Guidance to Master's Degree Programs in English at ETU "LETI"

1. AUTOMATION AND MECHATRONICS

The program is dedicated to robotics and mechatronics, mechatronics and robotic actuators, as well as modern applications of microcontrollers. The program provides students with deep knowledge of state-of-the-art automatic control theory, most notably analysis and design of nonlinear, adaptive and intelligent control systems.
You will learn about:
- Network Technologies
- SCADA Systems
- Applications of Real-Time Systems
- Electrical Drive Design
- Robot Design (manipulator robots, self-propelled mobile platforms).

COURSE	ECTS	SEMESTER	DESCRIPTION
Russian as a Foreign Language	**2**	**1, 2, 3**	The course is intended for international Master's students with no background in linguistics who graduated from Russian universities and have Russian language ability at the B2 level. The course provides students with a certain level of language ability to partake in various speech situations, as well as language and speech material. As a result, international students fulfil their communication needs, most notably in their academic and social life. It is a foundation for them to master specialized courses and finally successfully defend a Master's thesis. This Master's level Russian language course is aimed at equipping future graduates with communicative ability sufficient for working a job in a Russian language environment. The course uses text topics ranging from general science, major- and country specific ones, to literature and arts, politics and social life.
Social Communication in Professional Environment	**3**	**1**	The course covers some important issues of theoretical and practical interpersonal communication in business environment. The following issues are discussed in the course: situational and psychological factors of interpersonal communication, verbal and nonverbal practices of communication, active listening, specific methods of interpersonal pressure, influence and manipulation, emotional management, types of corporate culture and teambuilding.

COURSE	ECTS	SEMESTER	DESCRIPTION
Energy Management	**3**	**1**	Content of the course includes theoretical and practical aspects of enterprise energy management and covers the following issues: 1) evolution of management theory, and the role of EM in the enterprise management system. Special attention is paid to a conceptual framework of EM, its purposes, tasks and functions, classification; the model of an EM system is considered; 2)enterprise energy management. EM is studied as an extension of the enterprise's strategy, including a functional strategy, its place in the corporate management pyramid. The attention is focused on EM from the points of investment attractiveness and information, and marketing - actions that are directed to increase energy efficiency; 3) course implementation: cases (tasks solution) by economic assessment of efficiency of EM, an energy audit; on legalregulation of ensuring energy efficiency, and energy security, energy industry.
History of Science and Technology in the Field of Technical Systems	**3**	**1**	The main aims of the course are as follows: study of the newly-discovered physical phenomena, new scientific theories and laws, basic ideas and new technical solutions in the field of electrical engineering, electromechanics and control that formed the automatic control science.
Electric and Hydraulic Drives Mechatronic and RTS	**8**	**1**	Study the operating principles of electric and hydraulic drives of various types used in modern mechatronic and robotic devices and control methods of actuators and methods for their calculation and modeling. The examples of different types of actuators are given.
Computer-based Technologies of Control Technical System	**8**	**1**	The course is intended to provide a complete overview of modern information technology and software used in control systems on the basis of information and digital systems, primarily - in industrial processes. Presentation of the material is based on universal regulations applicable to the control of any complex system. Questions concerning the control of technical systems and various industrial automation systems are discussed in general terms. The functional, organizational, informational, software and hardware aspects of computer-aided control processes are given in detail. Important issues related to the development of up-to-date industrial systems - Intranet- and of Internet technologies – are considered. Following principals of SCADA-systems construction are discussed: the implementation of human-computer interaction, hierarchical principle of systems construction, the composition of hardware and software platforms and methods of software interactions. Problems of constructing and practical use of real time operating systems are studied. Theoretical training focused on the use of acquired knowledge in the development of practical issues related to the control tasks for contemporary industrial automation systems and technical systems for various applications. Practical development of computer technologies is carried out in a laboratory, consisting of research laboratory stands, equipped with the modern industrial controllers and SCADA-system InfinitySuite.

COURSE	ECTS	SEMESTER	DESCRIPTION
Introductory Practice	**3**	**1**	
Nonlinear and Adaptive Control in Technical Systems	**6**	**2**	The material of the course: the method of Lyapunov functions, including elements of its design; square and circle criteria for absolute stability; the study of periodic solutions, Poincare type methods and Galerkin harmonic balance; research methods of nonlinear dynamics, linear stability analysis, stability of periodic, quasi-periodic and chaotic solutions, local and nonlocal bifurcation; searchless algorithms and adaptive control systems, basic structure, synthesis methods, speed-gradient method; variable structure system. fuzzy and neural systems - intelligent control systems.
Mechatronic Systems and Robotics	**7**	**2**	The course includes the basics of mechatronic and robotic technology design complexes; discusses robotic drives systems, mathematical description and simulation of robots and mechatronic machines. The course includes a large number of practical and laboratory classes and students' independent work. The students undergo tests and routine knowledge assessment to ensure that the students receive proper education.
Intellectual Control in Technical Systems	**6**	**2**	
Modeling and Synthesis of Nonlinear Elements of Systems	**6**	**2**	The course introduces the basics of mathematical modeling and synthesis of nonlinear devices at the input/output mapping. Different forms of nonlinear models classified as multidimensional polynomials, regression models and neural networks are investigated. The comparative analyses of nonlinear models are made. The methods and algorithms of model building by solving the problems of nonlinear device operator approximation in the root mean square norm, using the input and output signal sets are studied. The approximation problems are solved in time, frequency, s- and z-domain. The skills of various neural network synthesis in MATLAB are given. The examples of modeling and synthesis of nonlinear transformers, filters, compensators.
Mathematical Modeling of Objects and Automatic Control Systems	**6**	**2**	The course covers physical and mathematical principles of model construction for objects and control systems, research methodology, the principles of creation and research models in interactive engineering software environments.

COURSE	ECTS	SEMESTER	DESCRIPTION
Technological (RnD) Practice	**3**	**2**	
Modern Methods of Control Theory	**8**	**3**	The first part of the course is dedicated to issues of stochastic nonlinear dynamics for deterministic systems of low order. The course uses linearization techniques for non-periodic and periodic attractors, considers the local bifurcations of a saddle equilibrium state, a limit cycle and structures of two-dimensional torus, and nonlocal bifurcations of these attractors. The second part of the course describes the construction of robust regulators for objects with limited uncertainty (H∞–theory) from the perspective of the external approach, presents the main mathematical results of robust stability, the problem of robust control and robust structures of the regulators.
Optimal Control Systems Development	**5**	**3**	
Systems of Ensuring the Safety for Technical Control Devices	**5**	**3**	The course considers general engineering issues in complex security, as well as the principles of design and construction of such systems. The focus is on the safety requirements in the test instrument.The course covers problems related to the features of technical equipment in terms of electromagnetic compatibility, ergonomic engineering and other.
Electromechatronical Complexes and Systems	**7**	**3**	In this course, students study the process of electromagnetic and electromechanical energy conversion processes associated with functional and design combining in EMTC electromechanical converter with electronic components. We consider the structure and operation of EMTC, exampled by synchronous machines and information type EMT systems. The technique for calculating the parameters and characteristics of EMTC are considered. Practical and laboratory classes are dedicated to development of methods for the preparation and analysis of EMTC performance.
Adaptive Control in Mechatronics and Robotics	**7**	**3**	The course familiarizes undergraduate and graduate students of technical universities with main scientific approaches to control of mechatronic and robotic systems. The problems of analysis and design of modern adaptive control systems for multi-degree nonlinear mechanical objects with extended geometry and elastic deformations under conditions of uncertainty of their mathematical description and external perturbations. Mathematical models of multi-degree-of-freedom rigid and elastic nonlinear mechanical objects in explicit form of Lagrange equations of the second genus are considered. The basic structures of searchless adaptive control systems for linear and nonlinear objects, their stability to additive perturbations, and dissipativity are studied. The technique of block-by-block calculation of the designed systems with direct and indirect adaptive control of nonlinear elastic objects is studied using the concept of compound programed, linear (modal or following the reference model), and adaptive control (with signal and parametric adjustment).

COURSE	ECTS	SEMESTER	DESCRIPTION
Field Experience (RnD)	**3**	**3**	
Methods and Means of Mathematical Optimization in the Field of Technical Systems	**2**	**3**	The course introduces the basics of optimization theory and decision-making. Models and decision-making methods, methods and algorithms of mathematical programming, various approaches used for modeling and control in optimal systems are considered. During the course, theoretical conclusions are considered on the basis of real-systems examples, namely: the use of linear programming for resource allocation in the planning of the production life cycle, the problem of balancing the factory assembly, queue problems in service systems, Markov chains in game theory, the use of filtering when direct measurements are not possible, for the case of a thermometer.
Robotics System Design	**2**	**3**	The course introduces students to the basic rules of designing robotic systems, methods and means of designing robots and robotic systems. The course covers the following topics in detail: regulations and criteria for robotics design, multidisciplinary aspects of robotics design including mechanic, electronic, control systems etc., criteria for mobile and industrial robots, robot protection against environmental conditions, EMC and safety considerations for design.
Pre-degree Internship	**21**	**4**	
Master's Thesis Defense	**9**	**4**	

2. COMPUTER SCIENCE AND KNOWLEDGE DISCOVERY

The Program offers students advanced courses in mathematical modeling, data processing and analysis, as well as software engineering. Curriculums focus on the latest trends in artificial intelligence and machine learning, image and signal processing, parallel and distributed computing, intelligent and embedded systems, image recognition systems and biometric technologies. Students additionally study economics and humanities.
Program graduates:

- are able to operate modern information and communication systems (applied software, local and global computer networks) in order to collect, process and analyze various types of data (information)
- possess the skills required for testing software; are able to apply software in their professional field
- have the professional expertise and skills required for reaching software solutions to information security problems in applied and computational mathematics
- have professional expertise in mathematical modeling and data analysis
- have the professional skills to design software, hardware, and distributed systems, to apply computer tools in education
- are especially proficient in artificial intelligence (Data Mining), digital signal processing, parallel and distributed computing and biometric technologies
- have expertise and skills in mathematical modeling, computer simulation and data recognition systems

COURSE	ECTS	SEMESTER	DESCRIPTION
Basics of Business	**2**	**1**	The course is aimed at familiarizing students with theoretical and practical aspects of enterprise activity in the Russian Federation. Students study the basics of developing their own business, acquire skills of adapting theoretical knowledge to Russian enterprise activity, study processes of enterprise activity and processes of implementing an enterprise project, business-planning,attracting resources, information on legal and economic aspects of starting an enterprise; possible difficulties facing a businessman especially at early stages and development of enterprise activity in Russia. Students acquire practical skills of starting an own business and handling tasks related to current enterprise activity, searching for new ideas and resources for business development.
Mathematical Foundations of Computer Science	**4**	**1**	This course can be viewed as a continuation of Discrete Mathematics and Mathematical Logic and Algorithm Theory. The purpose of the course is to advance mathematical background of students, master the main models and techniques of computer mathematics. The course consists of the following parts: basics of universal algebra, discrete analysis, discrete functional schemes, applied logic and proof theory.

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Russian as a Foreign Language	**2**	**1, 2, 3**	The course is intended for international Master's students with no background in linguistics who graduated from Russian universities and have Russian language ability at the B2 level. The course provides students with a certain level of language ability to partake in various speech situations, as well as language and speech material. As a result, international students fulfil their communication needs, most notably in their academic and social life. It is a foundation for them to master specialized courses and finally successfully defend a Master's thesis. This Master's level Russian language course is aimed at equipping future graduates with communicative ability sufficient for working a job in a Russian language environment. The course uses text topics ranging from general science, major- and country specific ones, to literature and arts, politics and social life.
Architecture of Parallel Computer Systems	**6**	**1**	The course is devoted to studying techniques of organizing academic computations and tools forparallel and distributed computing. We use modern techniques and tools of modern software and hardware. Students acquire skills of working with high-performance and computational systems, principles of scalar, flow and parallel, and vector computational tools. Special attention is devoted to designing parallel, cluster, and distributed computational systems of homogeneous and heterogeneous architecture. Students learn how to handle various tasks in parallel and distributed environment and assimilate basic facts for designing distributed applications and databases, basics of modernsoftware and hardware application.
Intelligent Systems	**4**	**1**	The course provides the basics of designing intelligent agents including movement, obstacle avoidance and pathfinding to tactical analysis and decision-making. The course also covers the use of algorithms based on decision trees, state machines, and elements of fuzzy logic. We consider applications of decision-tree training methods, the simplest neural networks and implementation of reinforcement training. The course also includes fundamentals of multiagent systems, specifics of designing intelligent agent environment, knowledge management, and natural language processing. This course discusses applications of the algorithms in a virtual environment (video game).
Computer Tools in Education	**4**	**1**	The course is devoted to studying software packages for numerical and symbol computing. We consider three different packages: numerical computations are represented in GNU Octave and R, symbol computations are represented in SageMath. All packages are distributed free of charge and are available for downloading. Special attention is paid to data types in embedded programming languages and visualization techniques, i.e. plotting graphs and diagrams.

COURSE	ECTS	SEMESTER	DESCRIPTION
Advanced Mathematical Methods	**5**	**1**	The course consists of selected topics from linear and multilinear algebra to numerical linear algebra that are important for applications in different branches of mathematics and physics, primarily in vector analysis, differential geometry, and numerical methods of ordinary and partial differential equations. Moreover, we discuss some natural applications of linear algebra such as recurrence relation and linear differential equations with constant coefficients.
Academic Internship (Design and Manufacturing)	**3**	**1**	During the internship, the student must learn how to plan, prepare, organize and carry out research work, and study the methods of results processing; students learn to formulate scientific problems, to review and compare the methods of problem solution. A result of internship should be a well-designed report based on the research.
Methodology of Learning Methods	**2**	**2**	The course is comprehensive and its purpose is to familiarize students with the structure of academic knowledge, research techniques, functions of academic theories and laws, broadening their outlook; develop ideas on criteria of scientific knowledge and requirements to academic research and its results. The course can be the basis for continuing studies. The course has been developed based on the university major and students' individual interests.
Algorithm Design and Optimization	**4**	**2**	The course is a continuation of Mathematical Foundations of Computer Science and it is an integral part of education in the field of computer science and information technologies. The purpose of the course is to advance the mathematical background of students and master the main techniques of designing, analysis, and optimization of algorithms. The course consists of the following parts: methods and strategies of algorithm design, algorithm complexity, sort algorithms and search algorithms, numerical algorithms, graph algorithms, general complexity theory of algorithms.
Software Development Technology	**6**	**2**	The course provides knowledge and skills in modern technologies of group development of software. We consider different models of software development life cycle, their advantages and drawbacks, capability maturity model integration (CMMI) and its key areas, team software process (TSP) and personal software process (PSP) developed in SEI University. We provide an overview of modern standards, methodologies, and documented processes and development environments: Rational Unified Process (RUP), Microsoft Solutions Framework (MSF), and TeamFoundation Server (TFS), agile development methodologies. We consider the issues of designing a project process, distribution of project roles, work planning and work tracking, quality monitoring and risk management.

COURSE	ECTS	SEMESTER	DESCRIPTION
Design Management of Information Systems	**4**	**2**	The course provides theoretical and practical training in the field of software project management and information systems design. The course considers notions and models of the life cycle of information systems and software, unified and extreme processes of information systems development, planning and managing the configuration of information systems, standards and quality of information systems, aspects of tracing information systems. All lectures are accompanied by the appropriate examples.
Digital Signal Processing	**4**	**2**	The course includes basic methods and algorithms of digital signal processing using computer simulation in MATLAB. The course includes discrete signals and their transforms, linear discrete systems and their characteristics, discrete Fourier transform (DFT) and its applications, design and analysis of FIR and IIR filters, quantization effects in digital systems, spectral analysis of signals, multirate signal processing, adaptive filters and wavelet transform. The course familiarizes students with theoretical fundamentals of basic methods and algorithms of digital signal processing, the computer simulation technology of these methods and algorithms in MATLAB. The course also introduces embedded software packages (FDATool, FVTool, SPTool, WAVETool)
Parallel Computing	**5**	**2**	Students acquire new knowledge for a possible career in the field of parallel programming. We provide principles for constructing parallel computational systems and consider mathematical models of parallel algorithms and programs for analyzing the efficiency of parallel computing. The course considers low-level possibilities of modern operating systems for providing parallelism.
Languages for Hardware Design and Verification of Software-Hardware Systems	**4**	**2**	The course covers the methodology and means for software-hardware codesign and coverification, including special data types, object oriented programming and random-constraned simulation of such systems.
Internship (Design and Manufacturing)	**3**	**2**	During the internship, the student must learn how to plan, prepare, organize and carry out research work, and study the methods of results processing; students learn to formulate scientific problems, to review and compare the methods of problem solution. A result of internship should be a well-designed report based on the research.

COURSE	ECTS	SEMESTER	DESCRIPTION
Information Technologies in Academic Research and Project Activity	**5**	**3**	The course is oriented to acquiring skills of applying high-performance computer engineering and information technologies for academic research and practical tasks from different knowledge domains. Students should be able to master new software packages and technologies for computational systems with different architectures, perform analysis of information technologies and select those that are the most efficient for handling practical and academic tasks formulated within the scope of industrial and/or pre-graduation practice. These tasks can be used for the research and graduation projects.
Algorithmic Mathematics	**4**	**3**	Algorithmic mathematics (computer algebra, symbolic or algebraic computations) deals with algorithms and software for handling mathematical expressions and other mathematical objects. This course familiarizes students with basic polynomial methods and algorithms over infinite and finite fields, Groebner bases, and algebraic varieties. The course allows students to get acquainted with theoretical fundamentals of basic methods and algorithms of polynomial factorization including Berlekamp's algorithm, algorithms for solving polynomial equations including those based on Groebner bases and Buchberger's algorithm.
Machine Learning on Big Data	**4**	**3**	The course provides advanced training in the field of big data analysis and extracting knowledge from raw data. We handle various machine learning tasks: classification, cluster-analysis, mining association rules and data visualization. Students will also acquire skills of using different data analysis tools including distributed data analysis: RapidMiner, Weka, R and Apache Spark.
Languages for Hardware Design and Verification	**4**	**2**	The course is aimed at studying tools for joint representation and debugging of software-hardware systems using SystemVerilog including special data types, object-oriented programming and quasi-stochastic representation of such systems.
Biometric Technologies	**4**	**3**	The course is aimed at studying biometric dynamic and static characteristics of humans. We consider all stages of image processing in biometric problems: data acquisition, face image preprocessing and feature extraction from images. We draw special attention to efficient algorithms of reducing feature space dimension using features oriented to image processing as two-dimensional data. The course also involves algorithm implementation using vector-matrix techniques in MATLAB. We discuss the main principles of constructing, simulating, and testing human recognition systems based on face images. Various simulation models are also widely discussed.

COURSE	ECTS	SEMESTER	DESCRIPTION
Distributed Systems and Technologies	**4**	**3**	The course covers a wide range of issues connected with the main principles, concepts, and technologies of distributed systems: connection, processes, identity, synchronization, integrity, and replication, fault protection, and security. The knowledge provided by this course can be used for constructing and managing distributed systems. The course includes practical training classes. Unsupervised work of students suggests studying the recommended sources of literature and preparation for classes. The final certification is based on graded examination results.
Mathematical Modeling of Linear and Non-Linear Systems	**4**	**3**	The course familiarizes students with the basics of mathematical modeling and synthesis of linear and non-linear systems at the input/output mapping. We study different forms of models classified as multidimensional polynomials, regression models, and neural networks. The comparative analysis of mathematical models is performed. The course also covers methods and algorithms of model design by solving the problems of system operator approximation in the root mean square metric using the input and output signal sets. Various neural network synthesis in MATLAB is represented. Modeling and synthesis of nonlinear transformers, filters, and compensators are represented. The course is also aimed at studying nonlinear behavior of dynamical systems. It covers the main properties of nonlinear processes during the design and use of a complex technical system. The course considers nonlinear dynamics and modern tools of dynamical analysis given through graphical programming environments. Students study mathematical representation of nonlinear systems and processes and their computer simulation through numerical integration.
Basics of System Theory	**4**	**3**	The course is oriented to mastering a number of areas of mathematics and system analysis used in engineering applications and academic research. The course encompasses all stages of complex system design beginning with information transform to digital form and its statistical processing and ending with system model design and its parameter optimization.
Data and Visual Analytics	**4**	**3**	Visual analytics is an advanced form of data analysis where analytical reasoning is followed by adoption of the highly interactive visualization techniques. This course introduces students to the concepts and tasks of visual analytics and examines several important data analysis and visualization techniques. It provides hands-on experience with both existing products and in the development of custom visual analytics software.

COURSE	ECTS	SEMESTER	DESCRIPTION
Information Security	**4**	**3**	The course covers all issues of determining, reaching, and supporting confidentiality as well as the following properties of information or its processing tools: integrity, availability, non-repudiation, accountability, authenticity, and reliability. The course helps students to master the main concepts and problems of information security and offers a number of important modern techniques of information security. The course is aimed at forming skills for working with existing products and developing information security software.
Design of On-chip Reconfigurable systems	**5**	**3**	The course deals with different aspects of SoC design. The main aspects of this problem exist: SoC components, CAD as on tool for design, design flow, for most significant SoC fragments. All these aspects are presented in the course. The main attention is paid to base problems in present-day approach for SoC design: project verification and debugging. The most significant project state – system level design – that recently becomes widespread is studies.
Internship Research Project	**3**	**3**	During the internship, the student must learn how to plan, prepare, organize and carry out research work, and study the methods of results processing; students learn to formulate scientific problems, to review and compare the methods of problem solution. A result of internship should be a well-designed report based on the research.
Internship (Pre-degree Internship)	**21**	**4**	During the internship, students must finalize the research for their final qualifying work. During the pre-graduation internship students learn to formulate a practical problem, to review and to compare the methods of its solution. A result of internship should be a well-designed report based on the research and the solutions of the practical problems.
Master's Thesis Defense	**9**	**4**	

3. EFFICIENT ELECTRIC POWER INDUSTRY

Electric energy is a similar kind of product as water or fuel and consumers have to control the quantity and quality of energy provided to him. Industrial enterprises now are facing the task of reducing power consumption to increase profits and ensure environment conservation. On the other hand, the quality of power they purchase needs to be controlled. They also need to make sure that power quality in a common network with their equipment does not decrease.

Master's program Efficient Electric Power Industry is focused on making the power generation technology and processes associated with it more energy efficient. Classes are held at the Electrotechnology and Converter Engineering Department and Robotics and Industrial Automation Department. These departments have been dealing with energy efficiency, taking part in European projects like TEMPUS jointly with universities of Hannover (Germany), Padua (Italy), Riga (Latvia) and others since 1994.

The program has theory and hands-on modules in energetics, electrical engineering and energy management.

COURSE	ECTS	SEMESTER	DESCRIPTION
Russian as a Foreign Language	**2**	**1, 2, 3**	The course is intended for international Master's students with no background in linguistics who graduated from Russian universities and have Russian language ability at the B2 level. The course provides students with a certain level of language ability to partake in various speech situations, as well as language and speech material. As a result, international students fulfil their communication needs, most notably in their academic and social life. It is a foundation for them to master specialized courses and finally successfully defend a Master's thesis. This Master's level Russian language course is aimed at equipping future graduates with communicative ability sufficient for working a job in a Russian language environment. The course uses text topics ranging from general science, major- and country specific ones, to literature and arts, politics and social life.
Energy Management	**2**	**1**	The course introduces students to the issues of energy saving in technological processes and at power transportation. Particular attention is paid to energy audit as a survey, allowing to determine potential of energy saving and to evaluate influence of industrial equipment on power quality. Students get practical experience in using modern tools for energy audits, performing instrumental survey as well as learn to make a power consumption balance.

COURSE	ECTS	SEMESTER	DESCRIPTION
Social Communication in Professional Environment	**2**	**1**	The main objective of the course is to develop the ability of students to critical analysis of specific communicative practices and situations of interpersonal interaction and management skills of communicative behavior in the business interaction. Specific topics are focused on basic communication skills in a business environment, techniques of group management and making group decisions, the rules of business written communication and business telephone communication.
History of Science and Technology in the Field of Technical System	**2**	**1**	The course is devoted to the study of a new physical phenomena discovery, new scientific theories and laws forming, basic ideas and technical solutions appearance in the field of electrical engineering, electro mechanics and control, which formed the automatic control science. Main stages in the history of the control theory and technology are overviewed. The discipline includes also the acquaintance with the history of St. Petersburg Electrotechnical University "LETI" and its main scientific schools.
Energy Saving and Quality of Electric Energy in Power Systems	**4**	**1**	The course introduces students to the issues of energy saving in technological processes and at power transportation. Particular attention is paid to energy audit as a survey, allowing to determine potential of energy saving and to evaluate influence of industrial equipment on power quality. Students get a practical experience in using modern tools for energy audits, performing instrumental survey as well as learn to make a power consumption balance.
Information Support in the Electric Power Industry	**5**	**1**	The course covers information support in electric power industry namely: the basics of classification, purpose and information support. Students learn databases, as the foundation of information systems. In the course of discipline are acquainted with information displays.
Power Converters	**4**	**1**	Calculation and design of the modern transforming devices on the basis of force electronic semiconductor elements is considered, namely: classification, assignment, main circuitry solutions of devices of force electronics; force semiconductor items and transformers as controls operation modes, protection and regulations of parameters of electrotechnical and electrical power systems; the physical phenomena in semiconductor items and bases of the theory of semiconductor items; principle of operation of the modern force semiconductor items, features of their construction; design methods, tests and simulations of force transforming devices.
Academic Internship	**9**	**1**	

COURSE	ECTS	SEMESTER	DESCRIPTION
Alternative Energy	**5**	**2**	The course introduces students to the functioning and use of alternative energy sources. The current state, examples of implementation and prospects of using wind, solar, geothermal waters, secondary energy resources, fuel cells and other alternative energy sources in Russia and abroad are considered.
Efficient Industrial Installations	**6**	**2**	The course introduces students to the issues of the use of electric heating in the industry; with technologies and devices for heating, heat treatment and metal melting; with structural materials used in design and features of heating and melting units for ferrous and non-ferrous metals.
Modeling and Synthesis of Nonlinear Elements of Systems	**5**	**2**	The course introduces the basis of mathematical modeling and synthesis of nonlinear devices at the input/output mapping. Different forms of nonlinear models classified as multidimensional polynomials, regression models and neural networks are investigated. The comparative analysis of nonlinear models is performed. The methods and algorithms of model building by solving the problems of nonlinear device operator approximation in the root mean square norm, using the input and output signal sets are studied. The approximation problems are solved in time-, frequency-, s- andz-domain. The skills of various neural network synthesis in MATLAB are given. The examples of modeling and synthesis of nonlinear transformers, filters and compensators are represented.
Mathematical Modeling of Objects and Automatic Control Systems	**5**	**2**	The course includes physical and mathematical bases of construction of models of objects and management systems, methodology of their research, the principles of creation and research models in interactive engineering software environments.
Internship (Research Project)	**12**	**2**	
Systems of Ensuring the Safety for Technical Control Devices	**3**	**3**	The course covers the general technical aspects of complex safety, which contain concept, principles of design and construction, which can be used for all technical control systems. Primary attention is paid to the tests requirements according to the standards of safety at the all stagesof the life cycle. Special features of control systems are examined from the potential danger point of view, created by electric current, fire and explosion, electromagnetic fields, mechanical, climatic actions and human factors.

COURSE	ECTS	SEMESTER	DESCRIPTION
Renewable Energy Automation Stations	**6**	**3**	Account and engineering of the modern stations of renewable energy is considered, namely: classification, purpose, the basic circuitry decisions of devices of solar stations; power semiconductor devices and reformers, as controls operation modes, protections and adjustments of arguments; charge control units; charge batteries; design techniques, testing and simulations of stations of renewable energy.
Intelligent Control Systems for Renewable Energy Stations	**5**	**3**	Engineering of intellectual guidance systems by stations of renewable energy is considered, namely: classification, purpose, the basic circuitry decisions of devices of intellectual guidance systems of stations of renewable energy; controls operation modes, protections and adjustments of arguments.
Modeling of Processes in Power Industry	**5**	**3**	The course introduces students to methods of solving problems of mathematical physics. For the equations of thermal and electromagnetic fields are shown all stages of the problem solution, starting from the choice of solution method and ending with the creation of the program in algorithmic language. Considers the finite differential and finite element methods for solving differential equations. The course also provides analytical and combined methods of solutions and discusses the solution of inverse problems. On using the commercial package ANSYS provides a solution to problems of electromagnetic field and thermal conductivity for two-dimensional and three-dimensional case.
Methods and Means of Mathematical Optimization in the Field of Technical Systems	**2**	**3**	The course introduces the basics of optimization theory and decision making. Models and decision-making methods, methods and algorithms of mathematical programming, various approaches used for modeling and control in optimal systems are considered. Within the framework of the course, theoretical conclusions are considered on the basis of examples of real systems, namely: the use of linear programming for resource allocation in the planning of the production life cycle, the problem of balancing the assembly at the factory, queue problems in service systems, Markov chains in game theory, the use of filtering when direct measurements are not possible, for the case of a thermometer.
Robotics System Design	**2**	**3**	The course introduces the basics of using of single board computers such as Raspberry Pi and ROS systems. Within the framework of the course, theoretical background for working with SBC and ROS is given on the basis of examples of real systems. The use of ROS with Rasberry Pi as a part of practical workshop is given.

COURSE	ECTS	SEMESTER	DESCRIPTION
Internship Project	**9**	**3**	
Pre-degree Internship	**21**	**4**	
Master's Thesis Defense	**9**	**4**	

4. HERITAGE SCIENCE

Master's program Heritage Science is an interdisciplinary education program that provides students with skills necessary to tackle modern aspects of cultural heritage conservation, which requires for them to study a unique mix of engineering and humanities. Students take lectures, hands-on training and laboratory sessions to understand complex issues of artwork restoration, authentication, attribution, storage and exhibiting. Students learn how to address these issues using modern scientific achievements.

COURSE	ECTS	SEMESTER	DESCRIPTION
Russian as a Foreign Language	**2**	**1, 2, 3**	The course is intended for international Master's students with no background in linguistics who graduated from Russian universities and have Russian language ability at the B2 level. The course provides students with a certain level of language ability to partake in various speech situations, as well as language and speech material. As a result, international students fulfil their communication needs, most notably in their academic and social life. It is a foundation for them to master specialized courses and finally successfully defend a Master's thesis. This Master's level Russian language course is aimed at equipping future graduates with communicative ability sufficient for working a job in a Russian language environment. The course uses text topics ranging from general science, major- and country specific ones, to literature and arts, politics and social life.
Social Communication in Professional Environment	**2**	**1**	The aim of the course is to discuss some important problems of theory and practice interpersonal communication in business environment. The following issues are discussed in the course: situate and psychological factors interpersonal communication, verbal and nonverbal practices of communication, active listening, specific ways of interpersonal pressure, influence and manipulation, emotional management, types of corporate culture and teambuilding.
History of Science and Engineering in Instrumentation	**2**	**1**	The discipline considers the development of technical sciences related to the receiption, transformation, presentation and transmission of information in technical systems from the ancient times to the present. History is seen as an evolution process of the main scientific and technical ideas from their inception to the present state, as well as changes in the methodology of scientific and technical creativity in the field of instrumentation in its historical perspective. Historical patterns are described and the current state of the organization of scientific and technical activities is substantiated, both individual and group methods of enhancing design and inventive creativity are considered. Features of development, current state and prospects of scientific and technical achievements are discussed.

COURSE	ECTS	SEMESTER	DESCRIPTION
Materials of Cultural Heritage Objects	**4**	**1**	The objectives of this course is to provide information on the properties of the most common minerals and rocks as well some metals and alloys, which are used in architecture and arts and crafts. Basic knowledge on fundamentals of mineralogy (including chemical bonds and crystal structures, crystal growth, the physical properties of minerals and mineral identification techniques) and petrography (the different groups of rock-forming minerals, and classification of rocks based on their mineral contents and textures) are discussed. Besides, the basic laws of mineral formation in natural and technological processes are given.
Environmental Impact on Materials, Ageing and Deterioration of Cultural Heritage Objects	**4**	**1**	This course gives students basic information about the environmental risk to cultural property caused by physical, chemical and biological factors. The students also study the impact of environmental factors of natural and anthropogenic nature. The course provides general information about environmental monitoring as one of the most effective modern instrument in the field of Cultural Heritage preservation around the world. In addition, the course includes practical laboratory works that allows one to master the methods of assessing the microclimate in the premises for the sustainable protectionof CH objects.
Chemistry in Restoration	**4**	**1**	This course involves the study of the chemical properties of both restored and restoration materials used in the conservation and restoration of various objects of cultural heritage. The diversity of the nature of these materials determines the problems that restorers encounter in the process of their activities. The objectives of this discipline are the development of the theoretical base, which includes questions of general, inorganic, organic, physic-chemical, colloidal and analytical chemistry, as well as the acquisition of practical skills in working with chemical compounds necessary for both research and restoration work itself.
Laser Physics	**4**	**1**	
Laser Diodes and Optoelectronics	**5**	**1**	
Academic Internship	**9**	**1**	

COURSE	ECTS	SEMESTER	DESCRIPTION
Commercialization of Results of Scientific Research and Development	**2**	**2**	Commercialization of the research work results is the process of involving them in the economic (commercial) turnover in order to ensure the innovative development of the national and international economy. The relevance of this discipline is due to the need to modernize the economy in the context of changing the existing technological structure based on the realization of the potential of high-tech branches of science and technology, including the "Digital Economy" program. The development and implementation of the research work results in the economic activities of organizations and enterprises is one of the key success factors for economic transformations. The implementation of the tasks of innovative development requires a qualified and competent assessment of the economic efficiency of projects focused on the production of high-tech products and the promotion of new technologies. The main goal of this discipline is to form a complex of knowledge, skills and practical skills of developing a business plan for the commercialization of innovative ideas in the form of creating new or improved types of products, goods, works and services studied in the course of R &D undergraduates. Mastering a phased methodology for business planning and design of various innovative projects will ensure the acquisition of competencies required in solving the problems of outputting the results to sales markets and assessing their economic efficiency.
Modern Problems of Electronics and Microprocessor Systems in Instrument Making	**3**	**2**	Construction of modern control and data processing systems based on programmable electronic circuits and microprocessor technology. Study of modern means of developing and debugging digital circuits. Study of methods and means of hardware implementation of digital data processing systems.
Biology in Restoration	**3**	**2**	The objectives of this course is to provide information on the theoretical aspects of the of materials biodeterioration problem, methods for evaluating and studying biodamage of monument materials, mechanisms of destruction processes in the anthropogenic environment and protection of materials from degradation in restoration practice. The role of microorganisms (microscopic fungi, bacteria and algae) in the destruction of monuments in different environment (in the open air in different climates, in the conditions of Museum storage) is discussed. The course will cover examples of biological deterioration to Cultural Heritage objects created from various materials: natural and artificial stone, wood, paper, etc. Special attention is paid to the interaction of biological and physical-chemical factors in the destruction of materials.

COURSE	ECTS	SEMESTER	DESCRIPTION
Physical Non-destructive Methods of Examining of CH Objects	**4**	**2**	This course provides basic knowledge about physical principles and applications of main kinds of non-destructive methods of examining of Cultural Heritage objects based on the use of X-rays, acoustic and electromagnetic waves. Among nondestructive techniques Infrared Termography, Nuclear Magnetic Resonance, X-ray Digital Radiography and 3D Computed Tomography will be considered. Also basic knowledge of Ion Beam Analytical techniques, including PIXE (Particle Induced X-ray Emission), PIGE (Particle Induced Gamma-ray Emission) and RBS (Rutherford Backscattering Spectrometry) will be discussed.
Computer Methods Applications in CH preservation	**4**	**2**	The purpose of this course is to study the impact of computer technology on art, as well as the specifics of the interaction between art and science and the results of this interaction. The course considers the use of information technologies for study and restoration of artworks, including computer reconstruction of lost parts of Cultural Heritage objects, as well as their archiving, museification and digitization (3D laser scanning, digital photography in the infrared range, etc.) and creation of copies. In addition, the use of computer methods for educational work (virtual museum) and scientific research of artworks (including their authentication and dating) is considered. The issues connected with introducing the blockchain technology to the art market using the case studies of use of new services, platforms and crypto auctions are also discussed.
Internship (Research Project)	**12**	**2**	
Opto-electronic Techniques for CH Materials Characterization	**4**	**3**	The course covers the most widely used methods, techniques and equipment for materials characterization such as light photometry, UV/Vis spectrometry, fluorescence spectroscopy, Fourier transform infrared spectrometry (FTIR), Raman spectroscopy, ellipsometry, scanning electron microscopy (SEM), atomic force microscopy (AFM), X-ray diffraction analysis (XRD) and some others. The course is focused on the basic physical principles, advantages and limitations of each method and their practical application for the investigation and characterization of Cultural Heritage objects.
Introduction in Heritage objects conservation	**4**	**3**	The course is focused on basic ideas of conservation/restoration science and practice. A short background of conservation theory and practice is aimed onto deeper understanding of its current ideas and methods. Definitions between operative and preventive conservation are discussed. Methodology and methods of practical conservation/restoration are analyzed, traditional and innovative ones being compared. The question of professional ethics in artworks restoration is one more essential topic of the course.

COURSE	ECTS	SEMESTER	DESCRIPTION
Laser Techniques in Restoration and Analysis of Artworks	**4**	**3**	This course gives students basic information about the use of laser techniques in cultural heritage preservation. Special attention is paid to consideration of laser cleaning of artworks. Basic physical principles of laser cleaning technology are considered and most important case studies connected with cleaning of CH objects created from different materials are overviewed. Use of 3D laser scanning for documentation, reconstruction and replication of CH objects is considered too. Furthermore, information about physical basics and practical use of other laser measuring techniques (LIBS, LIF, Laser Doppler Vibrometry and others) intended for analysis and non-destructive testing of artworks is presented.
Brief History of Art	**4**	**3**	Brief history of art course serves to navigate in diverse historic styles in art, as ability to distinguish general styles is an obligatory skill in expertise and attribution of art pieces. The course is aimed at forming the object of art study skills and their historical development and historical contexts. Another skill to be formed is the ability to compare different periods in art history and different groups of artworks belonging to different geographical and chronological locations. As for typological groups of artworks, general division is one to works of fine and decorative art.
Expertise and attribution of artworks	**4**	**3**	Since correct examination and attribution of artworks in most cases is possible only with a combination of various analytical methods, the course focuses on the consideration of art criticism methods of examination and attribution of works of art. None artwork cannot be attributed if it is not analyzed in terms of its state of preservation, technique of creation, composition, origin, previous restorations, and so on. Therefore, the course includes the study of various methods of analysis of fineand decorative arts. In particular, since stylistic analysis is a mandatory part of this process, the course includes consideration of the basic concepts of composition in the visual arts. Important features of existence, origin and restoration that serve as indirect proof of the authenticity of an art object and should be analyzed in the process of attribution are also studied in this course.
Internship (Research Project)	**9**	**3**	
Pre-degree Internship	**21**	**4**	
Master's Thesis Defense	**9**	**4**	

5. LASER TECHNOLOGIES

The Master's program mainly focuses on technologies for developing laser and quantum-based electronic devices and systems. Quantum electronic devices have a variety of unique characteristics combined in them (high coherence, achromatism, high stability and wavelength resettability, high directivity and capability to deliver large amounts of energy to a small space). This is a key factor that leads to breakthroughs in measuring technology, optics, recording and transfer of data, environment monitoring, material processing, medicine and biology. While studying, Master's students can learn about these technologies in a lot of detail and become very successful in the fields of science and technology mentioned before.

COURSE	ECTS	SEMESTER	DESCRIPTION
Commercialization of Results of Scientific Research and Development	**2**	**1**	Commercialization of the research work results is the process of involving them in the economic (commercial) turnover in order to ensure the innovative development of the national and international economy. The relevance of this discipline is due to the need to modernize the economy in the context of changing the existing technological structure based on the realization of the potential of high-tech branches of science and technology, including the Digital Economy program. The development and implementation of the research work results in the economic activities of organizations and enterprises is one of the key success factors for economic transformations. The implementation of the tasks of innovative development requires a qualified and competent assessment of the economic efficiency of projects focused on the production of high-tech products and the promotion of new technologies. The main goal of this discipline is to form a complex of knowledge, skills and practical skills of developing a business plan for the commercialization of innovative ideas in the form of creating new or improved types of products, goods, works and services studied in the course of R&D undergraduates. Mastering a phased methodology for business planning and design of various innovative projects will ensure the acquisition of competencies required in solving the problems of outputting the results to sales markets and assessing their economic efficiency.
Information Technologies in Instrumentation	**3**	**1**	The purpose of studying this course is to prepare students to use information technology as a toolfor solving scientific and practical tasks in their area of expertise at a high professional level, to participate in the development and implementation of these technologies.

COURSE	ECTS	SEMESTER	DESCRIPTION
Russian as a Foreign Language	**2**	**1, 2, 3**	The program is aimed at foreign students with no prior knowledge of the Russian language. The course includes language and speech models based on the requirements for the Elementary certification level. Achieving this level in Russian will satisfy the students' basic communicative demands imposed on him/her by the social, cultural and university life. The course provides students with the opportunity to master a set of instrumental competences and linguistic knowledge (the Russian language is the most important), which allows students to organize their speech in the communication process. The content of the program involves implementation of flexible training models, depending on the communicative purposes, native language and students' personality.
History of Science and Engineering in Instrumentation	**2**	**1**	The course considers the development of technical sciences related to the reception, transformation, presentation and transmission of information in technical systems from the ancient times to the present. History is seen as an evolution process of the main scientific and technical ideas from their inception to the present state, as well as changes in the methodology of scientific and technical creativity in the field of instrumentation in its historical perspective. Historical patterns are described and the current state of the organization of scientific and technical activities is substantiated, both individual and group methods of enhancing design and inventive creativity are considered. Features of development, current state and prospects of scientific and technical achievements are discussed.
Modeling of Technical Systems	**3**	**1**	The concepts and principles of the theory of modeling various technical objects and systems, the issues of constructing linear, nonlinear, discrete models are considered. The main aspects, the area and conditions for the application of simulation modeling, the stages of creating a simulation model, criteria for assessing the adequacy of the model are stated. Particular attention is paid to the acquisition of practical skills in constructing mathematical models of technical systems and the development of modern software tools for modeling.
Measurement Information Processing Methods	**3**	**1**	The course examines the theory of construction of algorithms for processing measurement information and their research based on the theory of assessment and filtering using modeling methods.The aim of the course is to obtain the knowledge and skills necessary for the main professional activity of a Master's student.

COURSE	ECTS	SEMESTER	DESCRIPTION
Basics of Optical Measurement Systems	**3**	**1**	The course is designed to form basic knowledge, ideas and skills, covering the following: basics of wave optics, interference, diffraction, postulates of special theory of relativity, Doppler and Sagnac effects, basics of the theory of optical images. The main types of imaging optical systems (telescopes, microscopes, photographic lenses, etc.), their features and general properties, as well as the main types of interferometers are considered. The basic concepts of quantum electronics, principles of operation and properties of some types of lasers are studied.
Fiber and Integrated Optics	**3**	**1**	Basic information about the principles of light propagation through optical fibers and waveguides is presented. Inter-modal and material dispersions in fibers are analyzed, as well as their influence onto the rate of data transfer via fiber-optical communication lines (FOCL). Waveguide connectors, including the grating and prism type ones, are described. Two- channel directed splitters and other elements of integrated optics are considered as well as their use in FOCL. The means and methods of time and spectral multiplexing are analyzed. The course describes modern schemes of FOCL architecture. Diode light sources for FOCL applications are discussed and in addition, the fiber-optical sensors of various nature.
Optical Methods of Information Processing and Transmission	**3**	**1**	The course covers the basic information about the principles of fiber-optic information transmission systems. Intermode and material dispersions in fibers are analyzed. Information on the elements of communication between waveguides, including lattice and prismatic communication elements, is given. Two-channel directional couplers and other elements of fiber-optic transmission systems are considered.
Academic Internship	**9**	**1**	
Social Communication in Professional Environment	**2**	**2**	The aim of the course is to discuss some important problems of theory and practice interpersonal communication in business environment. The following issues are discussed in the course: situational and psychological factors of interpersonal communication, verbal and nonverbal practices of communication, active listening, specific ways of interpersonal pressure, influence and manipulation, emotional management, types of corporate culture and teambuilding.
Modern Problems of Electronics and Microprocessor Systems in Instrument Making	**3**	**2**	Construction of modern control and data processing systems based on programmable electronic circuits and microprocessor technology. Students study the modern tools of developing and debugging digital circuits, methods of hardware implementation of digital data processing systems.

COURSE	ECTS	SEMESTER	DESCRIPTION
Laser Systems	**4**	**2**	The course covers physical fundamentals and design of modern laser systems. Requirements to laser systems, used in science and industry, are analyzed. Main characteristics and technical features of laser systems are presented. Applications of laser systems in industry, environmental monitoring, optical communication and biomedicine are discussed.
Optoelectronics	**4**	**2**	The course provides the theoretical background of passive optoelectronic devices. We consider the main components of such devices like light sources and sensors, the basics of photometry, the photo receivers' performance as well as the basics of evaluation of signal and noise amplitudes at the photo receiver output. Special attention is paid to the practical implementation of the theoretical information.
Special Issues in the Design of Safe Instrumentation	**3**	**2**	The course studies general technical issues of integrated safety, containing the concept, design and construction principles, and general aspects that can be applied to instrumentation and systems of all kinds. The main focus is on testing requirements for safety performance at all stages of the product life cycle. The issues related to the features of instrumental systems from the point of view of the risk of injury to a person by electric shock, fire and explosion safety, electromagnetic compatibility, protection against mechanical and climatic influences, ergonomic and engineering and psychological requirements, requirements for vibroacoustic factors in accordance with state standards and technical regulations on these issues.
Local Measurement and Calculation Systems	**4**	**2**	Modern local measurement and calculation systems are complex programmable structures that provide state control, analysis of characteristics, modeling and forecasting of local and distributed objects and processes. The architecture of building local measurement and calculation systems is completely determined by the selected instrument interface and the functionality of the measuring instruments. The discipline discusses in detail the issues of organizing the main types of modern interfaces and the principles of building local measurement and calculation systems based on them; the principles of constructing programmable measuring devices and their inclusion in the system are considered. Special attention is paid to the principles of constructing measurement and calculation devices as an important promising class of measuring transducers. The questions of the structural organization of local measurement and calculation systems are considered.

COURSE	ECTS	SEMESTER	DESCRIPTION
Computer Aided Design and Design of Devices and Systems	**4**	**3**	The goal of the course is to form a complex of knowledge, skills and abilities in the development of instrumentation designs based on technical ergonomic, aesthetic and economic criteria and the preparation of drawing and design documentation in an automated design system. The content of the discipline includes the following sections: the structure of the automated design system and its individual subsystems, graphic languages, graphic dialog systems, the structure and formation of databases, including graphic ones, design of instrumentation structures.
Laser and Fiber Optic Technologies in Navigation Systems	**3**	**3**	The subject of the course is the study of fundamentals and main types of optical gyros, based upon the use of quantum electronics and waveguide technologies – namely, of laser and fiber optical gyros, as well as of the systems, providing technique implementation in the measuring apparatus, in the inertial navigation and movement control systems.
Laser Radiation Control	**4**	**3**	The course presents the physical background of the devices, providing laser beam control and transformation. We consider the light polarization rotation and the basics of nonreciprocal devices on their basis; the nonlinear optical methods and devices for radiation frequency conversion. The course also presents the information about the light scattering, including the stimulated one and about the wave front transformation and correction by means of adaptive optics and holography.
Laser Measuring Systems	**5**	**3**	The course is devoted to the physical background and principles of design of the laser measuring systems for evaluation of movement parameters like linear and angular movement, speed and acceleration. We consider the schemes and performance principles of modern laser measurement systems. Special attention is paid to the accuracy of such systems and to their efficiency improvement. The tendencies of technique development are considered.
Interdisciplinary Project "Development and Design of Laser Measuring Instruments and Systems"	**3**	**3**	An interdisciplinary project is a form of independent work and is aimed at consolidating knowledge and skills in the course studied, mainly the variable part of the curriculum, acquiring the skills of independent solution of theoretical and practical engineering problems, the formation of competencies for successful professional activity in the field of instrumentation. The subject of the interdisciplinary project is determined by the goals and objectives of training masters in the program Laser Measuring Technologies.

COURSE	ECTS	SEMESTER	DESCRIPTION
Network Technologies in Information and Measurement Systems	**3**	**3**	Data transmission in information-measuring systems with an increase in the speed and cost of the element base and an increase in the bandwidth of channels is switching to the use of general-purpose protocols and technologies. High speed of modern computing networks eliminates, in most cases, the development of specialized data transmission systems. These general-purpose protocols are the protocols of the TCP/IP family, which are widely implemented by manufacturers in industrial controllers, and support for which exists in all operating systems of computers. In this regard, the overwhelming majority of information measuring systems uses TCP/IP protocols in one way or another. The subject of the discipline is the functioning of local and global computer networks based on the protocols of the TCP/IP family. Various protocols of this family and their interconnection whichprovide data transfer between network subscribers are considered. The examination takes place at a very detailed level in order to form an adequate understanding of the processes occurring when sendingand receiving data. The formed understanding of TCP / IP networks allows one to assess their inherent limitations and specifics and to achieve the required characteristics from the network layer in the development of information and measurement systems.
Internship (Research Project)	**9**	**3**	
Pre-degree Internship	**21**	**4**	
Master's Thesis Defense	**9**	**4**	

6. RENEWABLE SOLAR ENERGY

The program focuses on the latest trends in the field of renewable energy and photovoltaics. Students get acquainted with underlying physical principals and materials science aspects of photovoltaics, solar module manufacturing technology, the equipment involved in design and maintenance of solar power plants. The curriculum pays special attention to the newest solar cell production technique – HIT (Heterojunction with Intrinsic Thin layer). The curriculum also includes basic, specialized and comprehensive courses. The program has been independently certified and awarded the EUR-ACE® label by the European Network for Accreditation of Engineering Education (ENAEE).

COURSE	ECTS	SEMESTER	DESCRIPTION
Renewable Energy Sources	**5**	**1**	Renewable energy sources use the energy of the sun, wind, rivers, sea tide, peat, forest and geothermal wells. These sources do not add CO2 to the atmosphere, unlike fossil – coal, oil, gas. There are two exceptions to this rule: 1) forest and peat are considered renewable due to the short- term conservation of CO2, which does not violate its balance on geological scales, 2) nuclear energyis classified as a fossil, since it affects the isotopic composition land on this scale. The course "Renewable energy sources" contains the following topics: renewable energy sources; solar energy perspectives; photovoltaic solar energy converters classification; the main materials of photovoltaic solar energy converters; principle of operation, design and characteristics of photovoltaic solar energyconverters. Real photovoltaic solar energy converters parameters; energy loss in the solar cell; technology fundamentals for the formation of thin-film solar cells on the basis of thin films of various materials; features of photovoltaic solar energy converters based on aSi:H; the main directions of increasing the efficiency of photovoltaic solar energy converters.
Solar Energy Materials	**4**	**1**	The course includes main branches of Condensed Matter Physics and Solid State Optics. The main points of the theory of electronic spectra of solids are discussed, along with the basics of the theory of radiation interaction with matter. The light absorption, reflective, refractive and other physical phenomena, which determine the optical properties of crystalline, disordered semiconductors and conjugated organics systems are considered. Special attention is paid to physical interpretation of studied phenomena, theoretical description and the most important experimental facts. Moreover, the novel approaches to use the nano- and bio-objects are considered to make the optimization of the body and the surfaces of the materials used in the general optoelectronics.

COURSE	ECTS	SEMESTER	DESCRIPTION
Russian as a Foreign Language	**2**	**1, 2, 3**	The program is aimed at foreign students with no prior knowledge of the Russian language. The course includes language and speech models based on the requirements for the Elementary certification level. Achieving this level in Russian will satisfy the students' basic communicative demands imposed on him/her by the social, cultural and university life. The course provides students with the opportunity to master a set of instrumental competences and linguistic knowledge (the Russian language is the most important), which allows students to organize their speech in the communication process. The content of the program involves implementation of flexible training models, depending on the communicative purposes, native language and students' personality.
Diagnostics of Solar Energy Materials and Structures	**5**	**1**	The course is devoted to modern techniques and methods of diagnostics and characterization of materials and structures in micro- and optoelectronics. The main techniques used within the micro- and optoelectronics are explained. In particular, the subject is focused on the most widely used techniques such as charge-based and probe methods, as well as chemical and physical methods
Computer Technology and Simulation in Electronics	**3**	**1**	A number of software packages are available to simulate electronics devices at the present time: Synopsys Sentaurus TCAD, FlexPDE, MathCAD. With simulation, it is possible to quickly find out the effect of parameters devices on the electronics devices performance, and some of the time-consuming and expensive prototyping steps can be avoided.
Foundations of Scientific Research	**2**	**1**	This course in a general scientific cycle is comprehensive for Master's education. The purpose of the course is to acquaint the Master's students with the structure of scientific knowledge, methods of scientific research, with functions of scientific theories and laws, broadening their world outlook; as well as criteria, requirements and results of research.
Optical Systems and Components	**4**	**1**	The course presents the basic knowledge about the design, principles, calculation and adjustment of various optical systems. Main types of optical systems (telescopes, microscopes, photographic lenses etc.), their special features and general properties are presented. Basic understanding of optical image theory and aberrations is provided. The course also considers main types of the non-imaging optical systems like illumination systems, projectors, various types of interferometers, and basics of optical photometry are explained. In addition, the course presents basic knowledge about optical material science viewpoint of optical-physical and physical-chemical properties used in laser technology, both traditional and non-traditional optical materials. It also contains basic information on the processes of manufacture and control of standard optical components and considers normalized basic parameters of optical materials and technological bases of their production.

COURSE	ECTS	SEMESTER	DESCRIPTION
Academic Internship (Research Project)	**9**	**1**	
Micro- and Nanotechnology Processes	**4**	**2**	The course introduces materials deposition, etch and modifying methods at micro- and nanolevel used in solid electronics and integrated circuit components forming. Base processes and equipment used in conventional microtechnology and specific processes, permissive to form structures on molecular level and based on self-organization, selectivity, anisotropy abilities and matrices principle are studied. Discipline concludes lectures, practices and laboratories, self-dependent student's work, including individual tasks and interdiscipline course project
Microprocessor Techniques	**4**	**2**	Main objective of the course is to study modern microprocessor families, microcontroller devices construction principles and microprocessor devices programming. The students learn about the components of the microprocessor systems; learn how to use cross-compilers for the software development in C programming language. Laboratory bench including modern high-efficiency ARM microcontroller and various input/output peripherals is used in the discipline lessons and laboratory practice
Commercialization of Results of Scientific Research and Development	**2**	**2**	Commercialization of the research work results is the process of involving them in the economic (commercial) turnover in order to ensure the innovative development of the national and international economy. The relevance of this discipline is due to the need to modernize the economy in the context of changing the existing technological structure based on the realization of the potential of high-tech branches of science and technology, including the Digital Economy program. The development and implementation of the research work results in the economic activities of organizations and enterprises is one of the key success factors for economic transformations. The implementation of the tasks of innovative development requires a qualified and competent assessment of the economic efficiency of projects focused on the production of high-tech products and the promotion of new technologies. The main goal of this discipline is to form a complex of knowledge, skills and practical skills of developing a business plan for the commercialization of innovative ideas in the form of creating new or improved types of products, goods, works and services studied in the course of R &D undergraduates. Mastering a phased methodology for business planning and design of various innovative projects will ensure the acquisition of competencies required in solving the problems of outputting the results to sales markets and assessing their economic efficiency.

COURSE	ECTS	SEMESTER	DESCRIPTION
Foreign Economic Activity of Organizations	**2**	**2**	The expansion of foreign economic relations is a necessary prerequisite for the effective organization and reproduction of any macroeconomic system. This problem is particularly relevant in the current conditions of globalization and geopolitical instability. The purpose of the course Foreign Economic Activity of an Organization is to provide future theoretical and practical knowledge in the field of organization, management and legal norms of international business in the context of Russian and world practice. The main task of the course is to arm master students with practical skills and modern methods of working in foreign markets. The course includes consideration of a wide range of issues related to the legal, organizational and practical plane of conducting foreign economic activity by Russian and foreign companies. The method of studying the course is based on a combination of lectures, seminars and practical exercises.
Optics and Optical Measurements in Solar Energy	**3**	**2**	The course covers basic optical and spectroscopic methods, techniques and equipment such as light photometry, UV/Vis spectrometry, Fourier transform infrared spectrometry, Raman spectroscopy, ellipsometry and interferometry, which are widely used in the diagnostics of materials and thin film structures of solar photovoltaics. The course also includes an introductory part dedicated to the fundamentals of geometrical and wave optics, laboratory workshops and seminars.
Metrology of Solar Cells and Modules	**3**	**2**	The following will be considered during the study of this course: Sunlight, its Characteristics where the sunlight characteristics and methods of indoor light parameters modeling, also a quality monitoring of parameters of sunlight will be considered. 5 Reference Solar Cells and their Design. The section is devoted to design of reference solar cells, ways of their calibration. Spectral Characteristics of Solar Cells. In the given section techniques and the equipment for spectral characteristics measurement of thin-film solar cells, including multijunction cells are presented. Current-Voltage Characteristics of Solar Cells. The section acquaints with techniques and the equipment for measurement of the current-voltage characteristics of solar cells and solar modules, as well as specific features of tandem thin-film solar cells modules current-voltage characteristics. The Photoinduced Degradation of Solar Cells. The section acquaints with problems of the photoinduced degradation of thin-film solar cells and its characterization methods.
Laser Systems	**4**	**2**	The course contains information about physical fundamentals and design of modern laser systems. Requirements to laser systems, used in science and industry, are analyzed. Main characteristics and technical features of laser systems are presented. Applications of laser systems in industry, environmental monitoring, optical communication and biomedicine are discussed.
Internship (Research Project)	**12**	**2**	

COURSE	ECTS	SEMESTER	DESCRIPTION
Problems of Modern Electronics	**4**	**3**	The main purpose of the course is to introduce the latest trendsand achievements in various promising fields of electronics. Studying of the discipline is reinforced by practical exercises aimed at acquiring the 3 appropriate skills for formulating and solvingproblems when creating new components and technologies for nanoelectronics.
Interdisciplinary Project "Design, Technology and Metrology of Solar Cells and Modules"	**3**	**3**	The interdisciplinary project (TIR) solves the problems of calculation, computer simulation, design, production technology and metrology of thin film solar energy converters made of polycrystalline (amorphous) silicon, based on the knowledge and skills acquired by students in the process of learning at least two related disciplines of the master program Renewable Energy which are studied in 1-3 semesters.
Technology of Solar Cells and Modules	**4**	**3**	The study of the subject includes the following questions: Prospects of solar energy. Classification of the photoelectric converters of solar energy. Basics of silicon thin-film solar modules production. Main steps of silicon micromorph solar modules production. Quality of gases and materials used for silicon micromorph silicon solar modules production. Basic procedures of fabrication of micromorph silicon solar modules. Substrate choice and preparation procedure. Deposition process of transparent conductive ZnO layer. Laser scribing. Deposition of photoactive absorbing amorphous and microcrystalline hydrogenated silicon layers. Back-end process: contacts application, edge isolation, lamination process, junction box assembly. Main trends of research for thin-film silicon photoelectric solar energy con-verters. Production lines for silicon based thin film solar modules. High-tech equipment used in silicon based thin film solar modules production.
Laser Technologies in Manufacturing of Solar Modules	**4**	**3**	The description of work program contains information on physical fundamentals of laser technologies and architecture of industrial lasers. The requirements for lasers for microprocessing of materials are analyzed. Their main output parameters and features of operation are given. Case studies on applications of lasers for industrial processing of materials (mainly in microelectronics) are described. Separated part is dedicated to use of lasers in manufacturing the thin-film solar panels.
Multijunction Solar Cells Based on AIII–BV Compounds	**4**	**3**	The following subjects will be considered during the study of this discipline: Band-gap structure of the materials for solar photovoltaics. Formation of the I-V curves of the one-junction and multijunction solar cells, their modification under illumination, connection with basic properties of the semiconductor material. Practical approaches to minimization of the optical, recombination and ohmic losses in solar cells. Principles of design and practical use of the concentrator solar cells. Reliability and life time of the solar cells and photovoltaic systems. Perspectives of the solar photovoltaics.

COURSE	ECTS	SEMESTER	DESCRIPTION
Solar Hybrid Power Systems	**4**	**3**	The main types of solar hybrid power stations are discussed, and an overview of their most important parameters and characteristics is provided. Requirements for solar cells, wind power generators, energy storage systems, backup diesel-generators and other elements of hybrid power stations are considered. The basic principles of solar hybrid power stations design and operation are considered
Equipment and Automation of Solar Power Stations	**4**	**3**	The working program is devoted to studying of the equipment of solar power stations. Photovoltaic modules only represent the basic element of a solar power system. They work only in conjunction with complementary components, such as batteries, inverters, and transformers. Power distribution panels and metering complete the energy conversion process. In the working program characteristics of the equipment of solar power stations are resulted.
Energy Storage	**4**	**3**	The course focused on the characteristics and principles of operation of various types of electric energy storage devices used in renewable energy. Particular attention is paid to electric batteries of various systems and supercapacitors, the positive and negative aspects of their use, current trends in production and use. Also considered are hydraulic accumulators, electrical energy storage devices based on compressed air and kinetic storage devices (flywheels)
Hydrogen Energy	**4**	**3**	The course focused on various aspects of the development of hydrogen energy, among others, the main methods for producing, storing, transporting hydrogen, hydrogen safety. Particular attention is paid to the production of hydrogen using energy obtained from solar modules and other renewable sources. The main types and structures of fuel cells, including solid polymer, solid oxide, melt-carbonate and phosphoric acid and alkaline fuel cells are considered.
Internship (Research Project)	**9**	**3**	
Pre-degree Internship	**21**	**4**	
Master's Thesis Defense	**9**	**4**	

7. RF, MICROWAVE AND TERAHERTZ ENGINEERING OF WIRELESS SYSTEMS

The program is to train students who will manage successfully professional activity in a globally competitive environment in such an interdisciplinary field as design and technology of the state-of-the-art high-frequency, microwave, and terahertz devices for communications, radar, and other wireless applications.

COURSE	ECTS	Semester	DESCRIPTION
Russian as a Foreign Language	**2**	**1, 2, 3**	The program is aimed at foreign students with no prior knowledge of the Russian language. The course includes language and speech models based on the requirements for the Elementary certification level. Achieving this level in Russian will satisfy the students' basic communicative demands imposed on him/her by the social, cultural and university life. The course provides students with the opportunity to master a set of instrumental competences and linguistic knowledge (the Russian language is the most important), which allows students to organize their speech in the communication process. The content of the program involves implementation of flexible training models, depending on the communicative purposes, native language and students' personality.
Project Management	**2**	**1**	The course is the base for the disciplines of the professional cycle of the educational program and is designed to prepare masters who will manage innovative projects and relevant departments of organizations in the digital economy. The subject of its study is the project as a process and object of management; methods and technologies of selection of projects for implementationtaking into account the main organizational and commercial risks; methods and technologies of planning and project management and existing domestic and international standards in this area; methods of calculating the cost and determining the price of the project using modern pricing models; methods of assessing and managing the competitiveness of the product being created; methods and sources of projectfinancing; commercialization of the results of project activities, taking into account cost-effectiveness estimates.
Foundations of Micro and Nanotechnology for Radioelectronics	**5**	**1**	The main features of micro- and nanostructured materials used in radio electronics are studied on the basis of modern concepts of nanophysics and nanochemistry. The main technological processes of the formation of micro- and nanostructures, modern and promising control and measurement technologies, methods for quantitative and qualitative analysis of nanoscale structures are considered.

COURSE	ECTS	Semester	DESCRIPTION
Computational Electromagnetics	**5**	**1**	The course involves the study of physical bases and principles of numerical modeling of various microwave devices and antennas using finite-difference methods in the time and frequency domain, method of moments for wire and plane-layered structures, as well as using the mode-matching applied to the waveguide structures. 2 Various forms of writing boundary conditions for boundary problems of electrodynamics, algorithms for generating vector electric and magnetic fields values by the Lorentz potentials are considered.
Introduction to Wireless Systems	**5**	**1**	Studying the course, students learn physical foundations and design principles of wireless systems for data and energy transmission, gain an impression on main types of such systems, their evolution, applications, and future trends.
Basics of Antenna Design	**5**	**1**	In the course, the classification of antennas is given, their main characteristics are considered: the radiation pattern (RP), the width of the RP, the far and near antenna zones, the antenna input impedance, the directivity factor, the radiation resistance, the bandwidth, the gain factor, the efficiency. The basic types of antennas are considered: dipole, monopole, loop and printed antennas. The concept of phased array antennas (PhAA) is given. The lectures use the latest advances in the development and application of antennas in the field of wireless microwave systems. The practical study is aimed to obtain basic skills in the design of antennas for communication systems.
Modern Problems of Radioelectronics	**2**	**1**	The course aims to acquaint students with modern achievements in the field of radio engineering and radio electronics in various areas: signal processing devices and navigation systems; microwave technology, antennas and devices; radio systems; laser technology in electronics; information satellite systems and technologies; telecommunications and intelligent networks; data transmission and protection in information systems; semiconductor electronics and nanoelectronic; design and technology of electronic means; biomedical electronics; functional materials of micro- and nanoelectronics.
Academic Internship (Research Project)	**6**	**1**	
Foundations of Scientific Research	**2**	**1**	This course in a general scientific cycle is comprehensive for Master's education. The purpose of the course is to acquaint the Master's students with the structure of scientific knowledge, methods of scientific research, with functions of scientific theories and laws, broadening their world outlook; as well as criteria, requirements and results of research.

COURSE	ECTS	Semester	DESCRIPTION
Computer Technologies of End-to-End Design	**5**	**2**	The course includes methods and techniques to design radioelectronic functional units based on modern information technologies of the end-to-end design as well as CAD/CAM complexes using these methods and technologies.
Infocommunication Networks	**5**	**2**	On the basis of a tiered approach to the construction of open systems, the following is considered: seven-layer Open Systems Interconnection model, especially the physical realization of network communication, transmission and reception of data by means of the data link layer, local area network, the network layer as a means of building a large network, wireless network technology. In the course, thefollowing is studied: the functional layers of the communication process; functional-functional means of establishing, maintaining and disconnecting physical connections; the physical layer; data transfer protocols; routing and retransmission, multiplexing network connection, segmentation and consolidation; methods of transmission is given on the communication lines; typical network topology; 3 communication devices; structure of local networking standards; switching methods; implementation of interworking; domain name system; WANs
Passive Microwave Components and Devices	**5**	**2**	Studying the course is intended to familiarize students with microwave integrated circuit components, design principles and applications of passive microwave devices. 5 Besides, it allows students to master basic practical skills in the design of microwave integrated circuits.
Wireless Communication Systems	**5**	**2**	The basic principles of mobile communication systems, the features of the radio channel and the resulting limitations on the characteristics of wireless communication systems, estimation of the radio link budget, the features of propagation of radio waves on typical transmission paths, the structure and basic characteristics of mobile communication systems are considered.
Internship (Research Project)	**6**	**2**	
CAD of Microwave Devices and Systems	**6**	**3**	The course is devoted to the modern of computer-aided of microwave devices and system. The important aspects of building receiver and transmitter models as the system level are considered. A special attention is paid at the design of microwave devices such as low noise amplifiers, oscillators, mixers, filters, antennas etc. The basic principles of designing microwave devices on microstrip transmission lines, which are suitable for computer-aided manufacturing by means of the printed circuit board and hybrid integrated circuit technologies, are studied. Design of filters, diplexers and power dividers is considered. While studying the course, the students learn consequentially the full cycle of electronic device design and realization from the target specification to release for production.

COURSE	ECTS	Semester	DESCRIPTION
Active Microwave Devices	**6**	**3**	The course is focused on the basics of designing active devices such as microwave low-noise amplifiers, power amplifiers, and oscillators. Also, attention is paid to active elements and technologies providing improved performance, mass production and miniaturization of the devices. Practical study is aimed at obtaining elementary skills in designing devices used in receiver and transmitter microwave modules of communication systems.
Introduction to Microwave Measurements	**4**	**3**	When studying the course, students learn about methods to measure main characteristics of passive and active microwave devices as well as antennas. They master skills of practical work with the state-of-the-art measurement equipment. The course comprises basics of power measurement, scattering parameters and noise figure measurements of microwave devices as well as measurement of antenna characteristics, signal spectrum analysis and measurement of the dielectric material parameters at microwaves.
Metamaterials for Microwave and THz Applications	**6**	**3**	In the course, students study the main properties of metamaterials (artificial electromagnetic structures) designed for practical applications in microwave and THz 6 frequency range. The most important properties of metamaterials due to their lefthandedness are used for a design of microwave devices with improved performance and enlarged functionality. The following devices are under considerations: resonators and filters based on a combination of transmission lines with negative and positive dispersion, high impedance surfaces, multi-band passive devices, tunable devices, photonic band-gap metamaterials. The practical study focuses on obtaining basic skills for designing devices that are used in receiving modules of communication systems: miniature passive microwave devices, screening structures, printed antennas etc.
Microwave Devices of Telecommunication Systems	**6**	**3**	The course covers the design basics of microwave devices used in modern wireless communication systems. Practical exercises allow students to get the basic skills of designing miniature passive microwave devices, low-noise transistor amplifiers, power amplifiers, oscillators, and printed antennas.
Scientific Workshop	**2**	**3**	
Internship (Research Project)	**6**	**3**	
Pre-degree Internship	**21**	**4**	
Master's Thesis Defense	**9**	**4**	

8. SYSTEMS AND TECHNOLOGIES IN DIGITAL HEALTHCARE (IN THE FIELD OF BIOMEDICAL ENGINEERING)

The program produces biomedical engineering experts who are able to use modern information, telecommunication and computer technologies to monitor and control the condition of chronically ill outpatients remotely. The graduates are also able to find out in real time if chronic diseases have exacerbated, input information on chronic disease exacerbation and condition changes of treated patients into databases.

COURSE	ECTS	Semester	DESCRIPTION
Russian as a Foreign Language	**2**	**1, 2, 3**	The program is aimed at foreign students with no prior knowledge of the Russian language. The course includes language and speech models based on the requirements for the Elementary certification level. Achieving this level in Russian will satisfy the students' basic communicative demands imposed on him/her by the social, cultural and university life. The course provides students with the opportunity to master a set of instrumental competences and linguistic knowledge (the Russian language is the most important), which allows students to organize their speech in the communication process. The content of the program involves implementation of flexible training models, depending on the communicative purposes, native language and students' personality.
Social Communication in a Professional Environment	**2**	**1**	The main objective of the course is to develop the ability of students to critical analysis of specific communicative practices and situations of interpersonal interaction and also management skills of communicative behavior in the business interaction. Specific topics are focused on basic communication skills in a business environment, techniques of group management and of making group decisions, the rules of business written communication and business telephone communication.
Methods of Computer Processing and Analysis of Medical and Biological Data	**4**	**1**	The course covers the main aspects of biomedical data analysis. Special attention is paid to the machine learning methods. Different approaches to solving classification problems (linear Fisher discriminant, logistic regression, k-nearest neighbors method, support vector machine, decision trees) and clustering (DBSCAN method, k-means, hierarchical clustering), reduction of space dimension (principal component method) are being discussed as well as determination of significant features (selection algorithms). At the practical classes, students work in the MATLAB software environment, implement the analysis methods which have discussed on the lectures and become familiar with the data visualization approaches.

COURSE	ECTS	Semester	DESCRIPTION
Monitoring Systems in Digital Healthcare	**5**	**1**	After finishing the course, students will get basic knowledgeof the main biomedical signals used to assess the current health state of a person in telemedicine monitoring systems, such as electrocardiogram, pulse wave, blood pressure, respiration rate and others. In practical classes, students will study basic set of sensors for the registration of biomedical signals, current trends and approaches to the instrumental support of systems for remote monitoring in digital healthcare. During laboratory works, students will gain practical skills in registering signals using a modern Biopac Student Lab system, an integrated life science teaching solution that includes hardware, software and curriculum materials that students use in undergraduate laboratories to record and process data from their own bodies.
Telemedicine Systems and Technologies	**4**	**1**	The purpose of the course is acquaint student with methodology and basic principles of development of telemedicine systems for remote diagnostics and treatment. The main classes of telemedicine systems and tasks solved them; generalized structures and variants of development of systems for diagnostics and treatment of patients with chronicle diseases, problems of autonomy, continuous operation, and reliability of diagnostics and prognostics of the diseases exacerbation are considered.
Bases of Management and Marketing at Medical Industry Enterprise	**3**	**1**	The course is intended for students studying in medicine and technology. The course covers issues related to planning and managing the marketing activities of an enterprise, in particular: themarketing concept, types of marketing research, methods for assessing the competitiveness of high-tech products, pricing techniques, components of the demand generation and sales promotion system and the main types and categories of services in medical and technical enterprises profile. The system of development and introduction of medical devices, the procedure for registration of medical devices in theRussian Federation and the Eurasian Union, as well as the main directions of foreign economic activity enterprises are considered.
Motion Analysis Systems and Technologies	**4**	**1**	This is an introductory course in movement and gait analysis. It will help students to learn modern technologies for movement analysis using: optical motion capture systems, Inertial Measurement Units, EMG systems, force platforms, plantar pressure measurement and others. The main aim of this course is to introduce students to the techniques and methods of gait analysis and give them knowledge and tools to solve biomechanical problems, robotics, to improve rehabilitation techniques, research and treatments programs for people with different disabilities of the musculoskeletal system. Successful completion of this course will enable the student to acquire advanced knowledge of biomechanical mechanisms of human gait and to develop experience in the use of selected biomechanical measurements and analysis methods such as kinematic, kinetic, plantar pressures analysis, and joint modelling.

COURSE	ECTS	Semester	DESCRIPTION
Design of Digital Medical Systems	**4**	**1**	The course provides professional training in the design of diagnostic and therapeutic biomedical electronic systems using modern computer-aided design systems, such as MicroCap and Altium Designer. The main methods of finding technical solutions in the design of electronic systems designedto solve various practical problems are mentioned. The general theoretical and methodological information presented in the course of lectures is illustrated with specific examples and techniques for designing, calculating and simulating real modern diagnostic electronic systems. This discipline serves asthe foundation for the formation of a scientific and engineering approach in the field of design and industrial production of new and development of existing biomedical systems, and helps to form in the student the skills of a systems approach to solving complex engineering problems.
Internship (Research Project)	**6**	**1**	
Commercialization of Results of Scientific Research and Development	**2**	**2**	Commercialization of the research work results is the process of involving them in the economic (commercial) turnover in order to ensure the innovative development of the national and international economy. The relevance of this discipline is due to the need to modernize the economy in the context of changing the existing technological structure based on the realization of the potential of high-tech branches of science and technology, including the Digital Economy program. The development and implementation of the research work results in the economic activities of organizations and enterprises is one of the key success factors for economic transformations. The main goal of this discipline is to form acomplex of knowledge, skills and practical skills of developing a business plan for the commercializationof innovative ideas in the form of creating new or improved types of products, goods, works and servicesstudied in the course of R & D undergraduates. Mastering a phased methodology for business planning and design of various innovative projects will ensure the acquisition of competencies required in solving the problems of outputting the results to sales markets and assessing their economic efficiency.
Modern Problems of Biomedical Engineering	**3**	**2**	The course is intended for students studying in medicine and technology. This course introduces students with the current problems and the most promising areas of biomedical engineering. In particular, the issues of application of nanotechnology in medicine, various types of medical robots, modern X-ray techniques, telemedicine, systems for contactless recording of human physiological indicators are considered. The study of the discipline will allow future masters to more freely navigate the main problems of basic and applied research in the field of biomedical engineering, to identify its promising areas and practical applications.

COURSE	ECTS	Semester	DESCRIPTION
Automated Analysis of Images	**4**	**2**	The course is devoted to study of the images analysis and processing problems. The problems of automated analysis and digital images processing, methods and software are discussed. The course is focused on analysis and processing of biomedical images. The issue of images forming by using of different converters and optical systems are studied. The attention is focused at the image transformation and processing at the visual system. The problem of development of automated images analysis is discussed. Received theoretical knowledge is reinforced by the implementation of the automated images analysis methods at the laboratory lessons.
Automation of Biomedical Research	**4**	**2**	This course provides professional training in the fields of bioengineering systems and human control systems. It covers innovative technologies, which are used for automation of biomedical research as well as basic principles of systems construction that implement these technologies. The course examines the problems taking place during synthesis of this kind of systems, and in the course of their methodical, informational and instrumental support. The theoretical aspects of the automated research systems development are supplemented by the practical aspects of their application. The course is important for the development of the professional competence of the specialists involved in the design and use of the technical tools for the biomedical research automation.
Simulation on Bioengineering Systems	**3**	**2**	The course is dedicated to modeling in biomedical engineering and is aimed on providing advanced knowledge and experience in applying mathematical apparatus for different applications in medical and technical sciences. The course contains fundamental knowledge on modeling and system theory along with practical aspects for each topic provided in the course program. Learning materials covers a broad range of data-driven and theoretical models, including models based on differential equations, finite-state machines, Markov chains, queueing systems, Petri nets and time series among others. The course is supplemented with laboratory works dedicated to aspects of data-driven modeling in MATLAB, Simulink and R.
Special Aspects of Designing for Safe Device Techniques	**3**	**2**	The course is devoted to the general technical aspects of complex safety, which contain concept, principles of design and construction, which can be used for all device technologies and systems. Primary attention is paid to the requirements for the tests according to the standards of safety at the all stages of the life cycle. Special features of device systems are examined from the potential danger point of view, created by electric current, fire and explosion, electromagnetic fields, mechanical, climatic actions and human factors.

COURSE	ECTS	Semester	DESCRIPTION
Laser Systems	**4**	**2**	The course contains information about physical fundamentals and design of modern laser systems. The requirements to laser systems, used in science and industry, are analyzed. The main characteristics and technical features of laser systems are presented. Applications of laser systems in industry, environmental monitoring, optical communication and biomedicine are discussed.
History of Bioengineering Systems	**2**	**2**	The course provides the history and backgrounds of biomedical engineeringsystems. The main ways and stages of such system's evolution from the apparatus for electro physiological signals registration and processing to modern telemedical systems for diagnostics, monitoring and control of the patients health state, fulfillment of the minimally invasive and laparoscopy surgical operation, transplantation of the organs, NBIC systems improving the health care quality are considered.
Internship (Research Project)	**6**	**2**	
Bioengineering Systems and Technologies	**4**	**3**	The course covers the methodology and basic principles of biomedical engineering systems development, problems of modeling, synthesis and research of biomedical engineering systems, development of the generalized system's structure, research of biomedical engineering system's information interaction and control channels, structures of the information and methodical support, hardware, software and metrological support for biomedical engineering systems development, forming of professional skills and competencies for biomedical engineering systems synthesis for diagnostics and patient's disorders treatment, patient's health control, monitoring and prediction.
Interdisciplinary Project "Development of Monitoring System for Outpatients with Chronic Diseases"	**3**	**3**	The purpose of the course is to organize, enhance and broaden the theoretical and practical knowledge of students, applying the knowledge to solve particular scientific and engineering problems of system development for patient's health remote monitoring with chronic diseases. During the interdisciplinary project students develop and design the structure and elements of the remote monitoring system, form the ability for self-review and achievement of goals, form the skills for practical use of knowledge and ability to develop remote monitoring systems.

COURSE	ECTS	Semester	DESCRIPTION
Information systems in Digital Healthcare		**3**	Health information technology is becoming an integral part of our healthcare system and is invaluable to both treating patients and evaluating treatment parctices of any national health system of any country. Implementation of more advanced technologies has: greatly improved the quality of health services and patient healthcare, reducing the cost of health and care services. Health care information systems can give patients more control over their health, reduce the administrative burden for care professionals, improve clinical outcomes, enhance decision support, enable accurate reporting of data, improve the security of information (hard copies and electronic systems) as well as improve patient's access to information support, the development of new treatments and medicines. This Masters' level course introduces the fundamentals of information systems used for: managerial and clinical support in healthcare; benchmarking compared to healthcare systems in other countries; electronic health records and the use of medical databases; further exploration of medical databases and manipulation for decision support including evidence-based practice. Students will learn how to use medical databases, store and use statistical tools such as IBM SPSS statistics and IMB SPSS Modeler for evidence-based clinical research. The course has been designed to give both theoretical and practical knowledge.
Maintenance and Repair of Modern Medical Equipment		**3**	The course deals with the installation, commissioning, control of the technical condition, periodic and routine maintenance, repair of medical equipment. After studying the basic principles and legislative issues, the specifics of the implementation of the declared processes are considered in relation to certain types of medical equipment: X-ray, computed tomography scanners, ultrasound scanners, anesthetic, resuscitation devices, disinfection equipment, laboratory equipment, functional diagnostic equipment etc. During practical classes, students envelop plans for technical maintenance and perform tasks of finding and eliminating of typical malfunctions.
Advanced Methods and Tools for Biomedical Data Analysis		**3**	The course includes studying and analyzing basic machine learning algorithms with an emphasis on their mathematical description and specific properties of biomedical datasets. The issues of data preparation, selection of significant features, variance analysis, decision trees and forests, neural networks and Big Data technologies are discussed. In practical and laboratory classes, students learn to apply theoretical knowledge to practical problems of biomedical data analysis using Python programming language. Specialized mathematical Python modules, which are mandatory for modern specialists in the field of data analysis, are studied. The course is aimed at students who are familiar with the basics of statistics and data analysis methods.

COURSE	ECTS	Semester	DESCRIPTION
Internship (Research Project)	**12**	**3**	
Pre-Graduation Internship	**21**	**4**	
Master's Thesis Defense	**9**	**4**	

9. TECHNOLOGY INNOVATION MANAGEMENT

The program is intended for graduates of engineering and management departments who would like to work on their innovation, technology and engineering skills. Master's students learn the basics of project management, marketing and innovative activity. Students also learn how to manage innovations in a business and implement new technologies in resource management of a knowledge-intensive manufacturing company.

The program provides students with international-level education which is crucial in the era of digital economy. After graduation students can be hired by leading world technology companies.

COURSE	ECTS	Semester	DESCRIPTION
Business English	**3**	**1**	Business English is a part of the major courses in Master-level program. This course is aimed at acquiring English language skills in professional business communication, along with self-development and professional career progression. The course designed to help students build varied, precise and professional vocabularies, develop accurate grammar usage and to acquire communication skills in interpersonal dialogues with multi-national and multi-religious society.
Methods of Scientific Research	**5**	**1**	A basic Master's, aimed at future scientists and analysts for enterprises and organizations. The course covers the scientific knowledge, methodology and logic of a science, methods of scientific research in management, basic organization of scientific research and science language.
Basics of Cyber-Physical Systems Management	**5**	**1**	Introduction of innovative technologies, innovations in resource management of the enterprise which architecture is considered as multidimensional process model demands use of professional competences of the graduate who is equally owning managements of processes of components of innovative infrastructure computing, hardware-software, social and economic, technical, technological, etc. The digital enterprise is considered as cyberphysical system, the management of processes in which is engaged the graduate. The purpose of discipline is formation at students of submission of the modern concept of management of cyberphysical system.

COURSE	ECTS	Semester	DESCRIPTION
Technology Transfer	**4**	**1**	The course covers complex issues related to promotion, transfer and commercial use of information about technology. It focuses on the essence of technology transfer, its types and stages of implementation, registration (patent licensing) and legal aspects of the transfer of patents, organizational forms of interaction of participants (agents) of the technology market.
Advanced Strategic Analysis	**5**	**1**	In the course covers the organization of strategic management enterprises in a market economy, as exampled by practical application of strategies for domestic and foreign enterprises. The aim of the course is to examine the methodological foundations of strategic management, master basic skills needed in developing strategies for specific objects of governance. In the process, students analyze the current situation, mimic the behavior of the manager, depending on the conditions of competitiveness, using the knowledge of the macro-and microeconomics, as well as marketing, innovation and financial management and information technology management.
Internship. Acquisition of Professional Skills and Work Experience	**8**	**1**	The internship program depends on the department where it is carried out. The student's work is planned by the research supervisor appointed by specific department. Each students receives a specific problem to solve during the internship.
Internship. Acquisition of Professional Skills and Work Experience	**8**	**1**	The internship program depends on the department where it is carried out. The student's work is planned by the research supervisor appointed by specific department. Each students receives a specific problem to solve during the internship.
Management of Technological Innovations	**4**	**2**	The course covers technological innovations of ensuring life cycle of applied IT solutions (innovative projects) in IT infrastructure of the hi-tech production as a technological (process) innovation. Management of a technological innovation includes management of corporate resources. The course also covers engineering technologies - technologies of information management of the hi-tech production and parallel resource engineering. The course is aimed at familiarizing students with the modern management of technological innovations in a common information space of the enterprise.
Intellectual Property Management	**3**	**2**	The main objectives of the course are the foundations of Russian legislation in intellectual property and intellectual property management in the enterprise. The program includes 6 Subjects: Intellectual Property and intellectual rights; Legal protection of intellectual property; Legal protection of trademarks; Determination of the holder of rights; Commercialization of intellectual property, Intellectual property management.

COURSE	ECTS	Semester	DESCRIPTION
Open Innovation	**3**	**2**	The course is focused on the general principles, theoretical foundations and practical methods of implementing the concept of open innovation in foreign and domestic practice. The aim of the course is to form students' understanding of modern approaches to open innovation, advantages and challenges of this type of activity in modern conditions.
Information Technologies for Logistics	**3**	**2**	The course is intended for the Master's programs that concern introduction of technological innovations to the modern intellectual organizations of the 21st century. It focuses on providing knowledge and professional skills required for organizing business processes in the sphere of logistic. The course provides a theoretical basis of logistics, methods and management models for the logistic contour of the enterprise, and automation tools of logistic business processes. Students learn how to create information models of logistic business process in a specific enterprise, and identify key performance indicators in logistics management.
Network Technologies	**3**	**2**	The course covers the management of digital enterprises as applied to modern cognitive network technologies. It covers the methods and tools of network technologies used in knowledge-intensive production, modern principles, tools and methods of forming the infocommunication infrastructure in management of knowledge-intensive production.
Project Management Methods	**3**	**2**	The course is aimed at training of Master's students that are going to manage the structure departments of modern companies in conditions of market economy. Students are provided with the basic knowledge of project management functions, project classification, project life cycle and its stages, project financing, project planning and project performance evaluation.
Theory and Practice of Organizational Changes	**3**	**2**	The discipline is intended for training Master's students who are going to manage structural divisions of the modern intellectual organizations of the 21st century. The course is aimed at providing knowledge and professional skills in business process management and enterprise organizational changes. The course provides theoretical knowledge of social and economic systems management, methods and management models of enterprise organizational changes and IT tools for managing organizational changes of business processes. The students master the methods for creating information model of business processes for managing organizational changes in a specific enterprise and identify key performance indicators in case of organizational changes management.

COURSE	ECTS	Semester	DESCRIPTION
Marketing of Innovations	**2**	**2**	The course covers the issues of organizing the high-tech products development and promotion (commercialization) at the domestic and international markets. Commercialization of new technology products includes all aspects of technology development and development of modern enterprise and the choice of the optimal models of product promotion.
Econometric Analysis of Innovation Activities	**2**	**2**	A basic Master's program course, aimed at training highly qualified analysts for state and private innovative enterprises and organizations or preparing a future scientist. It provides training for a manager capable of formulating and verifying theoretical relationships based on statistical data, carrying out a quantitatively valid forecast of the financial and economic activities of the organization within the framework of innovative processes.
Internship (Research Project)	**12**	**2**	The content of the research internship is determined by the appropriate department based of the Federal State Educational Standard of Higher Professional Education, taking into account the interests and capabilities of the department, its laboratory and research team, etc.). The content of the student's work during the internship period is planned by the supervisor appointed by the department, the management of the unit in which it is performed and reflected in the individual assignment task for practice.
Innovative Computer Science and Software Engineering	**3**	**2**	The course is focused on the use of information technologies as the instrument of innovative activity and innovative activity in the field of information technologies; application of the engineering approach (engineering) to processes of creation, introduction, operation and support of software. The purpose of course is to familiarize the students with modern management in application to enterprises that reached technological maturity and within innovative activity of an enterprise achieved through information systems and technologies. The purpose of the course is to familiarize the students with modern cyberphysical system management
Financial and Economic Fundamentals of Business Process Modeling	**4**	**3**	The course is aimed at studying the basic principles and notations of business process modeling, reviewing the financial and economic fundamentals of business process reengineering, studying the composition of indicators used in the financial and economic modeling of business processes and performance criteria of innovative activity taking into account risks and possible social and economic consequences of the decisions made, researching domestic and foreign experience in the field of economic and financial modeling of business processes.

COURSE	ECTS	Semester	DESCRIPTION
Innovative Projects Expertise	**2**	**3**	The course covers the general principles, theoretical basesand practical methods of examining innovative projects of a digital entity. The purpose of the course is to teach students about modern approaches to efficiency evaluation of innovative projects of a digital entity, the principles, methods and models of business processes of conducting examination of innovative projects.
Knowledge Management at High-Tech Enterprises	**3**	**3**	The course is designed to study knowledge- and innovation-based theoretical economy, as well as the role and meaning of knowledge management in the organizations. The course teaches the methods ofcreation and collection of explicit knowledge and personal tacit knowledge, preservation, search and allocation of information, their effective application, staff teaching, motivation and stimulus of the knowledge and practice exchange. The subject regards such issues as intellectual capital and potential of organization, the culture of organization directed at the knowledge exchange modern informational and communicational technologies.
Organization of Digital Communications	**2**	**3**	The course relates to new communication methods, it is comprehensive and covers both theory and practice. It is directed at acquisition of the necessary knowledge and abilities which are the concept "digital communications" and also knowledge and abilities to work in thisformat and to organize work with employees, contractors and clients of the company in a digital format. In a century of digital technologies and globalization, the digital communication skills are essential for university graduates, irrespective of their major. The purpose of the course is to understand the general tendencies of development of a digital civilization and also specifics of communicative interaction in the conditions of digital realities. Special attention is paid to integration of skills of work in the digital mode in profile knowledge of young specialists.
Interdisciplinary Project "Developing an Innovation Strategy of an Enterprise"	**4**	**3**	The main contents of the project are devoted to the analysis of modern problems, tasks and tendencies of innovations management in relation to management of technological innovations of the hi-tech productions of the hi-tech enterprises of economy. The choice and justification of means of business simulation of processes of life cycle of the technological innovations integrated into IT infrastructure of business management (business) belongs to studying of methodological bases of information management. The informed choice of general scientific and special methods of scientific research will allow the study of the processes management of technological innovation knowledge-intensive industries, to carry out the management survey of the innovative capacity of enterprises, of the innovative diagnostics systems and technology audit.

COURSE	ECTS	Semester	DESCRIPTION
International Business Practices in English	**3**	**3**	It is an elective course in Master-level program. This course provides a broad view on best business practices in innovative companies, and it focuses on the characteristics of international business environment, and the main topics of the course revolve around the modern best business practices and the impact of innovations on them. The concentration is given to innovative companies on the global markets
International Business Environment in English	**3**	**3**	It is an elective course in Master-level program. This course provides a "macro" view of processes and institutions in global economy, it focuses on the characteristics of international business environment, and the main topics of the course revolve around the linkage between globalization and international management. In more specific terms this course provides students with approaches to how – to understand the impact of globalization on international business and domestic business; – to identify the influence of international business environment on countries' business practices; – to cultivate a global mindset, – to implement the rules of the global game. The concentration is given to innovative companies on the global markets.
Technological Audit	**2**	**3**	The course is devoted to problems of the organization of technological audit as comprehensive examination of the enterprise directed to identification of technologies and implementation of objective assessment of their potential as object. Technological audit is considered as a component of assessment of innovative capacity of the enterprise at a transfer of technologies. Subject of her studying are methodical and methodological bases of planning and the organization of scientific research on innovative the enterprises.
Multiagent Systems	**2**	**3**	The discipline is devoted to the problems of managing digital enterprises in the context of modern cognitive network technologies. The subject of its study is the methodological and methodological foundations of the network technologies of high-tech production, its modern principles, forms and methods, techniques and methods of forming an info-communication infrastructure for managing high-tech production.
Measurement in Innovation Management	**3**	**3**	The description of innovative activity in the conditions of digital economy and the concept of Industry 4.0 is impossible without description of processes of a full cycle of products, from acquisition of primary measuring information on a research object before adoption of the administrative decision on efficiency of activity of the enterprise. The purpose of discipline is formation at students of a complete picture of a full cycle of transformation of information – from primary information measured by sensors before interpretation of result about efficiency of innovative activity of the enterprise.

COURSE	ECTS	Semester	DESCRIPTION
Pre-Graduation Internship	**21**	**4**	The content of the research internship is determined by the appropriate department based of the Federal State Educational Standard of Higher Professional Education, taking into account the interests and capabilities of the department, its laboratory and scientific group, etc. in which it is conducted. The content of the student's work during the internship period is planned by the supervisor appointed by the department, the management of the unit in which it is performed and reflected in the individual assignment task for practice.
Master's Thesis Defense	**9**	**4**	