Ministry of Science and Higher Education of the Russian Federation
Federal State Autonomous Educational Institution of Higher Education
"South Ural State University (National Research University)"
Polytechnical Institute
Full-time Program
"Electric Drive, Mechatronics, and Electromechanics" Department

"APPROVED"
Deputy Director
of the Polytechnic Institute

_____ A.E. Bychkov
«_____»_____2025 г.

PROGRAM

OF THE ENTRANCE EXAMINATION FOR THE MASTER'S DEGREE

IN THE FIELD OF STUDY

15.04.06 "Mechatronics and Robotics"

FOR THE MASTER'S PROGRAM "Mechatronics"

Full-time form of study

Head of the Department
of "Electric Drive, Mechatronics,
and Electromechanics" M.A. Grigoriev

Chelyabinsk 2025

I. GENERAL PROVISIONS

Admission to the first year of the master's program is conducted on a competitive basis based on the results of entrance examinations, following a personal application from candidates. The competitive selection is carried out by the admissions committee. The competition ensures the enrollment of candidates who are the most capable and prepared to master the program.

The criterion for competitive selection is the results of the entrance examinations. To participate in the selection, candidates must submit the documents specified in the Admission Rules.

Following the competitive selection, the admissions committee announces the list of candidates recommended for enrollment in the master's program.

II. ORGANIZATION OF THE ENTRANCE EXAMINATIONS

The master's exam is a computer-based test.

III. ENTRANCE EXAMINATION PROGRAMS

The examination assesses knowledge acquired in the following disciplines: "Introduction to the Field of Study," "Computer Vision", " Control Theory", "Power Electronics", "Electric Drive", "Electrical Machines".

Recommended Literature:

1. Gorbenko, T.I. Fundamentals of Mechatronics and Robotics. / T.I. Gorbenko, M.V. Gorbenko. - Electronic data. - Tomsk: TSU, 2012. - 126 p.
2. Klette, R. Computer Vision. Theory and Algorithms: Textbook / R. Klette; translated from English by A.A. Slinkin. - Moscow: DMK Press, 2019. - 506 p.
3. Konovalov, B.I. Automatic Control Theory: Study Guide / B.I. Konovalov, Yu.M. Lebedev. - 4th ed. - St. Petersburg: Lan, 2016. - 224 p.
4. Gelman, M.V. Power Electronics. Textbook / M.V. Gelman, M.M. Dudkin, K.A. Preobrazhensky. - Chelyabinsk: SUSU Publishing Center, 2009. - 423 p.
5. Usynin, Yu.S. Electric Drive Control Systems. Textbook / Yu.S. Usynin. - Chelyabinsk: SUSU Publishing House, 2001. - 358 p.
6. Klyuchev, V.I. Electric Drive Theory. Textbook for universities in the specialty "Electric Drive and Automation of Industrial Plants." - Moscow: Energoatomizdat, 1985. - 560 p.
7. Bespalov, V.Ya. Electrical Machines. Textbook for universities / V.Ya. Bespalov, N.F. Kotelenets. - Moscow: Academy, 2006. - 312 p.

The entrance examination program for the master's degree program may include questions:

Onboard automotive mechatronic systems (autotronics), modern transport robots as mechatronic systems, mechatronic systems in unconventional vehicles, mechatronic systems in computer technology, mechatronic systems in office equipment, mechatronic systems in household appliances, mechatronic systems for medicine, mechatronic systems for municipal services (pipeline robots), industrial robots in construction and their development prospects, robotics in agriculture and its development prospects, mechatronic systems in the oil and gas industry (inspection robots), mechatronic systems in metallurgy, mechatronic machine tool systems, mechatronic systems in the textile industry, mechatronic systems in sports equipment, mechatronic systems in the food industry, mechatronic systems in printing and sensors in mechatronic systems.

Spatial reconstruction concepts, factors affecting image recognition, digital and analog image types, image discretization, coordinate systems, pixel modification in local neighborhoods, global image enhancement techniques, multi-image blending, image feature extraction, pixel neighborhood analysis, mask applications, object counting methods, functional differences between NumPy and SciPy packages, brightness level transformations, histogram analysis and equalization, principal component analysis for images, and various filters (Gaussian, Sobel, Prewitt).

General information about automatic control systems. Mathematical description of automatic control systems. Typical dynamic elements of automatic control. Time and frequency characteristics of first- and second-order dynamic elements. Block diagrams of automatic control systems and their

transformation. Parallel and series connections, feedback connections. Frequency characteristics and transfer functions of open-loop and closed-loop automatic control systems. Stability of linear automatic control systems. Algebraic stability criteria: Routh, Hurwitz, and Lienard-Chipart criteria. Frequency stability criteria: Mikhailov and Nyquist criteria. Analysis of control process quality. Direct and indirect quality indicators. Optimal linear automatic control systems with series compensation. Controller synthesis. Subordinate control systems.

Passive components of electronic devices. Physical principles of semiconductor device operation. Semiconductor diodes. Single-phase half-wave rectifier circuits. Single-phase full-wave rectifier circuits. Varicap diodes, tunnel diodes, backward diodes, Zener diodes. Parametric voltage regulators. Bipolar junction transistors (BJTs). Operating principles and key parameters. BJT connection configurations. Equivalent circuits and h-parameters. Field-effect transistors (FETs). Structure and operating principles. FET connection configurations. Power semiconductor devices. Insulated-gate bipolar transistors (IGBTs). Operating principles of thyristors and diacs. Key parameters. Current-voltage characteristics (CVC) of thyristors and diacs. TRIACs. Natural and forced commutation of thyristors. Gate turn-off thyristors (GTOs): physics of turn-on and turn-off processes. TRIACs. Applications of thyristors in power circuits.

Calculation schemes of the mechanical part of the drive. Equations of motion for a drive with rotary motion motors. Typical static loads of the drive. Mechanical characteristics and stability of the electric drive. Energy characteristics of the drive. Selection of electric motor power. Selection of power electronic converters. Typical operating modes of an electric drive. Regulation of coordinates in an automated DC electric drive. Implementation of subordinate coordinate regulation in DC drives with a thyristor converter. Tuning the armature current control loop. Tuning the speed control loop of the electric drive. Positional control system of the electric drive. Principle of vector control for an induction motor.

General issues of DC electrical machines. The DC commutator machine and the main elements of its design. The magnetic circuit of a DC machine. The magnetization curve and magnetic characteristics of the machine. The concept of magnetic system saturation. DC generators and motors. Speed control. Single-phase transformers. Purpose and applications of transformers. Classification and design of transformers. The operating principle of a transformer. Processes in a transformer under no-load conditions. The magnetization characteristic. The waveform of the magnetizing current. No-load losses. Transformer operation under short-circuit conditions. Transformer operation under load. External characteristics and secondary voltage variation in transformers. Three-phase transformers. Magnetic systems of three-phase transformers. EMF in three-phase windings. Connection schemes and groups of transformers, parallel operation of transformers. General issues of AC machines. Classification, design, and operating principles of AC machines. EMF in AC machine windings. Inductive reactance of AC windings. Electromagnetic processes in an induction machine with a stationary and rotating rotor. Operation modes of an induction machine with a locked rotor. Basic equations, vector diagrams, and equivalent circuits.

Master's Program	**Examination Committee Composition**
"Mechatronics" Field of Study 15.04.06 "Mechatronics and Robotics"	Chairman — Anton Evgenievich Bychkov, Ph.D., Associate Professor, Deputy Director for Energy Programs; Committee Members: 1. Maxim Grigoriev, D.Sc., Professor, Head of the Department; 2. Vladimir Kodkin, Professor of the Department; 3. Maxim Dudkin, Professor of the Department.