



## **Mechatronics, professional undergraduate study -learning outcomes-**

### **1st Semester**

#### **Mathematics I\* 6 ECTS**

1. Describe the set of natural, integer, rational, real and complex numbers, define arithmetic operations and calculate in the given sets of numbers.
2. Relate the trigonometry of right and obtuse triangles to everyday life and profession.
3. Explain the concepts of matrices and determinants, list their properties and use them in the calculus of matrices and determinants.
4. Distinguish between methods for solving systems of linear equations and solve systems of linear equations.
5. List and describe operations with vectors, calculate and apply scalar, vector and mixed products in specific examples.
6. Explain and apply the basic concepts of real functions of a real variable, analyze elementary functions and sketch their graphs.
7. Define a sequence, calculate the limit values of sequences and functions.
8. Use the rules of differentiation to calculate the derivatives of explicitly and implicitly given functions.

#### **Mechanics I\* 6 ECTS**

1. Recognize the basic axioms and theorems of statics of rigid bodies, determine the resultant forces and moment of force, and decompose the force into components.
2. Independently reduce the system of forces to selected points, isolate the body and free the body from the connections.
3. Recognize the equilibrium conditions and set up the equilibrium equations, and determine the reactions of the connections from the equilibrium conditions.
4. Distinguish between graphical and graph-analytical methods for solving plane systems with three and four forces.
5. Recognize the direction of the friction force and determine the amount of the friction force in the system.
6. Using the node method, solve the problem of a truss, determine the internal forces and moments in the cross-section of beams and frame beams, and draw graphs of internal loads,
7. Determine the center of gravity of a plane figure.
8. Apply the definitions of static moments of area and moments of inertia, use tabular data for simple geometric shapes, and apply Steiner's rule for complex shapes.

#### **Basics of Electrical Engineering I\* 5 ECTS**

1. Define electric force and electric field.
2. Explain potentials and voltages in an electric field.
3. Understand and explain simple circuits.
4. Describe the power and energy of electric current.
5. Explain electromagnetic induction.
6. Define Lenz's law.
7. Explain inductance and mutual inductance, and the energy of a magnetic field



### **Programming Languages, Algorithms and AI\* 5 ECTS**

1. Understanding the basic principles of programming
2. Independent programming in the C programming language
3. Independent development of programming tasks and program implementation
4. Independent planning and design of simpler algorithms
5. Using programming as a tool in professional work

### **Technical Presentation Skills\* 4 ECTS**

1. Define types of drawings.
2. Apply the rules of orthogonal projection when creating drawings.
3. Create a three-dimensional isometric projection of simpler mechanical parts.
4. Apply special rules of technical drawing.
5. Create technical drawings using the two-dimensional computer program Autocad.
6. Create workshop drawings of parts made of thin-walled materials.

### **Social and communication skills\* 2 ECTS**

1. Name and describe basic terms and essential communication skills,
2. Recognize and express basic communication styles,
3. Differentiate between different types of complaints, achieving solutions and optimal feedback,
4. Prepare a presentation on a specific topic,
5. Describe and demonstrate negotiation and debate on a given topic

### **Engineering Calculation Methods\* 2 ECTS**

1. Use advanced calculator functions
2. Applies elementary mathematics, geometry and trigonometry in engineering calculation.
3. Recognizes physical quantities and uses and converts basic and derived physical units
4. Apply the method of least squares to determine the parameters of the best direction and use parameters for solving a simple geometric problem
5. Solve an engineering problem using the line function and linear interpolation

## **2nd semester**

### **Mathematics II\* 6 ECTS**

1. Apply differential calculus to determine limits and equations of tangents and normals.
2. Apply differential calculus to analyze the graph of a function.
3. Define a primitive function and an indefinite integral, and determine a primitive function using basic integration properties.
4. Apply basic integration methods to different types of functions.
5. Calculate the area under the graph of a function and the area of a figure bounded by curves.
6. Calculate the arc length of a curve and the volume of a solid of revolution.
7. Explain the concept of a differential equation and solve basic differential equations

### **Mechanics II\* 6 ECTS**



1. Use equations to determine the position, velocity and acceleration of a particle in rectilinear and curvilinear motion, in rectangular and polar coordinate systems,
2. Be able to distinguish between translation, rotation around a fixed axis, and plane motion of a body, understand the relationships between kinematic quantities in such motions, and distinguish between the concepts of instantaneous pole velocity and acceleration
3. Draw a velocity and acceleration plan for plane motion of a body,
4. Apply Newton's second law of motion to a particle, system of particles and a rigid body,
5. Be able to calculate mechanical work, force, kinetic energy, potential energy, momentum, angular momentum and impulse of a force,
6. Apply the laws of conservation of mechanical energy, kinetic energy, momentum and angular momentum to the motions of a particle and a rigid body.

### **Basics of Electrical Engineering II\* 5 ECTS**

1. Define the basic concepts of alternating currents.
2. Analyze alternating current networks.
3. Distinguish between symmetrical and asymmetrical three-phase systems.
4. Explain the perfect, ideal and real transformer.
5. Describe the mutual inductance of coils.
6. Calculate currents, voltages and powers of three-phase systems.
7. Draw phasor diagrams.

### **Mechanics of deformable bodies\* 5 ECTS**

1. Determine the components of the stress vector in an oblique section without using the transformation expression, determine the components of the stress and strain tensors in an arbitrary rotated section using the transformation expression, determine the principal stresses and principal strains analytically and graphically using Mohr's circle.
2. Be able to apply Hooke's law,
3. Dimension axially loaded rods and rod structures, determine stresses and displacements in flat rods of constant and variable cross-section and in plane truss structures, determine thermal and assembly stresses in rod structures,
4. Determine the distribution of tangential stresses over the cross-section of a shaft loaded in torsion, dimension solid and hollow shafts according to the strength condition and the stiffness condition, solve statically indeterminate tasks in torsion,
5. Calculate normal and tangential stresses under arbitrary bending loads on a girder (beam), dimension a girder loaded in bending, calculate the deflection and inclination of flat solid girders, determine stresses under complex loading of a girder in two mutually perpendicular main planes.

### **Elements of Mechatronic Systems\* 5 ECTS**

1. Identify elements of mechatronic assemblies,
2. Calculate stresses in standard and simpler elements of mechatronic assemblies
3. Dimension and select standardized elements of mechatronic assemblies
4. Calculate basic ratios and basic dimensions of transmissions,
5. Identify and differentiate seals and sealing methods

## **3rd semester**

### **Thermodynamics and Fluid Mechanics \* 6 ECTS**



1. Recognize key thermodynamic and fluid processes in individual segments of plants and installations,
2. Describe individual thermodynamic and fluid principles that form part or whole of a process,
3. Interpret basic principles in thermodynamics and fluid mechanics through individual practical examples,
4. Apply their knowledge in solving practical tasks on examples of individual thermotechnical devices and assemblies,
5. Distinguish between methods of heat exchange, media distribution and efficiency of individual thermotechnical devices and devices,
6. Operate devices for the distribution of gaseous and liquid media.

#### **Firmness\* 5 ECTS**

1. Determine the components of the stress vector in an oblique section without using the transformation expression, determine the components of the stress and strain tensors in an arbitrary rotated section using the transformation expression, determine the principal stresses and principal strains analytically and graphically using Mohr's circle.
2. Be able to apply Hooke's law,
3. Dimension axially loaded rods and rod structures, determine stresses and displacements in flat rods of constant and variable cross-section and in plane truss structures, determine thermal and assembly stresses in rod structures,
4. Determine the distribution of tangential stresses over the cross-section of a shaft loaded in torsion, dimension solid and hollow shafts according to the strength condition and the stiffness condition, solve statically indeterminate tasks in torsion,
5. Calculate normal and tangential stresses under arbitrary bending loads on a girder (beam), dimension a girder loaded in bending, calculate the deflection and inclination of flat solid girders, determine stresses under complex loading of a girder in two mutually perpendicular main planes.

#### **Sensors\* 5 ECTS**

1. Recognize the technical and physical characteristics of sensors,
2. Understand measurement methods, methods and procedures of non-electrical and electrical quantities,
3. Understand signal processing and conversion in a sensor,
4. Select the optimal sensor for a mechatronic assembly and/or mechatronic system,
5. Connect the sensor to electronic devices.

#### **Design in 2D\* 2 ECTS**

1. Create a 2D drawing of a machine element with associated dimensions
2. Create an assembly drawing and positional drawings
3. Construct the developed shape of simpler geometric bodies

#### **Foreign Language I - English\* 2 ECTS**

1. Recognize and describe the basic grammatical categories of the English language and, based on this, independently form grammatically correct expressions in English in varied foreign language contexts.
2. Independently search for and find appropriate verb forms, noun forms and other types of words in English texts and adapt them to the given register and correctly apply them in a sentence.
3. Recognize the cultural characteristics of English-speaking countries.



4. Identify, extract and recognize the meaning of known and unknown words from a professional text.
5. Compile a list of unknown words from a professional text with their basic characteristics for the purpose of their use within one's own foreign language expression.
6. Outline the content of the text based on a global/detailed reading of the text in English and present it orally and in writing.

## **4th semester**

### **Digital technique\* 5 ECTS**

1. Use different number systems and codes
2. Design circuits for detecting and correcting errors in data transmission
3. Apply minimization of logic functions and basic logic circuits
4. Explain the operation of basic combinational and arithmetic circuits
5. Explain the operation of basic types of bistables
6. Use combinational circuits, registers and counters in the design of synchronous sequential circuits
7. Explain AD and DA conversion

### **Signals and Systems 4 ECTS**

1. Describe various signals mathematically
2. Recognize linear and nonlinear systems
3. Show various systems with block diagrams
4. Define and explain basic first and second order systems
5. Describe continuous linear systems with transfer functions and state variables
6. Describe discrete linear systems with transfer functions and state variables
7. Show signal discretization and reconstruction

### **Electromechanical and Electronic Converters\* 4 ECTS**

1. Calculate the magnetic state and load of a metal object,
2. Select an electrical machine according to the mechanical and electrical load,
3. Determine the operating mode and select the operating point regulation of the electrical machine,
4. Distinguish between basic power electronic elements for the design of power converters,
5. Calculate the electrical parameters of electronic converters according to the given operating requirements.

### **Mechanisms\* 4 ECTS**

1. Recognize the basic types of mechanisms and classify them into groups,
2. Analyze the kinematics of the driving and working members of the mechanism (path, speed, acceleration, angular rotation, angular velocity and angular acceleration),
3. Interpret the basic principles in the dynamics of a practical example of mechanisms,
4. Apply their knowledge in solving practical tasks and technical problems.

### **Basics of Entrepreneurship\* 2 ECTS**

1. Explain the concept of entrepreneurship, define the goals of entrepreneurship, expansion into new markets, creation of new products, to recognize the advantages and disadvantages of entering entrepreneurship,



2. Explain the stages of entrepreneurship development, describe a market economy characterized by individual choice of venture, define competitive advantages according to which a certain company differs from another,
3. Recognize the types of entrepreneurs and key characteristics of a successful entrepreneur and explain innovation in entrepreneurship.
4. Define the types of risks and explain what they are: external risks, internal risks, operational risks, financial risks, business risks,
5. Use and explain SWOT analysis as a strategic tool for assessing internal strengths and weaknesses and external opportunities and threats
6. Be able to define, explain and apply a business plan that elaborates in written form all the elements of investing in a business with an assessment of expected effects and variants of solutions for risky situations that the future brings.

#### **Foreign Language II - English\* 2 ECTS**

1. Recognize and describe the basic grammatical categories of the English language and, based on this, independently form grammatically correct expressions in English in varied foreign language contexts.
2. Independently search for and find appropriate verb forms, noun forms and other types of words in English texts and adapt them to the given register and correctly apply them in a sentence.
3. Recognize the cultural characteristics of English-speaking countries.
4. Identify, extract and recognize the meaning of known and unknown words from a professional text.
5. Compile a list of unknown words from a professional text with their basic characteristics for the purpose of their use within one's own foreign language expression.
6. Outline the content of the text based on a global/detailed reading of the text in English and present it orally and in writing.

#### **Renewable Energy Sources\* 3 ECTS**

1. Recognize and name key elements, devices and assemblies of installations and/or plants when using individual renewable energy sources.
2. Describe and explain individual operational processes and principles that form part or whole of a process,
3. Point out the efficiency and rationality of using renewable energy sources through individual practical examples,
4. Apply your knowledge in solving practical tasks using examples of individual devices, assemblies and installations,
5. Distinguish between types and methods of possible application of renewable resources, and propose more efficient procedures in certain practical cases,
6. Calculate basic thermotechnical and energy parameters and interpret them through individual devices, assemblies and functional units,
7. Select individual devices and assemblies applicable in professional practice, - handle devices and assemblies of individual systems applicable in practice.

#### **Basics of Machines and Devices\* 3 ECTS**

### **5th semester**



### Robotics\* 6 ECTS

1. Recognize and explain the basic properties and technical characteristics of robotic systems in industry.
2. Compare the basic structures of robotic manipulators.
3. Calculate the kinematics of a robotic manipulator and design the tool path.
4. Apply simulation tools for simpler technological operations with a robot in the production process.
5. Know how to control the operation of robots and transfer their knowledge to operators.

### Pneumatics and Hydraulics\* 5 ECTS

1. Define pneumatic and hydraulic elements and their functions within the system.
2. Create pneumatic and hydraulic system diagrams (project documentation) according to the given purpose that the system should satisfy.
3. Create electro-pneumatic and electro-hydraulic system diagrams according to the given purpose that the system should satisfy.
4. Specify the necessary pneumatic and hydraulic elements according to the diagram and select components from the catalog.
5. Connect the selected components according to the connection diagrams and establish the functionality of the system.
6. Solve possible maintenance problems of pneumatic (electro-pneumatic) and hydraulic (electro-hydraulic) systems.

### Maintenance of Mechatronic Systems\* 5 ECTS

1. Define the function and objectives of mechatronic system maintenance,
2. Explain the place and role of maintenance in the life cycle of mechatronic systems,
3. Define the information flow when mechatronic system maintenance is required,
4. Define criteria for purchasing new equipment from the aspect of mechatronic system maintenance,
5. Calculate the reliability of mechatronic systems,
6. Identify the costs of mechatronic system maintenance,
7. Identify mechatronic system maintenance methods,
8. Explain the importance of diagnostics in mechatronic system maintenance.

### PLC Control Systems\* 3 ECTS

1. Understand the requirements for creating a PLC program from the technological description of the problem,
2. Create a program flow chart from the technological description of the process,
3. Independently create simpler application programs,
4. Test and bring to functionality independently created simpler application programs,
5. Report on the possibilities offered by controlling systems using PLC, for various applications,
6. Apply the skill of logical thinking and following the sequence of the program line by line,
7. Show the possibilities of influencing the flow of the application program using the operation panel.

### Design in 3D\* 3 ECTS

1. Create a three-dimensional model of a mechanical part using a computer parametric modeling software package.



2. Modify an existing three-dimensional model.
3. Create an assembly using the created part models.
4. Create a three-dimensional model of a mechanical part from thin-walled material.
5. Create technical documentation from the finished models and assemblies.

#### **Basics of Mechanical Operations\* 3 ECTS**

1. Recognize and name key devices, assemblies, mechanisms and machines in the process of mechanical operations and transport of crushed solid materials,
2. Describe individual operational processes and principles that form part or whole of a process, - interpret the processes of mechanical operations through individual practical examples and use them practically,
3. Apply their knowledge in solving practical tasks on examples of individual mechanisms, devices, assemblies and installations, - distinguish types and methods of mechanical operations and propose more efficient procedures in certain cases of practice,
4. Calculate the basic elements of force and motion when transporting crushed particles using gaseous and liquid media, - select individual devices and assemblies applicable for mechanical operations or transport of crushed particles of various solid materials,
5. Operate devices when transporting crushed particles using gaseous and liquid media.

#### **6th semester**

#### **Production Systems and Technologies\* 5 ECTS**

1. Recognize the advantages and disadvantages of using a particular type of processing
2. Understand new possibilities for applying a particular processing
3. Choose the optimal processing method considering the characteristics of the manufactured piece
4. Compare the process of manufacturing a piece using multiple technologies

#### **Communication Skills\* 2 ECTS**

1. Name and describe basic terms and essential communication skills,
2. Recognize and express basic communication styles,
3. Differentiate between different types of complaints, achieving solutions and optimal feedback,
4. Prepare a presentation on a specific topic,
5. Describe and demonstrate negotiation and debate on a given topic.