Subject name	Automatic Control Theory (ECTS 9)
Subject/module code	ABN26709
Science taught semester (s).	6th and 7th semesters
Responsible teacher	Parsokhonov Abdulkobi Gafurovich (Candidat Nauk), dotsent.
Education language	Uzbek
Connection to the curriculum	Elective
Training hours (this including independent education)	**Total hours-270.** **Audience Training hours - 108.** Lecture training hour – 48 Laboratory training hour – 24 Practical training hour – 36 **Independent education -162 hours**
ECTS	**9**
The purpose and tasks of subject / learning outcomes	**The main goal of teaching this subject** is to provide students with basic concepts in the theory of automatic control, to familiarize them with the general structure of automatic control systems, the processes occurring in them, to equip them with the necessary knowledge needed for their selection, testing, operation and design of control systems. In addition, it is intended to equip students with the knowledge and practical skills to automatically control electrical systems used in industry, analyze their operation, select and synthesize appropriate elements; to teach their operating principles and to adjust and improve their performance. **The task of the subject** is to familiarize students with automatic control systems of electrical equipment used in industry, to analyze them, to equip them with knowledge on the selection, principles of operation, adjustment of appropriate systems and their elements, and to develop practical skills in their application in production. It is also to reveal to students the role and importance of automatic control in the development of humanity using theoretical knowledge, practical skills, Internet materials, and real-life examples. **Learning outcomes:** 1. To know of the structure of automatic control systems. 2. To master the principles of automatic adjustment, control and management. 3. To learn to analyze automatic control systems. 4. To be able to formulate equations for the elements of simple automatic control systems. 5. To be able to determine and analyze the stability of automatic control systems. 6. To learn methods for increasing stability. 7. To have an understanding of the economic foundations of automation. 8. To form an idea of the ecological aspects of automation. 9. To master the skills of applying the acquired knowledge in their field.
Course content (topics)	**I. Main theoretical part (Lecture)** **Topic 1.** Introduction. Basic concepts. The main purpose of automatic control. A look at the history of automation. The main functions of automatic control systems. Levels of automation. Examples of modern automatic control systems. **Topic 2**. Automation schemes. Classification of automatic control

	systems. Open and closed loop systems. Systems with one input and one output signal, multiple input and multiple output signals. Systems operating directly and with additional energy. Electrical, hydraulic and pneumatic systems. Regulating, programmed and monitoring systems. Linear and nonlinear systems. Continuous and non-continuous systems. **Topic 3**. General structure and main elements of an automatic control system. Control object. Automatic regulator, sensor, amplifier, programmable device, actuator and control body. **Topic 4**. Control objects and their properties. Capacitive property of a control object. Delay property. Self-adaptive property. Acceleration time of an object. Time constant of an object. **Topic 5**. Relay and its function. The principle of operation of a relay and its types. Contactless relays. Relay - contact schemes. Repeating, blocking and mutual blocking relay - contact schemes and their areas of application. **Topic 6**. Measurement of technological parameters. Technological parameters. Methods of measuring pressure, temperature, flow, level, geometric dimensions, displacements, concentration and other parameters. **Topic 7**. Laplace transforms. Direct and inverse Laplace transforms. Elementary link. Differential equation of the link. **Topic 8**. Mathematical representation of an automatic control system. Static and dynamic feedback. Disturbation. Feedback in equilibrium and during a transient process. Modeling linear systems. Linearization. **Topic 9**. Transfer function and rules for its transformation. Operator form of a differential equation. Rules for calculating the general transfer function when links are connected in series, parallel and using feedback. Rules for moving nodes used when links are connected in a complex way. **Topic 10**. Analysis of the feedback effects of first- and second-order systems. **Topic 11**. Frequency characteristics of automatic control systems. Comparison of time and frequency characteristics. Basic concepts. Amplitude-frequency and logarithmic amplitude-frequency characteristics. Phase-frequency and logarithmic phase-frequency characteristics. Controller design using frequency feedback methods. **Topic 12**. Typical dynamic elements and their characteristics. Division of an automatic control system into typical dynamic links. Proportional, inertial, oscillatory, differentiating, integrating and delay elements. Differential equation of these elements, operator form of the differential equation, transfer function, frequency characteristics. **Topic 13**. Stability of automatic control systems. Concept of stability, examples. Classical method for determining the stability of automatic control systems. **Topic 14**. Gurvitz and Mikhailov criteria for determining the stability of automatic control systems. **Topic 15**. Poles and zeros. Concepts of poles and zeros and their significance. **Topic 16**. Nyquist criterion. Rules for constructing a Nyquist hodograph and stability conditions. **Topic 17**. Bode diagram. Construction of a Bode diagram and determination of system stability. **Topic 18**. Ways to increase system stability. Correcting devices. **Topic 19**. Transient processes and control quality. Reliability of automatic control systems. **Topic 20**. Proportional, integral and differential regulators. **Topic 21**. Combined regulators. Regulator selection. **Topic 22**. Telemechanics systems. Telemetry, telesignaling and telecontrol systems.

Topic 23. Economic foundations and environmental aspects of automation. Stages of design of automatic control systems and tasks performed at these stages.

Topic 24. Use of artificial intelligence in automatic control (Neural networks, fuzzy algorithm controllers)

II. Instructions and recommendations for organizing laboratory exercises.

Laboratory experiments will be performed using laboratory equipment provided under a grant from the ISLAMIC DEVELOPMENT BANK.

Suggested topics for laboratory work:

1. Study of sensors at the "Control and measuring instruments and automation" laboratory stand.
2. Study of a system for ensuring constant water consumption and pressure in water supply at the "Automation of pumping stations" laboratory stand.
3. Arduino laboratory work. Controlling an LED (liquid crystal display) on a smartphone via the HC-05 bluetooth module
4. Arduino laboratory work. Learning to connect and use a 16×2 LCD (liquid crystal display) to a PC.
5. Study of the "Dobot CR5" industrial robot.
6. Study of the operation of a pumping station controlled via "SCADA".
7. Study of the "Programmable relay" laboratory stand.
8. Study of the technical characteristics and programming basics of the S7 1200 programmable logic controller at the "Automatic control system of a technological process" laboratory stand.
9. Study of the technical characteristics and programming basics of the S7 1500 programmable logic controller at the laboratory stand "Automatic control system of technological processes".
10. Study of the basics of the mathematical apparatus of logical algebra at the laboratory stand "Fundamentals of automation" and its application in the development of relay control schemes.
11. Study of the structure and principles of mechatronic schemes at the "NTC 2601 Mechatronics" stand.
12. Study of Pnewmo electric automation at the laboratory stand "Automation and control devices".

III. Instructions and recommendations for practical training

Practical training should be conducted in an auditorium equipped with multimedia devices by one professor per academic group. It is advisable that the training be conducted using active and interactive methods, and appropriate pedagogical and information technologies should be used.

Recommended practical training topics:

Topic 1. Automation schemes, functional circuit symbols.

Topic 2. Formulation of first-order differential equations of simple automatic control systems.

Topic 3. Formulation of second-order differential equations of simple automatic control systems.

Topic 4. Relay. Study of relay-contact schemes. Repeater, blocking and mutual blocking schemes.

Topic 5. Laplace transforms. Solving differential equations of dynamic systems.

Topic 6. Determination of transfer functions of automatic control systems.

Topic 7. Rules for changing the transfer function.

Topic 8. Obtaining frequency characteristics of automatic control systems.

Topic 9. First-order element analysis

Topic 10. Second-order element analysis.

Topic 11. Checking stability using the Hurwitz criterion.

Topic 12. Checking stability using the Mikhailov criterion.

Topic 13. Solving problems with poles and zeros.

Topic 14. Checking stability using the Nyquist criterion.

Topic 15. Checking stability using the Bode diagram.

Topic 16. Proportional, integral and differential regulators.

Topic 17. Combinational regulators.

Topic 18. Using artificial intelligence in automatic control (Neural networks, fuzzy algorithm controllers)

IV. Independent learning and independent work.

Independent learning tasks consist of topics formalized in the form of a scientific thesis, examples and problems to be solved on the topic, and are prepared in the form of a separate option for each student and are presented below.

On independently mastered topics, it is recommended that students prepare a scientific project, conclusion, tests, glossary, handouts, presentations, and write a scientific thesis and article, as well as "Case Studies" on the topic of independent learning in groups.

Recommended independent study topics:

1. Pros and cons of automation. Automatic adjustment, automatic control and automatic management. Partial, complex and full automation. Open and closed loop systems, their advantages and disadvantages.

2. Linear and nonlinear systems, time-invariant and time-varying systems. Systems without additional energy and with additional energy. Stabilizing, programmed and following systems. Continuous, pulsed and relay systems.

3. Forms and types of circuits. Structural diagram. Functional diagram. Principle diagram.

4. General, assembly, connection and location diagrams. General structure of the automatic control system. Sensors and measuring elements. Amplifiers.

5. Actuating mechanisms. Control bodies. Capacitance property of the object. Delay property of the object.

6. Self-adaptation property of the object. Acceleration time of an object. Time constant of an object. Function and types of relay.

7. Structure of a simple electromagnetic relay. Principle of operation of a thermal relay. Repeater and blocking circuits. Explain the mutual blocking circuit.

8. Types of pressure and vacuum measuring instruments and their operating principle. Types of temperature measuring instruments and their operating principle. Types of flow measuring instruments and their operating principle. Types of level measuring instruments and their operating principle.

9. Types of geometric displacement measuring instruments and their operating principle. Steps in solving the equation by using Laplace transforms. Elementary element definition and its equation. What is a mathematical model? How is it constructed and what types are there?

10. Derive its operator form from the element’s differential equation. Transfer function, formula and examples. Rules for finding the general

	transfer function when the links are connected in series, parallel and feedback. Rules for moving nodes in the transfer function. 11. Proportional element definition and examples. Equation, operator form of the equation and transfer function. Inertial element definition and examples. Equation, operator form of the equation and transfer function. Oscillating element definition and examples. Equation, operator form of the equation and transfer function. Differentiating element definition and examples. Equation, operator form of the equation and transfer function. 12. Integrating element definition and examples. Equation, operator form of the equation and transfer function. Delay element definition and examples. Equation, operator form of the equation and transfer function. Importance and disadvantages of time analysis. Importance and disadvantages of frequency analysis. 13. Formula for amplitude-frequency characteristics using Laplace transforms. Formula for phase-frequency characteristics using Laplace transforms. Formula for obtaining logarithmic amplitude and phase-frequency characteristics when amplitude and phase-frequency characteristics are known. Definition of stability, examples. 14. Stable, unstable and near-stable states. Absolute and relative stability. Experimental determination of system stability. Classical determination of system stability. Differentiation of stable and unstable systems. 15. Hurwitz criterion, stability conditions and Hurwitz matrices. Mikhailov criterion, stability conditions. System transfer function, poles and zeros. Explanation of the reflection effects of the system (stable and unstable) depending on the location of the poles in the complex plane. 16. Stability conditions of a closed-loop system for a stable state of an open-loop system according to the Nyquist criterion. Stability conditions of a closed-loop system for a unstable state of an open-loop system according to the Nyquist criterion. Explain the Bode diagram and its advantages. The influence of constant numbers on the amplitude-frequency and phase-frequency characteristics in the Bode diagram. 17. The influence of poles and zeros located at the origin of the coordinate in the Bode diagram on the amplitude-frequency and phase-frequency characteristics. The influence of poles and zeros not located at the origin of the coordinate in the Bode diagram on the amplitude-frequency and phase-frequency characteristics. Characteristics of the Bode diagram and Bode stability criteria. 18. 4 ways to ensure a stability reserve. Explain the requirements for an automatic control system. Transient characteristics of stable, near-stable and unstable systems. The most common and most severe feeding effects in the analysis of the quality of automatic control for the system. Reliability of the automatic control system.
Exam form	Written
Teaching/learning and examination requirements	Complete mastery of theoretical and methodological concepts and practical knowledge of the discipline, the ability to correctly reflect the results of analysis, independently reason about the processes being studied and carry out tasks in the current, intermediate forms of control and independent work, pass written work on the final control. When drawing up final exam questions, deviations from the content of the discipline program are not allowed. The bank of final exam questions for each discipline is discussed at the meeting and approved by the head of the department. No later than 1 week before the start of the final control, tickets signed by the head of the department, enclosed in an envelope, are sealed by the Dean’s office and opened 5 minutes before the start of the exam in the presence of students. Final exam duration is 80 minutes.

	Answers to final exam questions are recorded in copybooks with the seal of the Dean’s office. After completion of the final work, the work is immediately encrypted by a representative of the Dean’s office, and the copybooks are handed over to the commission for verification. From the moment of completion of the final exam, a period of 72 hours is allotted for checking and posting the results on the electronic platform. The teacher who taught the students in this discipline is not involved in the process of conducting the exam and checking the students' answers. Student(s) who are dissatisfied with the final exam results may submit a written or oral appeal within 24 hours of the publication of the final exam results. Complaints submitted after 24 hours from the publication of the final exam results will not be accepted.
Scope of assessment criteria and procedure	CURRENT CONTROL Purpose: Determining and assessing the student's level of knowledge, practical skills, and competencies on course topics. Instructions: The student's activity in daily classes is assessed through the student's mastery of course topics, as well as constructively interpreting and analyzing the educational material, developing module-specific skills, acquiring practical skills (in terms of quality and the specified number) and competencies, solving problem situations aimed at applying professional practical skills, working in a team, preparing presentations, etc. Current control form: Activity in lessons Preparing educational materials Working with sources within the subject Using educational technologies Working in a team Preparing presentations Working with projects. MIDTERM CONTROL Purpose: Assessing the student's knowledge and practical skills and level of mastery of lecture material after completing the relevant section of the course. Form and procedure of intermediate control: Midterm examination is held during the semester during the training sessions after the completion of the relevant module of the curriculum of the subject. Midterm examination is held once in written form within the framework of this subject. Midterm examination questions cover all topics of the subject. INDEPENDENT LEARNING Purpose: Independent learning is aimed at fully covering the content of this course, expanding the theoretical knowledge acquired, and establishing independent learning activities for students. Form and procedure of independent education: independent work assignments are completed in the form of an educational project, presentation, case study, problem solving, information search, digest, colloquium, essay, article, abstract, etc. Completed assignments for independent study are placed in the electronic system and checked based on the anti-plagiarism program and evaluated by the subject teacher. In this case, the uniqueness of the completed assignment should not be less than 60%, otherwise the assignment will not be accepted for assessment. The number of independent work assignments, depending on the nature of the subject, should not be less than 3 for one subject (module). Independent work assignments account for 60% of the points allocated for current and intermediate control. FINAL CONTROL Purpose: The final examination is held at the end of the semester to determine the level of mastery of the student's theoretical knowledge and practical skills in the relevant subject. The final examination is held at a specified time according to the examination schedule created by the

Registrar's Office on the electronic platform.

Requirements: The student must have passed the current control, intermediate control and independent learning assignments by the deadline for the final control type in the relevant subject. A student who has not passed the current control, intermediate control and independent learning assignments, as well as who has received a score in the range of "0-29.9" for these assignments and control types, is not included in the final control type. Also, a student who has missed 25 percent or more of the classroom hours allocated to a subject without a reason is excluded from this subject and is not included in the final control type and is considered not to have mastered the relevant credits in this subject. A student who has not passed or was not included in the final control type and has received a score in the range of "0-29.9" for this type of control is considered to be an academic debtor.

Final control form: The final examination in this subject will be conducted in written form. If the final examination is conducted in written form, the requirements for assessment must also be reflected.

Criteria for assessing student knowledge

5 grade	100 points		Assessment criteria
5	90-100	Excellent	When a student is considered to be able to make independent conclusions and decisions, think creatively, observe independently, apply the knowledge he has gained in practice, understand, know, express, and narrate the essence of the subject, and have an idea about the subject.
4	70-89,9	Good	When the student is considered to be able to observe independently, apply the knowledge he has gained in practice, understand, know, express, and narrate the essence of the subject, and has an idea about the subject.
3	60-69,9	Satisfactory	When the student is found to be able to apply the knowledge he has gained in practice, understands, knows, can express, and narrate the essence of the subject, and has an idea about the subject.
2	0-59,9	Unsatisfactory	When it is determined that the student has not mastered the science program, does not understand the essence of the subject, and does not have an idea about the science.

Course assessment criteria and procedure

Assessment type	Total points allocated	Control (task) form	Distribution of points	Qualifying score
Current assessment	30 points	System tasks	20 points (divided by the number of tasks)	18 points
		Student activity (in seminars, practical, laboratory classes)	10 points	
Midterm assessment	20 points	Supervision: Written work	10 points	12 points
		System tasks	10 points (divided by the number	

				of tasks)	
	Final assessment	50 points	Written assignment (5 questions)	50 points (10 points per question)	30 points
	* Note: 60% of the points allocated for current and intermediate control are allocated to independent work assignments. Independent work assignments are evaluated as system assignments through the electronic platform.				

Recommended Literature

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