- Select suitable heat treatment technologies for machine components or structures in order to achieve the required final properties after repair.

## **Materials Weldability and Welding Errors**

- Define the concept of weldability and describe the phenomena occurring in the weld metal zone and the heat-affected zone.
- Classify defects in welded joints as a consequence of manufacturing processes, service conditions, or improper selection of base material, filler material, and welding technology.
- Predict crack formation mechanisms caused by various material discontinuities resulting from structural changes due to non-stationary heat input.
- Calculate heat input in welding processes.
- Calculate preheating temperatures based on the carbon equivalent value.
- Justify the selection of welding technology with respect to the mechanical and chemical properties of the base and filler materials.



## **FEM in Engineering Design**

- Apply the finite element method in the analysis of engineering structures.
- Analyze and solve complex three-dimensional problems.
- Analyze and solve problems related to material nonlinearity, heat transfer, and dynamics.
- Interpret results obtained using the finite element method.

## **FOURTH SEMESTER**

### **Business communication and presentation**

- Formulating a clear message towards the interested party in accordance with wanted goal which should be achieved.
- Integrating understandable information which is to be incorporated in design documentation.
- Assessing, organising and presenting facts, statistics, empirical data and professional opinions in an informal way.

### **Methods of scientific research**

- Find, analyze, compare, and evaluate various data and information related to the field of mechanical engineering studies.
- Distinguish between types and methods of scientific research, fundamental methodological concepts, and research paradigms, and apply them in research activities and in writing academic papers in other courses within the Mechanical Engineering study program.
- Develop a research outline, select appropriate research methods, conduct research, apply research methods, and write a seminar paper incorporating all of the above elements.
- Evaluate professional and scientific papers and use their content and findings in the design and implementation of one's own research activities.
- Independently design and carry out a basic scientific research project.