Name of subject	Electric machines (ECTS 12)
Subject/module code	EM14512
Science taught semester (s).	4th and 5th semesters
Responsible teacher	Saodullayev Abror Saypullayevich, Senior teacher
Education language	Uzbek
Connection to the curriculum	Compulsory
Training hours (this including independent education)	**Total hours-360.** **Audience Training hours - 144.** Lecture training hour – 72 Laboratory training hour –24 Practical training hour – 48 **Independent education -216 hours**
ECTS	12
The purpose and tasks of subject / learning outcomes	**The purpose of teaching this subject:** The aim of the course is to teach students the structure and principles of operation of electric machines, their selection, operation, analysis of the physical processes occurring in them, calculation of the energy efficiency of electric machines, and formation and development of the design thinking of electric machines, teaching them to clearly state their opinions and conclusions in a well-founded manner, and to develop the skills to apply them in practice. **The task of the subject** is to teach students how to construct switching circuits for electric machines and determine their parameters, calculate and analyze the characteristics of electric machines, evaluate various operating modes of electric machines, control electric machines and adjust their speeds; design electric machines, and teach them the basic criteria for increasing and ensuring the efficiency of electric machines. **Learning outcomes:** 1. The student will study the nature of electromechanical phenomena in nature and technology of electric machines through the fundamental concepts of the science of electric machines. 2. The student will study the structure, operating principle, applications and characteristics of transformers. 3. The student will study the structure, operating principle, applications and characteristics of alternating current machines. 4. The student will study the structure, operating principle, applications and characteristics of direct current machines.
Course content (topics)	**I. Main theoretical part (Lecture)** **Topic 1:** Introduction to the science of "Electrical machines". Physical processes occurring in transformers. **Topic 2:** Magnetic cores of transformers and the structure of magnetic cores. Electromagnetic processes occurring in no-load and short-circuit modes of the transformer. **Topic 3:** EMF and currents in transformer windings. Conversion of the electrical parameters of the secondary winding of the transformer to the number of primary winding windings. **Topic 4:** T-shaped switching schemes and vector diagrams of the transformer. **Topic 5:** External characteristics of transformers. Voltage adjustment. **Topic 6:** Connection groups of transformer windings. Conditions for parallel connection.

Topic 7: Parts and schemes of the stator winding of alternating current machines.

Topic 8: Magnetic Motive Forces (MMF) and Magnetic Fields. Pulsating, elliptical, and circular rotating magnetic fields

Topic 9: Types of induction machines, their structure and operating principle. Topic 10: Operating modes of an induction machine.

Topic 11: Electromagnetic processes occurring in an induction machine with a braked rotor.

Topic 12: Conversion of rotor winding parameters to the number of stator winding windings

Topic 13: Obtaining experiments on the operation of induction motors and short circuits.

Topic 14: Vector diagrams of an induction machine

Topic 15: Energy diagram of an induction machine

Topic 16: Electromagnetic (rotating) torque and mechanical characteristics of an induction machine

Topic 17: Operating characteristics of an induction motor. Starting an induction motor.

Topic 18: Adjusting the frequency of rotation of an induction motor.

Topic 19: Induction generator, electromagnetic processes and characteristics in it.

Topic 20: Modern series and special types of induction machines. Induction frequency converter.

Topic 21: Types of synchronous generators, structure and operating principle of synchronous machines.

Topic 22: Types of excitation of synchronous generators.

Topic 23: Armature reaction.

Topic 24: Equations and vector diagrams of permanent and non-permanent pole synchronous generators.

Topic 25: Parallel connection of a synchronous machine to an electrical network. Synchronization methods.

Topic 26: Characteristics of a synchronous generator in parallel operation with an electrical network.

Topic 27: Angular characteristic of the reactive power of a synchronous machine.

Topic 28: Structure and operating principle of a synchronous motor.

Topic 29: Operating characteristics of a synchronous motor.

Topic 30: Operating characteristics of a small-power and linear synchronous motor at various loads.

Topic 31: Power losses and useful work coefficient in a synchronous machine.

Topic 32: AC machine. The structure of DC machines and the principle of operation as generators.

Topic 33: Characteristics of DC generators

Topic 34: The structure of DC motors and physical processes in motors.

Topic 35: Starting DC motors

Topic 36: Methods of adjusting the speed of DC motors

II. Instructions and recommendations for organizing laboratory exercises.

The department develops methodological instructions and recommendations for organizing laboratory exercises. In them, students will further enrich the knowledge and skills they have acquired on the topics of the main lectures and practical exercises by performing

laboratory exercises and performing relevant calculations.

Suggested topics for laboratory work:

1.Conducting experiments with single-phase toroidal transformers and Scott transformers.

2.Experiments with a single-phase autotransformer.

3.Conducting experiments with a three-phase transformer. Checking the characteristics and parameters of a three-phase two-winding transformer in the conditions of continuous operation and short circuit. Determining the connection groups of three-phase two-winding transformers.

4.Conducting experiments with a 400/690 V short-circuited asynchronous motor. Conducting experiments with a 230/400 V short-circuited asynchronous motor. Checking the continuous operation and short-circuit characteristics of a three-phase squirrel-cage rotor asynchronous motor and determining its parameters. Checking the operating characteristics of a three-phase squirrel-cage rotor asynchronous motor.

5.Conducting an experiment with a capacitor F electric motor.

6.Checking the characteristics of the synchronous generator for single-phase operation and load. Checking the external and adjustment characteristics of the synchronous generator.

7.Checking the characteristics of the synchronous generator in parallel with the electrical network and the V-shaped characteristics.

8.Conducting an experiment with a universal electric motor. Checking the operating characteristics of a three-phase synchronous motor.

9.Conducting an experiment with shunt-parallel excitation machines. Checking the condition of an independent excitation DC generator with an armature rotation speed of n=nn=const.

10.Experiment with step-by-step machines. Checking the details of adjustment, external and short-circuit.

11.Checking linear DC motors.

12.Checking a mixed-excitation DC motor.

III. Instructions and recommendations for practical training

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

Recommended practice topics:

1.Determination of the main parameters of a single-phase toroidal transformer;

2.Determination of the connection group of single- and three-phase transformer windings;

3.Determination of the parameters of single-phase toroidal and Scott transformers for short-circuit and short-circuit operation;

4.Determination of the voltage drop of a transformer operating with a load. Determination of the parameters of autotransformers.

5.Calculation of the useful efficiency of the transformer depending on its power;

6.Checking the conditions for parallel connection of transformers;

7.Starting an asynchronous motor using additional resistance;

8.Determination of the parameters of a repulsion electric motor;

9.Solving problems related to methods for adjusting the rotation frequency of an asynchronous motor;

10.Determination of the parameters of capacitor electric motors;

11.Calculation of the capacities of the working and starting capacitors for connecting a three-phase asynchronous motor to a single-phase network;

12.Calculation of the parameters of short-circuit motors with an alander chain;

13.Construction of the adjustment characteristic of a synchronous generator;

14.Construction of the external characteristic of a synchronous generator;

15.Construction of the U-shaped characteristic of a synchronous generator;

16.Construction of the angular characteristic of a synchronous generator;

17.Construction of the U-shaped characteristic of a synchronous motor;

18.Calculation of power losses in DC machines;

19.Calculation of the parameters of multifunctional DC motors;

20.Determination of the main parameters of an DC motor;

21.External characteristic of DC generators;

22.Calculation of the mechanical characteristics of an DC motor;

23.Solving problems related to methods for adjusting the rotation frequency of an DC motor;

24.Calculation of the parameters of shunt-parallel-excited DC motors.

IV. Instructions and recommendations for the course project

The course project develops the skills of creative independent work, forms in students the skills of performing electromagnetic and thermal calculations of transformers and asynchronous motors. Each student is given an individual assignment. The topics of the course project are regularly reviewed and approved.

Sample topics of the course project

1. Perform electromagnetic and thermal calculations of a three-phase two-winding transformer with a total capacity of (…) kVA, high and low voltage values (…) V, connection scheme and group (….);

2. Perform electromagnetic and thermal calculations of a three-phase two-winding transformer with a total capacity of (…) kVA, high and low voltage values (…) V, connection scheme and group (….);

V.Independent learning and independent work.

Independent learning competence serves to support students' independent self-development and increase the effectiveness of professional activities. Students perform independent work on their mobile devices under the guidance of a teacher in a traditional or electronic form.

Independent study for the recommended topics:

1.Transformers by operating modes.

2.Types of special transformers.

3.General issues of alternating current machines.

4.Special asynchronous machines.

5.Special synchronous machines.

	6.Special direct current machines. 7.Calculation of the main parameters of the transformer based on experimental data. 8.Construction of a characteristic of the transformer in the case of sudden and short-circuit operation; 9.Construction of an external and adjusting characteristic of the transformer; 10.Calculation of the useful efficiency of the transformer depending on its power; 11.Checking the conditions for parallel connection of transformers; 12.Starting an asynchronous motor using additional resistance; 13.Determination of the operating characteristics of an asynchronous motor using a circular diagram of currents; 14.Accurate calculation of the mechanical characteristics of an asynchronous motor; 15.Calculation of the working and starting capacitor capacities for connecting a three-phase asynchronous motor to a single-phase network; 16.Construction of the Potye diagram of a synchronous generator; 17.Construction of the adjustment characteristic of a synchronous generator; 18.Calculation of power losses in AC machines; 19.Switching in AC machines; 20.Determination of the main parameters of an AC motor;
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.Salimov J.S., Pirmatov N.B. Elektr mashinalari.– T.: O'zbekiston faylasuflari milliy jamiyati nashiryoti, 2011. –408 b.

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

3.Majidov S. Elektr mashinalari va elektr yuritma. - T.: O'qituvchi, 2002. -358 b.

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

5.Testing of Power Transformers under participation of ° Carlson Ake Jitka Fuhr Gottfried Schemel Franz Wegscheider 1st Edition published by Pro Print GmbH, Düsseldorf ISBN 3-00-010400-3-2003.

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.Копылова И.П. Электрические машины: Учебник для бакалавр – Москва:. Юрайт, 2012. – 675 с.
9.Иванов – Смоленский А.В. Электрические машины. В 2-х т. Учебник для вузов.– М.: Изд–воМЭИ, 2004. Том. 1 – 652 с, Том 2 – 532 с.
10.Salimov J.S., Pirmatov N.B., Bekchanov B.E. Transformatorlar va avtotransformatorlar. T.: “VEKTOR-PRESS”, 2010.-224 b.
11.N.B.Pirmatov, A.S.Saodullayev, A.Y.Bekishev, N.A.Qurbonov «Elektr mashinalari» o’quv qo’llanma O’zbekiston Respublikasi Oliy va o’rta-maxsus ta’lim vazirligi. – Toshkent: «ZEBO PRINT» nashriyoti. 2022.-197 b.
12.A.Saodullayev, U.Mirzayev «Elektr mashinalari fanidan tajriba mashg’ulotlarini bajarishga oid uslubiy ko’rsatma» Jizzax-2022. JizPI nashriyoti, 60 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.Pirmatov N.B., Yarmuxamyedova Z.A., Mustafakulova G.N. Elyektr mashinalari fanining transformatorlar qismi bo‘yicha kurs loyihasini bajarishga oid o‘quv-myetodik qo‘llanma. –T.: ToshDTU, 2012 – 117 b.
18.Кацман М.М. Сборник задач по электрическим машинам. Учеб. Пособие для вузов. –Москва.: – Издательский центр «Академия». 2012. –154 с.
19.Mustafakulova G.N., Toshev Sh.E. Elektr mashinalari fanidan laboratoriya mashg‘ulotlarini bajarish uchun metodik ko‘rsatma. –T.: TDTU, 2015. – 45 b.
20.Pirmatov N.B., Zayniyeva O.E. Elektromexanika (Elektr mashinalari) fanidan masalalar to‘plami. O‘quv qo‘llanma. –T.: TDTU, 2004. – 75 b.

Internet resources:

21.www.ziyonet.uz
22.http://dhes.ime.mrsu.ru/studies/tot/tot_lit.htm;
23.http://rbip.bookchamber.ru/description.aspx?product_no=854;
24.http://energy-mgn.nm.ru/progr36.htm