FERIT

FACULTY OF ELECTRICAL ENGINEERING,
COMPUTER SCIENCE AND INFORMATION TECHNOLOGY **OSIJEK**

REQUIREMENTS FOR THE ENROLEMENT OF THE GRADUATE STUDY PROGRAMME IN AUTOMOTIVE COMPUTING AND COMMUNICATIONS

FOR APPLICANTS WITH COMPLETED UNDERGRADUATE UNIVERSITY STUDY PROGRAMME IN MECHANICAL ENGINEERING

Osijek, January 2019.

1. Admission requirements

Students that completed an **undergraduate university study programme in mechanical engineering** can enrol in the graduate study programme in Automotive Computing and Communications at the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek.

In such cases, the Academic and Student Affairs Committee will determine differential exams (additional courses) to be passed based on a list of courses in the table below. If students have passed some of the listed courses during their study programme in mechanical engineering, those courses will be acknowledged, i.e. they will not be a part of differential exams.

Courses that are the basis for differential exams are as follows:

Course	ECTS
Basics of Automatic Control	7
Calculus I (Differential Calculus)	5
Calculus II (Integral Calculus -Differential Equations)	6
Calculus III	5
Communication Networks	6
Communication Skills	5
Company Economics	5
Digital Electronics	6
Electronics I	6
Engineering Graphics and Documentation	3
Fundamentals of Electrical Engineering I	6
Fundamentals of Electrical Engineering II	6
Linear Algebra	5
Measurement Basics	6
Object-oriented Programming	6
Physics	6
Probability and Statistics	5
Programming I	5
Programming II	5
Signals and Systems	5

2. Obligatory courses description

Basics of Automatic Control
Automatic control and its purpose. Basic terms and definitions. Basic structure and elements of the control loop. Implementation of a control system. Properties of controlled systems. Linearization of characteristic curve. Dynamic behaviour of the system and its mathematical description. Description of linear, continuous and time invariant systems in time and frequency domain. Laplace transform and transfer function. Bode and Nyquist plot. Basic dynamic elements. Control loop and its characteristics. Control loop stability and methods of stability analysis. Performance indices in time and frequency domain. Basic controller types. Control loop synthesis. Fixed set-point control and servo control. Control loop behaviour in regard to reference variable and disturbance. Classic methods of synthesis of linear continuous control systems. Synthesis in time and frequency domain. Empirical rules for setting the controller parameters. Improvement of dynamic properties of control systems by introducing feedforward and cascade control. Practical examples. Principles of digital implementation of control systems.
Calculus I (Differential Calculus)
1. Preliminaries. Real numbers, infimum and supremum, absolute value, intervals. Complex numbers. 2. Functions. Definition of a function. Basic properties. Composition of functions. Inverse function. Elementary functions (polynomial, rational, exponential, logarithm, trigonometric, cyclometric, hyperbolic and area functions). 3. Sequences of real numbers. Concept of a sequence, properties and convergence. Number e. 11 4. Limits and continuity of functions. Concept and properties of the limits of the function. Asymptotes. Continuity of functions. 5. Differential calculus. The derivative and the tangent. The derivative as velocity. Concept of the derivative. Derivative rules. The chain rule and the derivative of the inverse function. The derivative of elementary functions. Implicit differentiation. Parametric differentiation. Mean value theorem. Higher derivatives. Taylor's theorem. 6. Application of the differential calculus. Differential. Newton’s method. L'Hôpital's rule. Examination of functions (monotonicity, minima and maxima, convexity, asymptotes). Sketching curves.
Calculus II (Integral Calculus -Differential Equations)
1. Riemann integral. The integral as an area. Concept and properties of the Riemann integral. Integrability of monotonic and continuous functions. The mean value theorem for integral of the continuous function. Newton-Leibniz formulae. 2. Indefinite integral. Basic methods and techniques of integration (the method of substitution, integration by parts, integration of rational functions and integration of functions boiling down to integrals of rational functions, Euler substitution, binomial integral) 3. Application of integration. Area between two curves, surface and volumes of revolution, length of curve, work of power, moments, centre of mass. Improper integral. Numerical integration (trapezium and Simpson’s rule). 4. Series of real numbers. Concept of series and convergence. Criteria of convergence. 5. Series of functions. Uniform convergence. Power series. Taylor series of elementary functions. Exponential and logarithm function. 6. Ordinary differential equations. Sources of ordinary differential equations. General and particular solution. Cauchy problem. Geometric point of view. Problem of sensitivity to a change of initial values. Some types of ordinary differential equations of the first order (exact, homogeneous, linear, Bernoulli equation). Examples and applications. 7. Ordinary differential equations of the second order. Some special types. Linear differential equation of the second order. Lagrange's method of variation of the constant. Linear differential equation of the second order with constant coefficients. Examples and applications (harmonic oscillator).
Calculus III
Real functions of several real variables. Level curves and level surfaces. Limits and continuity. Partial derivatives and differential. Equation of tangent plane to a surface. Partial derivatives of composite functions and implicit functions. Partial derivatives and differentials of higher orders. Taylor's formula for functions of several variables. Extrema and conditional extrema of functions of several variables. Double and triple integrals - basic concepts, calculation and applications. Line integrals (of the first and of the second kind) – definition, properties, calculation and applications. Vector functions of several variables. Scalar and vector field. Gradient of a scalar field; divergence of a vector field; curl of a vector field; applications. Complex functions of a complex variable. Derivative. Cauchy-Riemann equations. Integral of function of a complex variable. Cauchy theorem and integral formula. Taylor and Laurent series. Singularities. Residues.
Communication Networks

Communication network definition. Communication efficiency. Information and traffic network characteristics. Network flows and capacities. Communication network model. The project network parameters. Communication networks applications. Telecommunication network. The integrated digital communication network. Intelligent network. Network signalisation. The physical network structure. The logical network structure. OSI reference model. TCP/IP reference model. Transmission media. Wireless communication. Mobile networks, Local area networks. Industrial LANs and protocols. Telemetric networks and technologies. Ad Hoc networks. Internet network architecture. Network routing. Communication networks examples. Network services. Quality of service. Network security. Network standardisation.
Communication Skills
Concept and process of communication. Verbal and nonverbal communication. Principles of successful communication. Listening skills and asking questions. Assertive communication. Public speaking. Presentation skills. Teamwork. Communication in a group. Conflict resolution. Bargaining skills. Conducting a meeting. Written communication. Business etiquette and protocol. Business ethics.
Company Economics
Introduction to business economics, production theory, types of production costs, cost dynamics, demand and supply, consumer behaviour, cost calculation, investment calculation, business calculations, business performance measures (economic performance measurement metrics, business success strength measurement methods), economic resources, purchasing, logistics, business plan, business information systems, entrepreneurship and entrepreneur (economic and social prerequisites for founding and successful business operations).
Digital Electronics
Digital circuit and system features. Development survey. Number systems and conversions. Digital arithmetic. Codes. Error detection and correction codes. Logic functions. Logic function simplification. Logic integrated circuits. Characteristics of TTL, CMOS and modern technologies. Combination circuits: analysis and synthesis. Integrated logic circuit examples. Sequential circuits. State diagram. Flip-flop types and realisation. Asynchronous and synchronous counters. Synchronous counters design. Register types. Memories. Semiconductor memories: bipolar and MOS. Static and dynamic RAM memories. ROM, PROM, EPROM, EEPROM memories. Memories programming. Magnetic media. Optical media. Programmable logic circuits: features, programming and applications. Visual displays. ADC and DAC circuits. Digital circuit and system design software tools. Development and testing of digital circuits and equipment. Digital circuit reliability.
Electronics I
Basics of semiconductor physics. Charge carrier generation. Current flow mechanisms in semiconductor. PN and metal-semiconductor junctions: static and dynamic characteristics. Solid-state diodes: static and dynamic characteristics, types of solid-state diodes. Bipolar junction transistor (BT): working principle, static IU-characteristics, dynamic models, frequency dependence of parameters. Junction and MOS FET: working principle, static IU- characteristics, dynamic models, frequency dependence of parameters. Thyristors: working principle, classification. Basic bipolar and unipolar transistor amplifiers. Power amplifiers: A, AB and B-class. Operational amplifier. Comparators. Basic logic circuits.
Engineering Graphics and Documentation
Orthogonal and axiomatic projections, cross-sections. Lines, technical script, paper formats. Draft and draft methods. Dimensions of models. Graphical interpretation in space and plane. Isometry. Norms and rules pertaining to construction and usage of technical documentations. Drawing selection and caption. Tolerances and endorsement. Meaning and options of graphical communication in electrical engineering. Basic symbols of electrical, electronic, electromechanical elements and systems. Types, design and usage of schemes in electrical engineering. Flowchart. Operation, electrical, connection schemes, access plan. Diagrams of logical systems and drawing methods. Connection schemes. Textual documentation. Technical description, manuals. Description of components and rules of using CAD systems. Using CAE systems in projects concerning electric power system and additional documentation. Introduction to electronic system documentation (systems, facilities) using the CAD computer programme. Exercises: Fundamentals of design and making documentation by means of a computer. Working in the AutoCAD programme applications. Marking elements according to IEC standards.
Fundamentals of Electrical Engineering I
Introduction. Force on the point charge and the vector of the electric field, Coulomb's law, Gauss's law. Electric induction, dielectricity. Field of a point (spherical) charge, line charge and a flat sheet of charge. Electric

potential and voltage, power in electric field. Potential surfaces and field lines, potential around point charge. On capacitance, capacitance of a plane capacitors and capacitance of two wire system. Energy in electrostatic field. Electric circuit, intensity, direction and density of curent. Various effects of electric current, electrical resistance and conductance, influence of temperature. The ideal voltage and current source. Ohm's law. Kirchhoff's laws. Power and energy in circuits, Joule's law, maximum of usable power and efficiency. Force on a moving charge, density of the magnetic flux, the magnetic field vector, Ampere's law, magnetic flux, imaging with field lines. Magnetic field around linear conductor and in the thorodial coil. Force influence on a conductor and between two conductors. Biot-Savart's law. Magnetic field of a coil. Permeability, ferromagnetism, magnetisation curve and hysteresis loop. Magnetic circuit and its reluctance. Faraday's law and Lenz's law. Self-induction and mutual induction, inductance and mutual inductance. Energy of the magnetic field.

Fundamentals of Electrical Engineering II

Currents changing in time. Alternating and sinusoidal currents. Basic effects of alternating currents. Average and RMS values. Connecting R, L and C on an AC voltage. Power and voltage relations in AC circuits. Phasor representation. Impedance and admittance, complex power. Methods for solving electrical networks: direct usage of the Kirchhoffov' laws, the method of node voltages, the method of loop currents, the method of superposition. Thevenin's theorem, Norton's theorem and Millman's theorem. Compensation of the reactive power. Resonance. Q factor and frequency characteristic. Multiphase currents. Three-phase system. Delta and wye connected load. Power of the three-phase system. Inductances and transformer. Total inductance of mutual coils. Coreless transformer - equation and scheme. Transformer with iron core.

Linear Algebra

Elements of mathematical logic. Vector space V3. Operations on vectors. Linearly dependent and independent vectors. Vector projection. Base of a vector space. Coordinate system. Scalar, vector and triple product. Analytic geometry. Point, line, plane and mutual relations. Matrix and elementary transformations of matrices. Operations with matrices. Vector space of matrices. Determinant and its properties. Calculation of determinant value. Rank of a matrix. Regular matrices. Inverse matrices. Systems of linear equations. Discussion of solutions. Methods for solving systems of equations. n-dimensional vector space. Base and space dimension. Subspaces. Examples of vector space. Linear operator. Representation of a linear operator in a basis. Algebra. Minimum polynomial. Similarity of matrices. Eigenvalues and eigenvectors. Characteristic polynomial. Hamilton-Cayley theorem. Matrix diagonalisation. Scalar product. Norm. Unitary spaces. Orthogonality. Gramm-Schmidt orthogonalisation. Quadratic forms. Curves of second degree. Second degree surfaces.

Measurement Basics

Basic terms in metrology. Measurement uniformity, metrology pyramid, traceability. International system of (measurement) units (SI). Numerical (ratio) units. Errors. Measurement uncertainty. Complete measurement result. Decision making based on the complete measurement result. Types of signals, signal parameters, visualisation in time and frequency domain. Measurement equipment. Measurement instruments (electromechanical, analogue electronic, digital). Maintenance of measurement instruments. Digital multimetre. Oscilloscope. Digital measurement systems (sensor, transducer, conditioner, display). Measurement methods (deflection, null, comparison, substitution, differential, direct, indirect). Measurement of electrical quantities (current, voltage, frequency, phase displacement, apparent power, active power, reactive power, power factor, energy, resistance, inductance, capacitance, dissipation factor, impedance and admittance). PC based automated measuring systems.

Object-oriented Programming

Software complexity. Complexity attributes, measurement of complexity. Decomposition, abstraction, hierarchy. Methods of analysis and software design. Object models. Types of programme paradigms. Elements of an object model. Data abstraction. Classes and models. Objects relation. Notation. Programming, software elements, development of object-oriented programmes. Programming language C++. Details of object-oriented programming in C++. COM and DCOM.

Physics

Introduction to physics (physical quantities and measurement units, mathematical basics of physics). Particle kinematics. Forces and force fields in nature (gravity, inertial and non-inertial systems). Newton's laws and application to solving equations of motion. Work, power, energy. Laws of conservation of energy and momentum (two body collisions). Many body mechanics - rigid bodies and fluids. Heat and thermodynamics (kinetic-molecular theory of heat, laws of thermodynamic, heat transfer). Mechanical vibration and waves (sound waves). Electromagnetic waves (fundamental laws of electromagnetism - Maxwell equations,

electromagnetic fields, formation and expansion of electromagnetic waves). Electromagnetic radiation spectrum. Geometric and physical optics. The wave-particle nature of electromagnetic radiation and matter. Quantum nature of light. Atomic structure (atomic spectra).
Probability and Statistics
Fundamentals of combinatorics. Algebra of events. Probability and properties. Random variable. Distribution function of a random variable. Discrete and continuous probability distributions (hypergeometric, binominal, Poisson, normal, uniform, exponential, Chi-squared, student`s t-distribution). Numerical properties of distributions. Two-dimensional probability distributions. Moments and correlations. Statistical set with parameters. Empirical and two-dimensional distributions. Correlation and regression analysis. Samples and numerical properties of samples. Parameter estimation. Interval estimation. Statistical hypothesis testing. Examples of statistical models, statistical thinking and application of statistical programmes.
Programming I
Basic terminology and historical overview of computer science. Fundamentals of computer organisation: CPU, peripheral units. System and application software. Networking and the Internet. Number systems and data formats. Basics of mathematical logic. Algorithms: notation forms, timing and space complexity on examples. Programming fundamentals, programming language structure, program development, languages of different abstraction level, compiler, interpreter and browser on examples. Programming in C: programme structure, keywords, data types, C preprocessor, variables, arithmetic and logic expressions, input and output, control - flow statements, functions, basics of pointers, arrays and structures, files.
Programming II
Basics of C programming language. Complex data types: arrays, structures and unions. Pointers: interconnections with arrays, pointers arithmetic. Function, parameter exchange by a value and an address. Features for working with file system (files): binary files, textual files, files with a direct access. Systematic approach to software development: top-down and bottom-up approaches. Algorithm and the conversion process to the programming code. Examples of search and sorting algorithms. Fundamentals of object-oriented programming. Classes and objects. Inheritance.
Signals and Systems
Mathematical models of time-continuous and time-discrete signals and systems. Classification. Analysis of linear systems. Fourier transforms of time-continuous and time-discrete signals (FS, FT, DTFT and DTFS). Frequency characteristics and filtering principles. Laplace and Z-transform. Decomposition and realisation of systems. Stability, controllability and observability of systems. Signal sampling and regeneration. Equivalence of time-continuous and time-discrete systems. Software used for analysis and simulation of systems.