UNIVERSITY NORTH, UNIVERSITY CENTRE VARAŽDIN, DEPARTMENT OF MECHANICAL ENGINEERING

Undergraduate study program in Mechanical Engineering (Bachelor program)

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

FIRST SEMESTER

Mathematics I

- Describe and apply properties and operations of natural, integer, rational, real, and complex numbers.
- Apply trigonometry of right-angled and oblique triangles to everyday and engineering problems.
- Explain and use matrices, determinants, and methods for solving systems of linear equations.
- Define, compute, and apply vector operations, including scalar, vector, and mixed products.
- Explain, analyze, and sketch real functions of a real variable, including limits and continuity.
- Apply differentiation rules to calculate derivatives of explicitly and implicitly defined functions.

Mechanics I

- Identify and explain fundamental axioms and theorems of rigid body statics, and determine resultants, moments, and force components.
- Reduce force systems, isolate bodies, and construct free-body diagrams.
- Formulate and solve equilibrium equations to determine support reactions.
- Distinguish and apply graphical and graphical–analytical methods for solving coplanar force systems.
- Determine friction forces and analyze trusses, beams, and frames, including internal forces, moments, and diagrams.
- Determine and apply centroid, static moment, and moment of inertia concepts, including the parallel axis (Steiner's) theorem.

Materials I

- Define the basic groups of engineering materials.
- Explain the crystallization process and the formation of different crystal structures.
- Explain the characteristics of metastable and stable crystallization of Fe–C alloys.
- Describe the basic mechanical testing methods of materials.
- Interpret the differences between plastomers, elastomers, and duromers (thermosetting polymers).

Programming languages, algorithms and AI

- Analyze and compare fundamental programming paradigms and languages, and apply appropriate constructs to solve computational problems.
- Design and implement efficient algorithms using suitable data structures, and evaluate their time and space complexity.
- Apply algorithmic thinking and problem-solving strategies to model and solve real-world computational tasks.
- Develop and test basic artificial intelligence models, including search, optimization, or machine learning approaches, for practical applications.
- Evaluate the ethical, societal, and practical implications of artificial intelligence systems in modern software development.

Technical presentation skills

- Define different types of technical drawings.
- Apply the rules of orthogonal projection in the preparation of technical drawings.
- Produce freehand isometric projections of simple mechanical components.
- Apply special rules of technical drawing.
- Produce technical drawings using the two-dimensional computer-aided design software AutoCAD.
- Produce workshop drawings of components made from thin-walled materials.

Social and communication skills

- Evaluate one's own communication patterns and team dynamics in order to identify areas for professional and personal development.

- Critically assess communication styles and adapt verbal and non-verbal communication to different professional and intercultural contexts.

- Create persuasive, well-structured, and visually supported public presentations based on rhetorical principles and an understanding of the audience.

- Design and implement active listening and expression strategies in professional conversations and teamwork.

Engineering calculation methods

- Use advanced functions of a calculator.

- Apply elementary mathematics, geometry, and trigonometry in engineering calculations.

- Identify physical quantities and use and convert basic and derived physical units.

- Apply the method of least squares to determine the parameters of the best-fit line and use these parameters to solve a simple geometric problem.

- Solve an engineering problem using a linear function and linear interpolation.

SECOND SEMESTER

Mathematics II

- Apply differential calculus to determine limits, tangents, and normals, and to analyze function graphs.

- Define antiderivatives and indefinite integrals, and determine antiderivatives using basic integration rules.

- Apply fundamental integration methods to various types of functions.

- Calculate areas under function graphs and areas of regions bounded by curves.

- Calculate arc lengths of curves and volumes of solids of revolution.

- Explain the concept of differential equations and solve basic differential equations.

Mechanics II

- Use equations to determine the position, velocity, and acceleration of a particle in rectilinear and curvilinear motion, using both Cartesian and polar coordinate systems.

- Distinguish between translation, rotation about a fixed axis, and planar motion of a rigid body, understand the relationships between kinematic quantities in such motions, and differentiate the concepts of the instantaneous centers of velocity and acceleration.

- Construct velocity and acceleration diagrams for planar motion of rigid bodies.

- Apply Newton's second law of motion to a particle, a system of particles, and a rigid body.

- Calculate mechanical work, power, kinetic energy, potential energy, linear momentum, angular momentum, and impulse of a force.

- Apply the laws of conservation of mechanical energy, kinetic energy, linear momentum, and angular momentum to the motion of particles and rigid bodies.

Materials II

- List and classify ferrous materials.

- Define the basic properties of cast irons and their applications.

- Describe the fundamental properties of structural and tool steels.

- Explain the basic parameters of heat treatment processes.

- Define the basic properties of non-ferrous materials and their fields of application.

Mechanics of deformable bodies

- Determine stress vector components on inclined sections, stress and strain tensor components on rotated sections, and principal stresses and strains using analytical methods and Mohr's circle.

- Apply Hooke's law.

- Design axially loaded bars and bar structures, and determine stresses, displacements, and thermal effects in bars and planar truss structures.

- Determine shear stress distribution in shafts under torsion, design solid and hollow shafts according to strength and stiffness criteria, and solve statically indeterminate torsion problems.

- Calculate stresses in beams under bending and combined loading, design beams, and determine deflections and slopes.

Software tools

- Produce engineering documentation in accordance with established examples of good professional practice.

- Use the Mathcad interface at a level that enables independent input and evaluation of complex mathematical expressions, creation of functions and graphs, and solution of systems of equations.

- Apply physical units correctly when solving problems in Mathcad.

- Independently use Mathcad to solve linear approximation problems using the method of least squares.

- Independently use Mathcad to solve engineering problems by applying linear interpolation functions.

- Independently use Mathcad functions for cubic approximation.

- Use Mathcad symbolic commands to perform symbolic mathematical analysis.

Design in 2D

- Produce a 2D technical drawing of a machine element with the appropriate dimensions.

- Create an assembly drawing and corresponding detail (positional) drawings.

- Design and construct the developed (unfolded) shapes of simple geometric solids.

THIRD SEMESTER

Machine Elements II

- Calculate and adjust transmission ratios for belt, chain, and gear drives.

- Calculate the fundamental parameters of belt, chain, and gear drives.

- Design components of belt, chain, and gear drives.

- Adapt gear geometry to changes in centre distance.

- Calculate the geometry of a worm gear drive.

- Calculate loads acting on gear, bevel gear, and worm gear drives.

Stress Analysis

- Determine stress vector components on inclined sections, stress and strain tensor components on rotated sections, and principal stresses and strains using analytical methods and Mohr's circle.

- Apply Hooke's law.

- Design axially loaded bars and bar structures, and determine stresses, displacements, and thermal effects in bars and planar truss structures.

- Determine shear stress distribution in shafts under torsion, design solid and hollow shafts according to strength and stiffness criteria, and solve statically indeterminate torsion problems.

- Calculate stresses in beams under bending and combined loading, design beams, and determine deflections and slopes.

Thermodynamics

- Define thermodynamic properties and their units, and explain the concepts of open and closed thermodynamic systems.

- Apply thermodynamic system concepts to the analysis and solution of engineering problems.

- Identify state changes of ideal gases and calculate state variables and energy exchange using appropriate thermodynamic relations.

- Retrieve and use data from thermodynamic tables and diagrams for problem solving.

- Explain the behavior of real substances during phase change processes, using water as an example.

- Perform calculations of basic heat transfer problems and simple heat exchangers under steady-state conditions.

Statistics

- Identify, distinguish, and apply basic combinatorial methods to solve simple problems.

- Define and explain the fundamental concepts of probability, including conditional probability.

- Organize, graphically present, and analyze data using measures of central tendency and dispersion.

- Define and correctly interpret discrete and continuous random variables and their probability distributions.

- Explain the concept of statistical testing and apply basic hypothesis testing procedures, interpreting the results appropriately.

- Define and apply correlation and regression analysis to examine relationships between variables.

Electrical Engineering and Electronics

- Define the fundamental laws of electrical engineering and electronics, including related physical quantities and measurement units.

- Perform calculations, measurements, and analyses in basic electrical and electronic circuits.

- Solve standard electrical and electronic circuit problems and compare the obtained solutions logically.

- Describe circuit elements and basic electrical and electronic components, including their functions and characteristics.

- Select appropriate electrical machines for mechanical engineering applications and explain their main characteristics.

- Understand the operation of electrical, electronic, and power engineering systems, including modern production technologies for electrical and electronic components.

Production Machinery

- Explain machining possibilities and select appropriate machine tools for material removal processes based on a given product.

- Identify main components of machine tools and their functions.

- Solve simple numerical problems related to machining processes using previously acquired engineering knowledge.

- Define and apply concepts of cutting forces, cutting power, machining time, and installed machine power.

- Describe tool holding, tool changing, and measurement systems used on machine tools.

- Describe the basic elements of transport systems in flexible manufacturing systems.

Foreign Language I - English

- Recognize and describe fundamental grammatical categories of the English language and independently produce grammatically correct expressions in English across varied foreign-language contexts.

- Search for and identify appropriate verb forms, noun forms, and other parts of speech in English texts, adapt them to the required register, and correctly use them in sentences.

- Recognize cultural characteristics of English-speaking countries.

- Identify, extract, and interpret the meaning of familiar and unfamiliar words in professional texts.

- Compile a list of unfamiliar words from professional texts together with their basic features for use in their own foreign-language expression.

- Outline the content of a text based on global and detailed reading of English texts and present it in both oral and written form.

FOURTH SEMESTER

Production Techniques I

- Describe the fundamentals of metal casting.

- Describe the most commonly used metal casting processes.

- Explain the fundamentals of machining by material removal.

- Select appropriate tools for specific cutting processes.

- Calculate the main machining time for manufacturing operations.

- Calculate the main cutting force and cutting power.

- Define machining parameters for a workpiece.

Fluid Mechanics

- Define physical quantities in Fluid Mechanics and their corresponding units.

- Apply the manometer equation and calculate forces acting on plane and simple curved surfaces.

- Explain and apply Bernoulli's equation in fluid flow problems.

- Explain and apply the law of conservation of momentum in Fluid Mechanics.
- Explain and identify different fluid flow regimes.
- Perform calculations for a simple pipeline system.

Production Management

- Recognize the roles and position of the production process within the organizational structure of an enterprise.
- Determine and design the optimal layout of machines and workplaces within a production process.
- Explain the general principles of workplace organization and production system structure.
- Draw and interpret organizational charts of the production process and the enterprise using appropriate methods.
- Explain and analyze key performance indicators and basic time elements of the production process.
- Understand and apply basic production planning techniques and modern production concepts, including operational and technological preparation and Lean manufacturing.

Fundamentals of Entrepreneurship

- Explain the concept of entrepreneurship, define the objectives of entrepreneurship such as expansion into new markets and the creation of new products, and recognize the advantages and disadvantages of entering entrepreneurship.
- Explain the stages of entrepreneurial development, describe a market economy characterized by individual entrepreneurial choice, and define competitive advantages that distinguish one enterprise from another.
- Identify different types of entrepreneurs and key characteristics of successful entrepreneurs, and explain the role of innovation in entrepreneurship.
- Define types of risk and explain external risks, internal risks, operational risks, financial risks, and business risks.
- Use and explain SWOT analysis as a strategic tool for assessing internal strengths and weaknesses, as well as external opportunities and threats.
- Define, explain, and apply a business plan as a written document that elaborates all elements of an investment in a business venture, including evaluation and assessment.

Foreign Language II - English

- Recognize and describe the fundamental grammatical categories of the English language and independently produce grammatically correct expressions in English across varied foreign-language contexts.

- Locate and select appropriate verb forms, noun forms, and other parts of speech in English texts, adapt them to the required register, and apply them correctly in sentences.

- Recognize key cultural characteristics of countries in the English-speaking world.

- Identify, extract, and interpret the meaning of familiar and unfamiliar vocabulary from a professional text.

- Compile a list of unfamiliar terms from a professional text, including their basic features, for use in one's own foreign-language expression.

- Outline the content of a text based on global and detailed reading of an English text and present it in both oral and written form.

Professional Training I

- Understand the organization and operating principles of a company.

- Understand production processes within a company.

- Prepare technical documentation.

Design in 3D

- Create a three-dimensional model of a mechanical part using a parametric computer-aided design (CAD) software package.

- Modify an existing three-dimensional model.

- Create an assembly using previously developed part models.

- Create a three-dimensional model of a mechanical part made of thin-walled material.

- Prepare technical documentation based on completed models and assemblies.

Renewable Energy Sources

- Identify and describe key components, devices, and assemblies of installations and plants using renewable energy sources.

- Explain operational processes and governing principles of systems based on renewable energy sources.

- Evaluate the efficiency and rational use of renewable energy sources through practical examples.

- Apply acquired knowledge to solve practical tasks involving renewable energy devices, assemblies, and installations.

- Differentiate types and application methods of renewable resources and propose more efficient solutions for selected practical cases.

- Calculate and interpret basic thermo technical and energy parameters, and select and operate appropriate devices and assemblies applicable in professional practice.

Joining Techniques

- Define the basic procedures of detachable and non-detachable joining techniques.

- Explain the basic classification of welding processes.

- Identify the fundamental methods of joining polymer materials.

- Explain the physical principles of soldering, adhesive bonding, and thermal spraying.

FIFTH SEMESTER

Production Techniques II

- Demonstrate understanding of the basic concepts and definitions of polymer processing methods and metal forming by deformation.

- Select an optimal process for manufacturing a polymer product based on technical drawings or a prototype.

- Apply knowledge of the specific characteristics of polymer processing methods in comparison with other manufacturing processes.

- Select an optimal metal forming by deformation process based on technical drawings or a prototype.

- Apply knowledge of the specific characteristics of metal forming by deformation processes in comparison with other manufacturing methods.

CNC Machining Systems

- Explain the basic operating principles of CNC machining systems and their role in modern manufacturing.
- Differentiate between types of CNC machines and control systems with respect to their construction, purpose, and technological capabilities.
- Program simple and moderately complex machining processes using G- and M-codes.
- Analyze technological documentation and select appropriate tools, machining parameters, and fixturing devices for CNC machining.
- Apply setup, simulation, and CNC program verification procedures to ensure machining quality and operational safety.

Production Measurements

- Explain the basic SI units, derived units, and permitted units of measurement.
- Explain the basic statistical quantities required for metrology.
- Identify fundamental metrology concepts and terminology.
- Perform a length measurement process using a manual length measuring instrument.
- Calculate measurement uncertainties for the performed measurement.
- Explain and correctly interpret the results of the performed measurement.

Industrial Maintenance

- Define the function, objectives, and role of maintenance throughout the life cycle of an industrial plant.
- Explain the organization of maintenance activities, including the flow of information when maintenance intervention is required.
- Define criteria for the procurement and selection of new equipment from a maintenance perspective.
- Calculate the reliability of an industrial plant and analyze factors affecting system performance.

- Identify and analyze maintenance costs and their impact on operational efficiency.

- Identify maintenance methods and explain the importance of diagnostics in maintenance management.

Production Process Planning

- Define and interpret given data using graphical, textual, and technical standards in order to describe the characteristics of the finished part and develop an appropriate manufacturing process.

- Explain the selected primary manufacturing process, including the sequence of operations, selection of machines and tools, workholding methods, fixtures, processing parameters, and the relationship between production volume and the level of automation.

- Apply the given data to prepare technical documentation and to develop and compare alternative manufacturing process variants.

- Analyze manufacturing process variants using defined criteria and evaluation measures.

- Develop and select the most appropriate manufacturing process with respect to constraints such as production quantity, applied technologies, available capacities, manufacturing costs, delivery deadlines, and consistent quality levels.

- Predict and generalize the optimal manufacturing process by applying prior experience, optimization methods, and principles of sustainable manufacturing to process planning and production.

Fundamentals of Mechanical Operations

- Identify and name key equipment, assemblies, mechanisms, and machines used in mechanical operations and in the transport of comminuted solid materials.

- Describe and interpret mechanical operation processes and governing principles through practical examples.

- Apply acquired knowledge to solve practical problems involving mechanical operations, mechanisms, devices, assemblies, and installations.

- Distinguish between different types and methods of mechanical operations and propose more efficient procedures for selected practical applications.

- Calculate basic power and motion parameters involved in the transport of comminuted particles using gaseous and liquid media.

- Select and operate appropriate devices and assemblies for mechanical operations and for the transport of comminuted particles of various solid materials.

Pneumatics and Hydraulics

- Define pneumatic and hydraulic components and explain their functions within a system.
- Design simple pneumatic and hydraulic system schematics according to a specified functional requirement.
- Design simple electro-pneumatic and electro-hydraulic system schematics according to a specified functional requirement.
- Solve basic maintenance problems related to pneumatic (electro-pneumatic) and hydraulic (electro-hydraulic) systems.

Surface Engineering

- Define individual surface treatment processes of materials.
- Distinguish the most important characteristics of individual surface treatment processes.
- Categorize and interrelate the functional properties of products treated by different methods of metal surface modification and coating.
- Identify and propose appropriate methods for the protection of materials and structures.
- Select methods for verifying the effectiveness of material and structural protection processes.

SIXTH SEMESTER

Production Techniques III

- Define the fundamental significance and purpose of welding.
- Select an appropriate welding method based on the base material.
- Define corrosion and methods of material protection.
- Select suitable protective coatings.

Quality Control

- Recognize the importance of product and service quality in modern manufacturing.
- Analyze and explain the key aspects of quality.

- Explain the structure and requirements of a quality management system based on the ISO 9001 standard.
- Calculate basic statistical indicators used in quality control.
- Calculate and interpret process capability indices.
- Apply basic and advanced tools and methods for quality improvement.

Professional Training II

- Understand the modes of operation and functions of individual departments within a company.
- Understand manufacturing procedures and production processes within a company.
- Prepare technical documentation.