Subject name	Mikromachines (ECTS 5)
Subject/module code	M2605
Science taught semester (s).	6th semester
Responsible teacher	Parsokhonov Abdulkobi Gafurovich, PhD, Associate Professor
Education language	Uzbek
Connection to the curriculum	Elective
Training hours (this including independent education)	**Total hours - 150** **Contact hours - 60** Lecture training hours - 30 Practical training hours - 30 **Independent education -90**
ECTS	**5**
The purpose and tasks of subject / learning outcomes	I. **The purpose of the subject** is to provide students with basic concepts of micromachines, to familiarize them with the general structure of micromachine systems, the processes occurring in them, to equip them with the necessary knowledge necessary for their selection, testing and operation. In addition, it is intended to equip students with appropriate knowledge and practical skills in the automatic control of electrical micromachines used in industry, analysis of their work, selection and synthesis of relevant elements; principles of their operation and adjustment and improvement of their performance. The structure of micromachines, structural elements and principles of their operation, the laws of their automatic control, economic foundations and environmental aspects of the use of micromachines are described in the program. **The task of the subject** is to form students' theoretical knowledge, practical skills, methodological and scientific outlook on financial phenomena and processes. Applications of mathematical modeling will be of great importance in solving economic problems during the transition to a market economy. Therefore, teaching this subject is relevant to the purpose. **Learning outcomes:** 1. To have an idea of micromachines. 2. To know the properties and areas of application of microtransformers. 3. To have information about microtransformers used in rectifier circuits. 4. To know the structure and principles of operation of asynchronous micromotors. 5. To have information about asynchronous tachogenerators and selcins, their structure, principles of operation and areas of application. 6. To know the structure, principles of operation and areas of application of synchronous micromachines. 7. To know the structure, principles of operation and areas of application of direct current micromachines.
Course content (topics)	**I. Main theoretical part (Lecture)** **Topic 1.** General information about micromachines and microtransformers. Electric micromachines and microtransformers. Basic technical requirements for electric micromachines and microtransformers. Equivalent circuit of a transformer. Structure of low-power transformers and their types. Specific characteristics of low-power transformers. Areas of application, nominal

	operating modes. **Topic 2.** Microtransformers for electric welding, structure and principle of operation, areas of application, advantages and disadvantages. Microtransformers for rectifier devices, structure and principle of operation, factors affecting their operation and areas of application, advantages and disadvantages. Rectification schemes. Smoothing filter. **Topic 3.** Microtransformers for rectifier schemes and electrical measuring schemes. Structure and principle of operation. Accuracy classes and error limits. Areas of application. Advantages and disadvantages. Rotary transformers. Rotary transformers and their types. Structure and principle of operation. Areas of application. Advantages and disadvantages. **Topic 4.** Induction machines. Rotating field. Analysis and fundamentals. Magnetic micromachines, general characteristics. Two-phase symmetric micromotors. Two-phase symmetric asynchronous micromotor. Switching scheme. Electromagnetic power and torque. Power dissipation and energy diagram. **Topic 5**. Single-phase asynchronous micromotor, main characteristics, switching scheme. Various phase shifting elements. Rotating field in a capacitor motor. Control of asynchronous micromotors. Asynchronous motors with starting resistance. Asynchronous motor with starting capacitor. **Topic 6.** Hybrid and universal asynchronous motors. Asynchronous micromotor with starting and working capacitors. Universal asynchronous micromotors. Power asynchronous motors with shielded poles, structure, specific characteristics, operating principle, areas of application, advantages and disadvantages. **Topic 7.** Permanent magnet synchronous micromotors, characteristics. Synchronous mode. Angular characteristic. Starting mode. Reactive synchronous micromotors, characteristics. Operating mode. Angular characteristic. Starting mode. Characteristics of the operation of induction machines during power on and off. **Topic 8.** Hysteresis synchronous micromotors, Start-up mode. Operating mode. Source voltage control in AC machines. Collector DC micromotors, structure, characteristics, applications, operating principle, advantages and disadvantages. **Topic 9.** Collector AC micromotors, structure, characteristics, applications, operating principle, advantages and disadvantages. Universal collector micromotors. Methods of using three-phase squirrel-cage asynchronous motors as single-phase asynchronous motors, applications and possibilities. **Topic 10.** Inverters: single-phase and multi-phase high-voltage AC power sources. Micromotors of automatic devices. Requirements for them, their specific characteristics, areas of application, tasks. Executive asynchronous micromachines. Control of executive asynchronous micromotors using amplitude and phase. **Topic 11.** Amplitude-phase control of asynchronous micromotors. Self-propulsion and its prevention. Direct current micromotors. Continuous control using an armature. Continuous control using a pole. Control using a pulse. Electromechanical and electromagnetic constants. **Topic 12.** Stepping micromotors. Stepping micromotors as frequency-controlled synchronous micromotors. Their structure, principle of

operation, areas of application, advantages and disadvantages.

Topic 13. Rectifiers. Diode bridges. Input voltage, capacitor smoothing. Asynchronous micromotors with a non-magnetic rotor, structure, principle of operation, areas of application, advantages and disadvantages.

Valve (non-contact) - indicator micromotors, structure, principle of operation, areas of application, advantages and disadvantages.

Topic 14. Single-phase and three-phase controlled bridge circuits. Tachogenerators. Asynchronous tachogenerators. Residual EDF (electrical driving force) and methods of combating it. Amplitude and phase errors and methods of their compensation. Accuracy classes. Synchronous tachogenerators.

Constant current tachogenerators. Analysis of characteristics, insensitivity zone. Errors of constant current tachogenerators. Output voltage pulsations.

Topic 15. Synchronous rotation and synchronous turning systems. Structure of selcins. Indicator operation mode. Synchronizing torque. Parameters characterizing the operation of selcins in indicator mode.

Operation of selcins in transformer mode. Longitudinal and transverse components of the MDF (magnetic driving force) and the resultant magnetic flux in the selcin-receiver. Parameters characterizing the operation of selcins in transformer mode.

II. Instructions and recommendations for practical training

The department will develop instructions and recommendations for organizing practical training. In it, students will further enrich their knowledge and skills on the main lecture topics through practical exercises and cases. It is also recommended to consolidate students' knowledge on the basis of textbooks and manuals, use handouts, increase students' knowledge by publishing scientific articles and abstracts, solve problems, prepare presentations and visual aids on topics, use regulatory and legal documents, etc.

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

Recommended practical training topics:

Topic 1. Determination of the nominal power S_N and the secondary current I_{2N} of a single-phase step-down microtransformer. Determination of the cross-sectional areas q_1 and q_2 of the windings of the single-phase step-down microtransformer.

Topic 2. Finding the transformation coefficient of a single-phase microtransformer and the voltage of the supply network. Determination of the load current I_2 passing through the secondary winding of a single-phase step-down microtransformer.

Topic 3. Determination of the transformation coefficient of a three-phase microtransformer and the nominal values of the phase currents of the primary and secondary windings. Construction of a short-circuit triangle of a three-phase microtransformer.

Topic 4. Determination of the nominal rotation frequency and torque, induction of a microasynchronous motor. Construction of operating and mechanical characteristics.

Topic 5. Calculation of parameters for the stator winding of a microasynchronous motor with a short-circuited rotor in the "star" and "delta" connection. Determination of the power dissipation of a three-phase microasynchronous motor at nominal load.

Topic 6. Determination of the length of the winding section of a non-

polar synchronous micromotor and its average induction in the air gap.

Topic 7. Calculation of the induction and fundamental harmonics of a synchronous micromotor.

Topic 8. Finding the amplitude and the calculated coefficient of pole closure of a permanent-pole synchronous micromotor. Finding the braking torque and torque.

Topic 9. Calculation of the parameters of a parallel-excited direct current micromotor, constant, self-induction losses and FIK characteristics, and construction of their characteristics.

Topic 10. Construction of the operating characteristics of a series-excited direct current micromotor.

Topic 11. Calculation of the rheostat of a DC micromotor with independent excitation.

Topic 12. Determination of the main parameters of asynchronous machines with a phase rotor;

Topic 13. Asynchronous frequency converter and asynchronous cascades.

Topic 14. Determination of the angle of rotation of a stepper motor.

Topic 15. Calculation of the main parameters of AC machines.

III. Independent study and independent work.

Independent educational 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, level tests, glossary, handouts, presentations, and write a scientific thesis and article, as well as "Case Studies" on the topic of independent education in groups.

Recommended topics for independent study:

1. General information about micromachines and microtransformers. Theory of electric micromachines and specific features of their calculation. Basic technical requirements for electric micromachines and microtransformers. Low-power transformers. Specific features of low-power transformers. Equivalent circuit for low-power transformers. Operating frequency of low-power transformers. Areas of application, nominal operating modes. Use of toroidal transformers. Their technical parameters. Structure and principle of operation of toroidal low-power transformers, advantages and disadvantages.

2. Microtransformers for electric welding. Structure and principle of operation of microtransformers for electric welding. Areas of application, advantages and disadvantages. Microtransformers for rectifier devices. Structure and principle of operation of microtransformers for rectifier devices, reasons affecting their operation and areas of application, advantages and disadvantages. Rectification schemes. Smoothing filter. Load characteristics.

3. Microtransformers used in rectifier circuits and for power supply circuits. Bridge circuit of transformers used in rectifier circuits, transformers for voltage and current measurement circuits. Structure and principle of operation. Accuracy classes and error limits. Areas of application. Advantages and disadvantages. Rotary transformers. Rotary transformers and their types. Structure and principle of operation. Areas of application. Advantages and disadvantages.

4. Magnetic micromachines. General characteristics of magnetic micromachines. Magnetic fields of two-phase symmetric micromotors. Conditions for generating a rotating field. Symmetrical component method. Two-phase symmetric asynchronous micromotor. Switching

	circuit of a two-phase symmetric asynchronous micromotor. Electromagnetic power and torque. Power dissipation and energy diagram. 5. Single-phase asynchronous micromotor. Main characteristics of single-phase asynchronous micromotors. Switching scheme of a single-phase asynchronous motor. Various phase shifting elements. Rotating field in a capacitor motor. Control of asynchronous micromotors. Asynchronous motors with starting resistance. Asynchronous motor with starting capacitor. 6. Hybrid and universal asynchronous motors. Asynchronous micromotor with starting and working capacitors. Universal asynchronous micromotors. Power asynchronous motors with shielded poles. Structure, specific features, principle of operation, areas of application, advantages and disadvantages of shielded pole asynchronous motors. 7. Permanent magnet synchronous micromotors. Characteristics of permanent magnet synchronous micromotors. Synchronous mode. Angular characteristic. Starting mode. Reactive synchronous micromotors. Characteristics of reactive synchronous micromotors. Operating mode. Angular characteristic. Starting mode. 8. Hysteresis synchronous micromotors. Characteristics of hysteresis synchronous micromotors. Start-up mode. Operating mode. Collector DC micromotors. Structure, specific features, areas of application, principle of operation, advantages and disadvantages of collector DC micromotors. 9. Collector AC micromotors. Structure, specific features, areas of application, principle of operation, advantages and disadvantages of collector AC micromotors. Universal collector micromotors. Use of three-phase squirrel-cage asynchronous motors as single-phase asynchronous motors. Methods of using three-phase squirrel-cage asynchronous motors as single-phase asynchronous motors, areas of application and possibilities. 10. Micromotors of automatic devices. Requirements for micromotors of automatic devices, their specific features, areas of application, tasks. Executive asynchronous micromachines. Executive asynchronous micromotors. Control of executive asynchronous micromotors using amplitude. Control of executive asynchronous micromotors using phase. 11. Amplitude-phase control. Amplitude-phase control of actuator asynchronous micromotors. Self-propulsion and its prevention. DC actuator micromotors. DC actuator micromotors. Continuous control using an armature. Continuous control using a pole. Electromechanical and electromagnetic constants. Control using impulses. 12. Characteristics of actuator DC actuator micromotors. Characteristics of actuator DC actuator micromotors. Stepping micromotors. Stepping micromotors as frequency-controlled synchronous actuator micromotors. Their structure, principle of operation, areas of application, advantages and disadvantages. 13. Asynchronous actuator micromotors with a non-magnetic rotor. Structure, principle of operation, areas of application, advantages and disadvantages of asynchronous actuator micromotors with a non-magnetic rotor. Valve (non-contact) - indicator micromotors. The structure, principle of operation, areas of application, advantages and disadvantages of valve (non-contact) - indicator micromotors. 14. Tachogenerators. Asynchronous tachogenerators. Residual ESR and methods of combating it. Amplitude and phase errors and methods of their compensation. Accuracy classes. Synchronous tachogenerators. Constant current tachogenerators. Constant current tachogenerators. Analysis of characteristics, insensitivity zone. Errors of constant current tachogenerators. Output voltage pulsations.

	15. Synchronous rotation and synchronous rotation systems. Synchronous rotation and synchronous rotation systems. Variants of the structure of selcins. Indicator operation mode. Synchronizing torque. Parameters characterizing the operation of selcins in the indicator mode. Operation of selcins in transformer mode. Operation of selcins in transformer mode. Longitudinal and transverse components of the ESR and the resultant magnetic flux in the selcin-receiver. Parameters characterizing the operation of selcins in transformer mode
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

Main literature:

1. Sahdev S.K. Electrical Machines. UK: Cambridge University Press. 2017. 980 b.

2.Mustafakulova G.N., Toirov O.Z., Bekishev A.E. Elektr mashinalari. Toshkent.: Tafakkur avlodi. 2020. 191 b.

3. Boldea Ion, Tutelea Lucian N. Electric Machines, 2nd Edition. CRC Press, Taylor & Francis Group, 2022. 455 p

4.S. K. Sahdev/Electrical Machines/ © Cambridge University Press 2018

5. Hughes A., Drury B. Electric Motors and Drives: Fundamentals, Types and Applications, 3th Edition. Newnes, 2019. 495 p.

6.Alimxodjayev K.T., Pirmatov N.B., Ziyoxodjayev T.I. Elektr mashinalari.- T.: “Fan va texnologiya”, 2018. -344 b.

7.Alimxodjayev K.T., Pirmatov N.B., Ziyoxodjayev T.I., Mustafakulova G.N. Elektr mashinalari va transformatorlarning ekspluatatsiyasi. - T.: “Fan va texnologiya”, 2019. -240 b.

8. Melkebeek J.A. Electrical Machines and Drives: Fundamentals and Advanced Modelling. Springer International Publishing AG, 2018. 740 p

9. Mustafakulova G.N., Toirov O.Z., Bekishev A.E. Elektr mashinalari. Toshkent.: Tafakkur avlodi. 2020. 191 b.

11.N.B.Pirmatov, A.S.Saodullayev, A.Y.Bekishev, N.A.Qurbonov «Elektr mashinalari» o’quv qo’llanma Toshkent: «ZEBO PRINT» nashriyoti. 2022.-197 b.

12. Toirov O.Z., Mirxonov U.K., Bekishev A.Y. Maxsus elektr mashinalari. – T.: TDTU, 2023. 236 b

Additional literature:

13.Mirziyoyev Sh.M. Erkin va farovon, demokratik O‘zbekiston davlatini birgalikda barpo etamiz. O‘zbekiston Respublikasi Prezidentining lavozimiga kirishish tantanali marosimiga bag‘ishlangan Oliy Majlis palatalarining qo‘shma majlisidagi nutqi. – T.: “O‘zbekiston” NMIU, 2016. – 56 b.

14.Mirziyoyev Sh.M. Qonun ustuvorligi va inson manfaatlarini ta’minlash – yurt taraqqiyoti va xalq farovonligining garovi. O‘zbekiston Respublikasi Konstitusiyasi qabul qilinganining 24 yilligiga bag‘ishlangan tantanali marosimdagi ma’ruza 2016 yil 7 dekabr. – T.: “O‘zbekiston” NMIU, 2016. – 48 b.

15.Mirziyoyev Sh.M. Buyuk kelajagimizni mard va olijanob xalqimiz bilan birga quramiz. – T.: “O‘zbekiston” NMIU, 2017. – 488 b.

16.O‘zbekiston Respublikasini yanada rivojlantirish bo‘yicha Harakatlar strategiyasi to‘g‘risida. – T.:2017 yil 7 fevral, PF-4947-sonli Farmoni.

17.Mustafakulova G.N., Toshev Sh.E. Elektr mashinalari fanidan laboratoriya mashg‘ulotlarini bajarish uchun metodik ko‘rsatma. –T.: TDTU, 2015. – 45 b.

Internet resources:

1.www.ziyonet.uz

2.http://dhes.ime.mrsu.ru/studies/tot/tot_lit.htm;

3.http://rbip.bookchamber.ru/description.aspx?product_no=854;

4.http://energy-mgn.nm.ru/progr36.htm