National Technical University of Ukraine
Igor Sikorsky Kyiv Polytechnic Institute "

Department of
Electromechanical Systems
Automation and Electrical
Drives

ELECTRIC DRIVE

Working program of the academic discipline (Syllabus)

Details of the academic discipline	
Level of higher education	***First (undergraduate)***
Discipline	*14 "Electrical engineering"*
Specialty	*141 "Electric power engineering, electrical engineering and electromechanics"*
Educational program	*ELECTROMECHANICAL AUTOMATION SYSTEMS, ELECTRIC DRIVE AND ELECTRIC MOBILITY*
Discipline status	*Normative*
Form of education	*daytime*
Year of training, semester	*3 (2) course, fall semester*
Scope of the discipline	*150 hours / 5 ECTS credits*
Semester control/ control measures	*Exam /MKR/ Calculated - graphic work*
Class schedule	*http://rozklad.kpi.ua*
Language of teaching	*Ukrainian*
Information about the head of the course / teachers	*Lecturer* : *Ph.D. Krasnoshapka Natalia Dmitrivna, 0681262902* *Laboratory* : *Ph.D. Krasnoshapka Natalia Dmitrivna, 0681262902*
Placement of the course	*https://classroom.google.com/u/0/c/MTUyMzQzNjQ1OTEx*

Program of study discipline

1. **Description of the educational discipline, its purpose, subject of study and learning outcomes**

The program of the study discipline "Electric drive" was compiled in accordance with the educational program "Electromechanical systems of automation, electric drive and electromobility " of the bachelor's training, specialty 141 - Electric power engineering, electrical engineering and electromechanics.

The purpose of the educational discipline *is to form students of the following competencies : ZK02 – Ability to apply knowledge in practical situations; ZK03 – Ability to communicate in the state language both orally and in writing: ZK05 – Ability to search, process and analyze information from various sources; ZK06 – Ability to identify, pose and solve problems; From K07 – Ability to work in a team; ZK08 – Ability to work autonomously; ZK09 – The ability to realize one's rights and responsibilities as a member of society, to realize the values of civil (free democratic) society and the need for its sustainable development, the rule of law, the rights and freedoms of a person and a citizen in Ukraine; F K01 – Ability to solve practical problems using automated design and calculation systems (CAD); Ф K05 – Ability to solve complex specialized tasks and practical problems related to the operation of electric machines, devices and automated electric drive; FK07 – Ability to develop*

projects of electric power, electrotechnical and electromechanical equipment in compliance with the requirements of legislation, standards and technical specifications ; FK09 – Awareness of the need to improve the efficiency of electric power, electrotechnical and electromechanical equipment; FK10 – Awareness of the need to constantly expand one's own knowledge about new technologies in electric power, electrical engineering and electromechanics; FK11 – Ability to promptly take effective measures in emergency (emergency) situations in electric power and electromechanical systems; Ф К 17 – Ability to solve complex practical problems related to energy conversion in renewable sources and electric transport.

The subject of the educational discipline *is the main properties of electric drives, including their mechanical part and electromechanical properties of electromechanical converters of various types.*

Program learning outcomes, the improvement of which is aimed at the discipline : *PRN03 – Know the principles of operation of electric machines, devices and automated electric drives and be able to use them to solve practical problems in professional activities; PRN06 – Apply application software, microcontrollers and microprocessor technology to solve practical problems in professional activities; PRN07 – Analyze processes in electrical power, electrotechnical and electromechanical equipment, relevant complexes and systems; PRN08 – Choose and apply suitable methods for the analysis and synthesis of electromechanical and electric power systems with specified indicators; PRN09 – To be able to evaluate the energy efficiency and reliability of the operation of electric power, electrotechnical and electromechanical systems; PRN10 – Find the necessary information in scientific and technical literature, databases and other sources of information, evaluate its relevance and reliability; PRN11 – Communicate freely about professional problems in national and foreign languages orally and in writing, discuss the results of professional activity with specialists and non-specialists, argue one's position on debatable issues; PRN18 – To be able to learn independently, acquire new knowledge and improve the skills of working with modern equipment, measuring equipment and application software; PRN19 – Apply suitable empirical and theoretical methods to reduce the loss of electrical energy during its production, transportation, distribution and use PRN27 – Know the equations of motion of an electric drive for different types of masses; methods of calculating the mechanical part of the electric drive; methods of controlling DC and AC motors; methods of selecting electric motors by power.*

2. Pre-requisites and post-requisites of the discipline (place in the structural and logical scheme of training according to the relevant educational program)

To successfully master the discipline, the student must have knowledge of the disciplines "General Physics", "Theoretical Basics of Electrical Engineering", "Electric Machines", "Theory of Automatic Control". Competences, knowledge and skills acquired in the process of studying the discipline are necessary for further study of the educational components "Automated electric drive" and " Electromobility ", as well as for high-quality implementation of the diploma project (work).

3. Content of the academic discipline

*The discipline is structurally divided into **2 sections** , namely:*

*1. **Electric drive mechanics** .*

Topic 1.1. . Calculated schemes and rules of induction parameters .
Topic 1.2. Typical static load electric drive .
Topic 1. 3 . The equation of mechanical motion parts electric drive .
Topic 1.4. Dynamic properties of the elastic mechanical part of the electric drive.
Topic 1. 5 . Modes work electric drive .
Topic 1.6. Dynamic loads of the electric drive .
Topic 1.7. Optimization of the transmission ratio of the kinematic chain

2. ***Electromechanical conversion of energy and electromechanical properties of engines*** .

Topic 2.1. Electromechanical properties engines direct current .
Topic 2.2. Electromechanical properties engines alternating current .
Topic 2.3. Electromechanical properties others types engines .
Topic 2.4. Interconnected electric drives.

4. Educational materials and resources

Main information resources:

1. *Electric drive: Mechanics of an electric drive. Electromechanical conversion of energy and electromechanical properties of DC motors: [Electronic resource]: training . help for studies specialty 141 "Electroenergetics, electrical engineering and electromechanics" / KPI named after Igor Sikorskyi ; comp.: V.M. Pyzhov , N.D. Krasnoshapka , M.Ya. Ostroverkhov. – Electronic textual data (1 file: 2.48 MB). – Kyiv : KPI named after Igor Sikorsky , 2019. – 198 p. (access through the link https://ela.kpi.ua/handle/123456789/41950).*
2. *Theory electric drive : Textbook / Ed. M.G. Popovich - K.: V ischa school, 1993. - 494 p.*
3. *A. A. Vydmysh , L. V. Yaroshenko. Foundations electric drive . Theory and practice. Part 1. / Educational guide . – Vinnytsia : VNAU, 2020. – 387 p. + Vasilega P.O. Electric drive workers machines: textbook / P. O. Vasilega . – Amounts : Sumy state University , 2022. – 290 p.*
4. *Bezruchenko V. M. Theory electric drive [Electronic resource] : textbook . Dnipropetrovsk : DNUZT, 2011. Access mode http://eadnurt.diit.edu.ua/jspui/handle/123456789/402*
5. *Zelenov A.B. Theory electric drive : Design methodology electric drives : Textbook . – Luhansk : PUBLISHING House " Knowledge ", 2010. – 670 p.*
6. *Electromechanical automatic control systems and electric drives / Ed. M.G. Popovich - K.: Lybid , 2005. – 672 p.*
7. *theory -1: Methodical instructions for execution laboratory works for students specialty 141 - " Electric power engineering , electrical engineering and electromechanics " specialization " Electromechanical systems automation and electric drive » / Comp. N.D. Krasnoshapka , V.M. Pyzhov , M.V. Pushkar - Kyiv: KPI named after Igor Sikorsky , 2017. – 48 p. (access through the link https://ela.kpi.ua/handle/123456789/31848)*
8. *Electric drive. Calculation and graphic work [Electronic resource]: teaching . help for studies specialty 141 "Electroenergetics, electrical engineering and electromechanics" / KPI named after Igor Sikorskyi; editor: S.O., Buryan, N.D. Krasnoshapka , M.Ya. Ostroverkhov – K.: KPI named after Igor - Electronic text data (1 file: 1.41 MB). – Kyiv: KPI named after Igor Sikorskyi, 2019. – 61 p. (access via the link https://ela.kpi.ua/handle/123456789/41847) .*

Additional:

9. *Leonhard W. Control of Electrical Drives. Berlin: Springer-Verlag, 2001.*
10. *Methodical instructions for practical classes in the discipline " Theory electric drive -1" for students directly training 6.050702 - " Electromechanics " specialty " Electromechanical systems automation and electric drive » / incl . O.I. Kiselichnyk , N.D. Red hat . - K.: NTUU "KPI", 2015. - 33 p.*

Educational content

5. Methods of mastering an educational discipline (educational component)

Lecture classes

No s/p	The name of the topic of the lecture and a list of main questions (list of didactic tools, links to information sources)
1	**Introduction** *Development and species electric drive . The main ones functions and coordinates management electric drive . Definition and composition of the electric drive according to to the standard . Place electric drive in the structure electromechanical systems . Property theories electric drive and its communication from fundamental and professionally oriented disciplines cycles preparation . Literature [1], [2], [3].*
2	*Topic 1.1. Calculation schemes and parameters reduction rules* *The sequence of development of the calculation scheme of the mechanical part of the electromechanical system. Kinematic scheme and parameters mechanical parts electromechanical systems . Conditions lead parameters real scheme to settlement . Lead rules parameters to one speed Simplification rules initial calculation schemes. Typical calculation schemes mechanical parts .. Literature [1], [2], [3].*
3	*Topic 1.2. Typical static loads of the electric drive* *Typical static load electric drive . Composition of moments which act on the mechanical part Static moments and moments useful load Mechanical characteristics of the mechanism . Kinds static moments Accounting losses in the elements kinematic chain .. Literature [1], [2], [3].*
4	*Topic 1.3. The equation of motion of the mechanical part of the electric drive* *Sequence composition and equation of motion of mechanical parts electric drive . General form of record differential equations in the form Lagrange equation of the 2nd kind. Equations of motion and structural diagram of a one-mass calculation schemes . Equations of motion and structural diagram of a two-mass calculation scheme without taking into account internal viscous friction Equations of motion and structural diagram of a two-mass calculation scheme taking into account internal viscous friction Equations of motion and structural diagram of a two-mass calculation schemes with clearance not taken into account internal viscous friction Equations of motion and structural diagram of a two-mass calculation schemes with clearance taken into account internal viscous friction Equations of motion of mechanisms from non-linear kinematic connection .. Literature [1], [2], [3].*
5	*Topic 1.4. Dynamic properties of the elastic mechanical part of the electric drive* *Dynamic properties elastic mechanical parts electric drive . Transmission function two-mass calculation scheme by the controller variable . Characteristic equation system and its roots Analysis properties elastic mechanical parts based on the type of roots equation and respectively parameters mechanical parts Literature [1], [2], [3], [4] .*
6	*Topic 1.5. Operating modes of the electric drive* *Static and dynamic modes of operation of the electric drive . Static mechanical characteristics and their parameters. Condition of stability of steady motion. Mechanical transient processes with a constant dynamic moment, typical examples. Mechanical transient processes with a dynamic moment that depends linearly on the speed. The transient process of starting the electric drive represented by the two-mass calculation scheme. Literature [1], [2], [3].*
7	*Topic 1.6. Dynamic loads of the electric drive* *Dynamic loads of the electric drive. Dynamic loads with a single-mass calculation scheme and a two-mass scheme with a gap. Dynamic load factor.* *Topic 1.7. Optimization of the transmission ratio of the kinematic chain*

	Optimization of the transmission ratio of the kinematic chain. Criteria for optimizing the gear ratio of the kinematic circle. Determination of the gear ratio based on the differential equation of motion of the system. . Literature [1], [2], [3]. *Modular control work.*
8	*Topic 2.1. Electromechanical properties of DC motors* *Kinds engines direct current. Structural diagram of electromechanical converter . Modes work converter energy Advantages and disadvantages engines direct current. Kinds engines depending from implementation systems excitement . Literature [1], [2], [3].*
9	*Electromechanical properties engines direct current with independent excitement Passport data Switching scheme . Equation electromechanical and mechanical characteristics. Natural and artificial mechanical characteristics. Management speed at the expense of changes armature voltage , magnetic flux and changes electric resistance of the armature circle. Advantages and disadvantages ways management speed Literature [1], [2], [3].*
10	*Change direction of movement, start-up and modes braking engine direct current with independent excitement Methods changes direction of movement, them advantages and disadvantages . Kinds braking engine , them advantages and disadvantages . Mechanical characteristics of the engine in braking modes. Control of the amount of the braking moment . Launch methods . Intensity selector . Calculation electric resistances of the starting rheostat. Literature [1], [2], [3].*
11	*Dynamic properties electromechanical converter engine direct current with independent excitement Transmission function electromechanical converter . Structural schemes engine direct current with independent excitation when feeding the armature circuit from sources voltage and current. Equation dynamic mechanical and electrodynamic characteristics. Dynamic stiffness characteristics. established dynamic process under by the action of a static moment with a periodic one constituent Literature [1], [2], [3].*
12	*Electromechanical properties of a DC motor with serial excitation. Scheme of turning on the engine. Equations of electromechanical and mechanical characteristics. Artificial mechanical characteristics and speed control methods. Changing the direction of movement of the engine. Engine braking modes. Structural diagram of a DC motor with series excitation.* *Electromechanical properties of a DC motor with mixed excitation. Scheme of turning on the engine. Natural and artificial mechanical characteristics. Speed control methods. Changing the direction of movement of the engine. Engine braking modes. . Literature [1], [2], [3].*
13	*Topic 2.2. Electromechanical properties of alternating current motors* *Electromechanical properties of an asynchronous motor. Advantages and disadvantages of the engine. Types of engines. Passport data. Schemes of turning on the stator winding. Engine phase replacement diagram. Basic mathematical dependencies. Engine slippage. Natural mechanical and electromechanical characteristics, its characteristic points . Literature [1], [2], [3].*
14	*Artificial mechanical characteristics of an asynchronous motor and methods management speed Mechanical characteristics of an asynchronous motor and methods management speed at the expense of changes amplitudes , frequencies voltage power supply , electrical resistance of the rotor circuit, changes in the number of pole pairs and use energy sliding in cascade schemes, changes electrical resistance of the stator circuit and double feeding engine . Literature [1], [2], [3].*
15	*Changing the direction of movement, starting and braking modes of an asynchronous motor. The method of changing the direction of movement of the engine and the*

	corresponding mechanical characteristics. Starting the motor with a short-circuited rotor and a phase rotor. Types of asynchronous motor braking, advantages and disadvantages. Mechanical characteristics and ways of controlling the amount of braking torque. *Dynamic properties of an asynchronous motor. Simplified transfer function of the electromechanical converter of an asynchronous motor. Transmission function of the motor and mechanical characteristics when powered from a voltage and current source . Literature [1], [2], [3].*
16	*Electromechanical properties of a synchronous motor . Advantages and disadvantages engine . Schemes enabling engine . Angular and mechanical characteristics. Management speed Dynamic properties engine and its structural diagram ., Literature [1], [2], [3].*
17	*Topic 2.3. Electromechanical properties of other types of engines* *Electromechanical properties of other types of engines. Arc stator and linear asynchronous motors: design, mechanical characteristics, advantages and disadvantages. Valve Engine: Design, Equations of Mechanical Characteristics, Speed Control and Artificial Mechanical Characteristics, Advantages and Disadvantages. Stepper motor: design, principle of operation, mechanical characteristics . Literature [1], [2], [3].*
18	*Topic 2.4. Interconnected electric drives* *Interconnected electric drives. Electric drive with a mechanical connection of shafts: mechanical characteristics, moments of the electric drive as a whole and individual motors, methods of equalizing the motor load. Electric drive with an electric shaft: typical schemes, principle of operation. Literature [1], [2], [3].* *Modular control work.*

Practical classes

No s/p	*Name of the subject of the lesson and list of main questions (list of didactic tools, links to information sources)*
1	*Electric drive mechanics. One-mass calculation scheme.* *SRS: Calculation of parameters of lifting mechanisms and machines.* *Literature [1], [2], [3], [10].*
2	*Electric drive mechanics. Two-mass calculation scheme.* *SRS: Calculation of parameters of mechanisms with a two-mass mechanical part.* *Literature [1], [2], [3], [10].*
3	*Electromechanical properties of a DC motor with independent excitation.* *SRS: Calculation of natural and artificial mechanical characteristics.* *Literature [1], [2], [3], [10].*
4	*Braking modes of a DC motor with independent excitation.* *SRS: Calculation of mechanical characteristics in braking modes.* *Literature [1], [2], [3], [10].*
5	*Electromechanical properties of a DC motor with serial excitation.* *SRS: Calculation of mechanical characteristics in different modes of operation.* *Literature [1], [2], [3], [10].*
6	*Electromechanical properties of an asynchronous motor.* *SRS: Calculation of natural and artificial mechanical characteristics.* *Literature [2], [3], [4], [10].*
7	*Braking modes of an asynchronous motor.* *SRS: Calculation of mechanical characteristics in braking modes.* *Literature [2], [3], [4], [10].*
8	*System "controlled converter-motor".*

	SRS: Calculation of mechanical characteristics during speed control. *Literature [2], [3], [4], [10].*
9	*Interrelated electric drive .* *SRS: Calculation mechanical characteristics and definition workers point* *Literature [2], [3], [4], [10].*

Laboratory work

No s/p	***List of laboratory works***	***Number audio hours***
1.	***Introductory lesson***	*2*
2.	***Laboratory work No. 1*** *. Research mechanical characteristics of engines direct current with independent excitement*	*4*
3.	***Laboratory work No. 2*** *. Study of mechanical characteristics of DC motors with series excitation.*	*4*
4.	***Laboratory work No. 3*** *. Study of the static characteristics of the electric drive according to the SHIP-D scheme*	*4*
5.	***Laboratory work No. 4*** *. Study of the mechanical characteristics of an asynchronous motor with a phase rotor.*	*4*

Calculation and graphic work (RGR)

As an individual task, students perform calculation and graphic work (RGR). The purpose of RGR is to consolidate theoretical knowledge of the discipline, students to acquire practical skills of independent solution of problems in the calculation and research of the electric drive. Students perform one calculation and graphic work (RGR), which contains the following questions: kinematic diagram of the electric drive; bringing moments of inertia, masses, static moments and forces, stiffness and damping coefficients to one speed; consideration of losses in the kinematic chain; simplification of calculation schemes of real mechanisms; calculation of engine parameters based on passport data; construction of natural and artificial mechanical characteristics of DC motors with independent excitation; organization of braking modes of operation; study of the structural scheme of the engine; electromechanical transient processes. The topics and tasks for RGR are given in [8] section "Basic Literature".

6. Student's independent work

No s/p	*Type of independent work*	*Number hours of SRS*
1	*Preparation for lectures*	*9*

2	*Preparation for practical classes*	*9*
3	*Preparation for laboratory work*	*9*
4	*Implementation and protection of RGR*	*15*
5	*Preparation for MKR*	*6*
6	*Preparation for the exam*	*30*
	Together	*78*

Policy and control

7. Policy of academic discipline (educational component)

The system of requirements that the teacher sets before the student:

- *rules for attending classes: in accordance with Order 1-273 dated 14.09.2020, it is prohibited to evaluate the presence or absence of the winner at the classroom class, including the awarding of incentive or penalty points. According to the RSO of this discipline, points are awarded for the relevant types of educational activity in lectures and the performance and defense of laboratory work.*
- *rules of behavior in classes: the student has the opportunity to receive points for the appropriate types of educational activity in lectures and laboratory classes, provided by the RSO of the discipline. The use of means of communication to search for information on the teacher's Google Drive, on the Internet, in a distance course on the Sikorsky platform is carried out on the condition that the teacher instructs;*
- *rules for the protection of individual tasks: the protection of the RGR from the discipline is carried out individually.*
- *policy of deadlines and rescheduling: if a student did not pass or did not appear at the MKR (without a valid reason), his result is evaluated at 0 points. Recompilation of MKR results is not provided for;*
- *policy on academic integrity: the Code of Honor of the National Technical University of Ukraine "Kyiv Polytechnic Institute" https://kpi.ua/files/honorcode.pdf establishes general moral principles, rules of ethical behavior of individuals and provides a policy of academic integrity for persons working and studying at the university, which they should be guided by in their activities, including when studying and preparing control measures in the discipline "Electric drive";*
- *when using digital means of communication with the teacher (mobile communication, e-mail, correspondence on forums and social networks, etc.), it is necessary to observe generally accepted ethical norms, in particular, to be polite and limit communication to the working hours of the teacher.*

8. Types of control and rating system for evaluating learning outcomes (RSO)

Current control *: MKR, implementation and protection of RGR, implementation and protection of laboratory work.*

Calendar control *: is carried out twice a semester as a monitoring of the current state of meeting the requirements of the syllabus .*

Semester control: *exam.*

Conditions for admission to the semester control *: defense of all laboratory work, performance and defense of calculation and graphic work, starting rating of at least 25 points.*

Table of correspondence of rating points to grades on the university scale:

Number of points	*Rating*
95-100	*Perfectly*

85-94	*Very good*
75-84	*Good*
65-74	*Satisfactorily*
60-64	*Enough*
Less than 60	*Unsatisfactorily*
The conditions for admission to the semester control have not been met	*Not allowed*

The student's overall rating after the end of the semester consists of points obtained for:

- *work in practical classes;*
- *performance and protection of laboratory work;*
- *performance and protection of calculation and graphic work;*
- *execution of modular control works (MCR).*

Work in practical classes	*performance and protection of laboratory work*	*RGR*	*MKR*
9	*20*	*13*	*18*

Work in practical classes

The weighted score of the lesson is 1.

The maximum number of points for all practical classes is 1 point x 9 classes = 9 points.

Evaluation criteria

- *active participation and correct independent solution of the problem - 1 point;*

Performance and protection of laboratory work

Weight score – 5.

The maximum number of points for all 4 laboratory works is 5 points × 4 = 20 points.

Evaluation criteria

Implementation:

- *full and timely performance of work - 1 point;*

Protection:

- *the protocol is prepared without errors, the answers to the questions are clear and meaningful, the correct answers are at least 90% - 4 points;*
- *the protocol is prepared with some inaccuracies, the answers to the questions have minor errors, the correct answers are at least 75% - 3 points;*
- *the protocol is prepared with errors, the answers to the questions are unclear and have significant errors, the correct answers are at least 50% - 2 points;*
- *the protocol is prepared with errors, the student does not actively participate in the performance of laboratory work, the answers to the questions are incorrect. Laboratory work is not protected - 0 points;*
- *repeated defense of laboratory work or defense of laboratory work beyond the set deadline without a good reason - a fine of 1 point;*

Individual semester assignment (calculation and graphic work)

According to the working curriculum, each student performs calculation and graphic work.

The maximum number of points for the execution of the RGR is 13 and consists of the maximum point for registration - 3 points, for protection - 10 points.

Evaluation criteria

For registration:

- compliance with registration requirements - 3 points;
- slight deviation from the requirements for registration - 2 points;
- significant deviation from the registration requirements - 1 point;
- RGR is not properly executed - 0 points and is returned for processing.

For protection:

- understanding of the presented material, complete answers to the defense questions - 9–10 points;
- understanding of the presented material, complete answers to the defense questions with some inaccuracies - 7–8 points;
- incomplete answers to defense questions - 6 points;
- the work is completed with significant errors, the student cannot give an answer to the defense - 0 points.

Untimely protection of the RGR without a good reason - a fine of 1 point

Modular control work

The number of MKRs is 2, each lasting 1 academic hour
The MKR weight score is 9.
The maximum score for MKR is 9 × 2=18.

Evaluation criteria

- *complete answer to the question (more than 90% of the required information) - 8 - 9 points;*
- *sufficiently complete answer (at least 75% of the required information) - 7 points;*
- *incomplete answer (at least 50% of the required information) - 5 - 6 points;*
- *the answer contains less than 50% of the necessary information - 0 points.*

Additional (bonus) points

The rating system provides additional points for completing additional tasks. One student cannot receive more than 5 bonus points in a semester. When receiving more than 5 points, they are limited to the level of 5. Bonus points can be received for the following types of work "Tasks to lectures".

Tasks for lectures *. Students, if they wish, can perform additional tasks based on lecture materials (solve an example, work out additional questions). 0.5 points are awarded for one additional task. The maximum number of points that can be obtained for assignments before lectures is 5 points.*

Calendar control is based on the current rating. A condition for a positive assessment is the value of the student's current rating of at least 50% of the maximum possible at the time of assessment.

The form of semester control is an exam

The maximum amount of points makes up 4 0.
A necessary condition for admission to the exam is the completion and defense of all laboratory work, the completion and defense of calculation and graphic work, a starting rating of at least 30 points.
The exam paper consists of answers to three theoretical questions and one practical task.

Evaluation criteria of the exam

Each question is worth 10 points.
The evaluation system of theoretical questions:
- "excellent", complete answer (at least 90% of the required information) - 9-10 points;

- "good", a sufficiently complete answer (at least 75% of the required information), or a complete answer with minor inaccuracies - 8 points;
- "satisfactory", incomplete answer (at least 60% of the required information) and minor errors - 6-7 points;
- "unsatisfactory", an unsatisfactory answer (does not meet the requirements for 6 points) - 0 points.
Evaluation system of the practical task :
- "excellent", complete error-free solution of the task - 9-10 points;
- "good", complete solution of the task with insignificant inaccuracies - 8 points;
- "satisfactory", the task was completed with certain shortcomings - 6-7 points;
- "unsatisfactory", task not completed - 0 points.

Starting amount points and points for the examination the control paper is transferred to the examination paper evaluations according to the table:

Rating rating (sum of points)	*Traditional rating*
95-100	*Perfectly*
85-94	*Very good*
75-84	*Good*
65-74	*Satisfactorily*
60-64	*Enough*
Less 60	*Unsatisfactorily*
Admission conditions not met	*Not allowed*

9. Additional information on the discipline (educational component)

List of topics that are submitted for semester control

1. *Kinematic scheme and parameters of the mechanical part of the electromechanical system. Conditions for reducing the parameters of the real scheme to the estimated one. Rules for reducing parameters to one speed. Rules for simplifying initial calculation schemes. Typical calculation schemes of the mechanical part.*
2. *Typical static loads of the electric drive . Composition of moments acting on the mechanical part. Static and payload moments. Mechanical characteristics of the mechanism. Types of static moments. Accounting for losses in the elements of the kinematic chain.*
3. *Assembly sequence and equation of motion of the mechanical part of the electric drive. The general form of writing differential equations in the form of a Lagrange equation of the 2nd kind. Equations of motion and structural diagram of a one-mass calculation scheme. Equations of motion and structural diagram of the two-mass calculation scheme without taking into account internal viscous friction. Equations of motion and a structural diagram of a two-mass calculation scheme taking into account internal viscous friction. Equations of motion and structural diagram of a two-mass calculation scheme with a gap without taking into account internal viscous friction. Equations of motion and structural diagram of a two-mass calculation scheme with a gap taking into account internal viscous friction. Equations of motion of mechanisms with nonlinear kinematic connection.*
4. *Dynamic properties of the elastic mechanical part of the electric drive. The transfer function of the two-mass calculation scheme by the control variable. The characteristic equation of the system and its roots. Analysis of the properties of the elastic mechanical*

part based on the form of the roots of the equation and, accordingly, the parameters of the mechanical part.

5. *Mechanical transient processes with a constant dynamic moment, typical examples. Mechanical transient processes with a dynamic moment that depends linearly on the speed. The transient process of starting the electric drive represented by the two-mass calculation scheme.*
6. *Dynamic loads of the electric drive. Dynamic loads with a single-mass calculation scheme and a two-mass scheme with a gap. Dynamic load coefficient.*
7. *Optimization of the transmission ratio of the kinematic chain. Criteria for optimizing the gear ratio of the kinematic circle. Determination of the gear ratio based on the differential equation of motion of the system.*
8. *Types of DC motors. Structural diagram of an electromechanical converter. Modes of operation of the energy converter. Advantages and disadvantages of DC motors. Types of engines depending on the performance of the excitation system.*
9. *Electromechanical properties of DC motors with independent excitation . Passport data. Switching scheme. Equations of electromechanical and mechanical characteristics. Natural and artificial mechanical characteristics. Speed control by changing the armature voltage, magnetic flux and changing the electrical resistance of the armature circuit. Advantages and disadvantages of speed control methods.*
10. *Reversing, starting and braking modes of an independently excited DC motor. Ways of changing the direction of movement, their advantages and disadvantages. Types of engine braking, their advantages and disadvantages. Mechanical characteristics of the engine in braking modes. Control of the amount of braking moment. Launch methods. Intensity selector . Calculation of electrical resistances of the starting rheostat.*
11. *Dynamic properties of an electromechanical converter of a DC motor with independent excitation. The transfer function of the electromechanical converter. Structural diagrams of a DC motor with independent excitation when feeding the armature circuit from a voltage and current source. Equations of dynamic mechanical and electrodynamic characteristics. Dynamic stiffness characteristics. A steady dynamic process under the action of a static moment with a periodic component.*
12. *Electromechanical properties of a DC motor with serial excitation. Scheme of turning on the engine. Equations of electromechanical and mechanical characteristics. Artificial mechanical characteristics and speed control methods. Changing the direction of movement of the engine. Engine braking modes. Structural diagram of a DC motor with series excitation.*
13. *Electromechanical properties of a DC motor with mixed excitation. Scheme of turning on the engine. Natural and artificial mechanical characteristics. Speed control methods. Changing the direction of movement of the engine. Engine braking modes.*
14. *Electromechanical properties of an asynchronous motor. Advantages and disadvantages of the engine. Types of engines. Passport data. Schemes of turning on the stator winding. Engine phase replacement diagram. Basic mathematical dependencies. Engine slippage. Natural mechanical and electromechanical characteristics, its characteristic points.*
15. *Artificial mechanical characteristics of an induction motor and speed control methods. Mechanical characteristics of an asynchronous motor and methods of speed control by changing the amplitude, frequency of the supply voltage, electrical resistance of the rotor circuit, changing the number of pole pairs and using slip energy in cascade circuits, changing the electrical resistance of the stator circuit and dual power supply of the motor.*

16. *Changing the direction of movement, starting and braking modes of an asynchronous motor. The method of changing the direction of movement of the engine and the corresponding mechanical characteristics. Motor start with short-circuited rotor and phase rotor. Types of asynchronous motor braking, advantages and disadvantages. Mechanical characteristics and ways of controlling the amount of braking torque.*
17. *Dynamic properties of an asynchronous motor. Simplified transfer function of the electromechanical converter of an asynchronous motor. Motor transfer function and mechanical characteristics when powered from a voltage and current source.*
18. *Electromechanical properties of a synchronous motor. Advantages and disadvantages of the engine. Engine start-up schemes. Angular and mechanical characteristics. Speed control. Dynamic properties of the engine and its structural diagram.*
19. *Electromechanical properties of other types of engines. Arc stator and linear asynchronous motors: design, mechanical characteristics, advantages and disadvantages. Valve Engine: Design, Equations of Mechanical Characteristics, Speed Control and Artificial Mechanical Characteristics, Advantages and Disadvantages. Stepper motor: design, principle of operation, mechanical characteristics .*
20. *Interconnected electric drives. Electric drive with a mechanical connection of shafts: mechanical characteristics, moments of the electric drive as a whole and individual motors, methods of equalizing the motor load. Electric drive with an electric shaft: typical schemes, principle of operation.*

Working program of the academic discipline (syllabus):

Compiled by an associate professor of the Department of Automation of Electromechanical Systems and Electric Drives, Ph.D. Krasnoshapka N.D.

Approved by the Department of Automation of Electromechanical Systems and Electric Drives (Protocol No. 15 dated 13.06.2024)

Agreed by the Methodical Commission of the faculty (protocol No. 10 of June 20 , 2024)