Ministry of Education and Science of Ukraine

Dnipro University of Technology

Department of Electrical Engineering

«APPROVED»
Head of Departrment
Tsyplenkov D.V. _____
«_30_»____08_____2022

WORK PROGRAM OF THE ACADEMIC DISCIPLINE

«Electric Machines»

Field of study	14 Electrical engineering
Specialty	141 Electrical energetics, electrical engineering and electromechanics
Academic level	first (bachelor)
Academic program	«Electrical energetics, electrical engineering and electromechanics»
Specialization	-
Status	normative
Total workload	6 credits ECTS (180 hours)
Type of summative assessment	exam
Period of study	3, 4 semesters (6-8 terms)
Language of study	English

Lecturer: Prof. Ivanov O.B.

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Dnipro
DNIPROTECH
2022

Work program of the academic discipline «Electric Machines» for bachelors of the educational and professional program «Electrical energetics, electrical engineering and electromechanics» of the specialty 141 Electrical energetics, electrical engineering and electromechanics / Dnipro University of Technology, Department of Electrical Engineering. – D.: DNIPROTECH, 2022 – 17 p.

Author:

– Ivanov Oleksii Borysovych –Professor, Candidate of Technical Sciences, Professor of the Department of Electrical Engineering.

The work program regulates:

- the aim of the discipline;
- the disciplinary learning outcomes generated through the transformation of the intended learning outcomes of the degree program;
- basic disciplines;
- volume and distribution by forms of organization of the educational process and types of classes;
- discipline program (thematic plan by type of training);
- algorithm for assessing the level of achievement of disciplinary learning outcomes (scales, tools, procedures and assessment criteria);
- tools, equipment and software;
- recommended sources of information.

The work program is designed to implement a competency approach in planning an education process, delivery of the academic discipline, preparing students for control activities, controlling the implementation of educational activities, internal and external quality assurance in higher education, accreditation of degree programs within the specialty.

Approved by the decision of the Scientific and Methodological Commission of the specialty 141 Electrical energetics, electrical engineering and electromechanics (protocol №21/22-07 of 14.07.2022).

CONTENTS

1 AIM OF THE DISCIPLINE

In the educational and professional program «Electrical energetics, electrical engineering and electromechanics» of the specialty 141 Electrical energetics, electrical engineering and electromechanics the distribution of program learning outcomes (PLO) for the organizational forms of the educational process is done. In particular, the following learning outcomes are attributed to the discipline Ф1 «Electric Machines»:

ПР03	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

The aim of the discipline – formation of competencies in the classification, design, principle of operation, features of operation, characteristics and design of electrical machines.

The implementation of the aim requires transforming program learning outcomes into the disciplinary ones as well as an adequate selection of the contents of the discipline according to this criterion.

2 INTENDED DISCIPLINARY LEARNING OUTCOMES

Code PLO	**Discipline learning results (DLO)**	
	Code DLO	**contents**
ПР03	ПР03.1-Ф1	To determine principle of construction and functioning of electric machines units as part of electric power, electrical, and electromechanical complexes, and systems.
	ПР03.2-Ф1	To assess working parameters of electric machines as part of electrical, electric power, and electromechanical equipment and relevant complexes and systems, and to develop measures of their energy efficiency and reliability improvement.
	ПР03.3-Ф1	To solve professional tasks on designing and maintenance of electric machines.
	ПР03.4-Ф1	To master methods of electric machines with specified properties synthesis.
	ПР03.5-Ф1	To carry out tasks of technical maintenance of electric machines as part of electromechanical systems, electric power stations, substations, systems, and networks electrical equipment by means of relevant instructions and practical skills.
	ПР03.6-Ф1	To carry out new ways for solving problems of economic conversion, distribution, transmission, and application of electrical energy by means of electric machines.

3 BASIC DISCIPLINES

Discipline name	**Achieved learning outcomes**
Б2 «General physics»	ПР07.2-Б2 To analyze physical mechanisms that are essential when considering processes in electric power, electrotechnical and electromechanical equipment, relevant complexes and systems. ПР07.3-Б2 Formation of abilities to generalize, analyze, perceive information, set a scientific problem and choose a way to solve it.

Discipline name	Achieved learning outcomes
	ПР08.2-Б2 Apply knowledge of the basic fundamental laws of classical and modern physics to solve electrical engineering problems. ПР08.3-Б2 correctly reproduce physical ideas and correctly apply the principles and laws of physics for the analysis and synthesis of electromechanical and electric power systems with specified indicators
Б1 «Higher Mathematics»	ПР07.2-Б1 Be able to use a mathematical apparatus for objective analysis of processes in electromechanical equipment. ПР08.1-Б1 Know the principles of solving technical problems based on mathematical analysis, construction and solution of differential equations.
Б3 «Computing and programming»	ПР06 To apply application software, microcontrollers and microprocessor technology to solve practical problems in professional activities.
Ф3 «Fundamentals of metrology and electrical measurements»	ПР02 To know and understand the theoretical foundations of metrology and electrical measurements, the principles of automatic control devices, relay protection and automation, have the skills to perform appropriate measurements and use these devices to solve professional problems. ПР 8.1- Ф3 Be able to learn independently, acquire new knowledge and improve skills in working with modern measuring equipment.
Б5 «Theoretical foundations of electrical engineering»	ПР05 To know the basics of the theory of the electromagnetic field, methods of calculating electric circuits and be able to use them to solve practical problems in professional activities.

4 WORKLOAD DISTRIBUTION BY THE FORM OF EDUCATIONAL PROCESS ORGANIZATION AND TYPES OF CLASSES

Types of classes	**Distribution by forms of education**, *hours*							
	Full-time			**Part-time**		**Extramural**		
	Volume	Classroom lessons	Self-study	Classroom lessons	Self-study	Volume	Classroom lessons	Self-study
lectures	120	52	68			120	8	112
practical								
laboratory	60	23	37			60	8	52
seminars								
TOTAL	180	75	105			180	16	164

5 DISCIPLINE PROGRAM BY TYPES OF CLASSES

Code DLO	**Types and topics of training sessions**	**Volume of components,** *hours*
ПР03.1-Ф1 ПР03.3-Ф1 ПР03.4-Ф1 ПР03.6-Ф1	**LECTURES**	**120**
	1. Transformers	**24**
	1.1 Principle of operation, construction, cooling	
	1.2 Induced voltage and magnetization curves, magnetizing current	

Code DLO	Types and topics of training sessions	Volume of components, *hours*
	1.3 Electromagnetic processes in transformers	
	1.4 Magnetic losses in transformers	
	1.5 Parameters and transformer equivalent circuit for no-load mode	
	1.6 Transformer magnetic field, and its equations under load	
	1.7 Equivalent circuit of loaded transformer	
	1.8 Transformation of three-phase currents	
	1.9 Experimental determination of transformer parameters	
	1.10 Performance characteristics and operating modes of transformers	
	1.11 Transformers parallel operation	
	1.12 Transformers of special types	
	2. Issues of general theory of AC machines	**8**
	2.1 Principles of energy conversion in electric machines	
	2.2 Structure of AC machine windings	
	2.3 Magnetic field of mutual induction of electric machines	
	2.4 Flux linkage and induced voltage of Ac winding	
	2.5 Electromagnetic torque of electric machine, electromechanical energy conversion	
	3. Asynchronous machines (induction machines)	**31**
	3.1. Construction of induction machines	
	3.2. Principle of induction machines operation	
	3.3. Analogy of processes in induction machine with equivalent locked rotor and in transformer	
	3.4. Induction machine voltage and current ratio	
	3.5. Equations of magnetomotive forces and currents of induction machine; no-load current	
	3.6. Induction machine parameters at rotating and locked rotor. Rotor current as a function of slip	
	3.7. Quantities and parameters of locked rotor referred to the stator side	
	3.8. Equations of referred induction machine with locked rotor	
	3.9. Equivalent locked rotor of induction machine; the machine equivalent circuits	
	3.10. Main set of equations of induction machine with equivalent locked rotor	
	3.11. Three-phase phase regulator. Three-phase voltage regulator.	
	3.12. Parameters, EMF and current of the rotating rotor	
	3.13. Main equations of an induction machine during rotor rotation.	
	3.14. Power flow diagram of induction motor	
	3.15. Efficiency of an induction machine.	

Code DLO	Types and topics of training sessions	Volume of components, *hours*
	3.16. Determination of the electromagnetic power and electromagnetic torque of an induction machine due to electrical losses in the rotor winding circuits.	
	3.17. Reducing electromagnetic processes during rotor rotation to processes in a transformer	
	3.18. Electromagnetic torque and characteristics of induction machine	
	3.19. The circular diagram of an induction machine and its use for determination of mechanical and operating characteristics. Additional features of the induction machine	
	3.20. Starting induction motors	
	3.21. Induction motors speed regulation	
	3.22. Operation of three-phase induction machines under non-symmetrical conditions	
	4. Synchronous machines	**21**
	4.1. Construction of synchronous machines	
	4.2. Processes in synchronous machines under no-load conditions	
	4.3. Magnetomotive force and armature circuit parameters	
	4.4. Electromagnetic processes in synchronous machine under load	
	4.5. Losses and efficiency of synchronous generators	
	4.6. Electromagnetic power and torque of synchronous machines	
	4.7. Characteristics of synchronous generator at independent operation	
	4.8. Switching synchronous generator to parallel operation with power network	
	4.9. Processes and properties of synchronous machine at parallel operation	
	4.10. Synchronous motors	
	4.11. Synchronous compensators	
	5. DC machines	**21**
	5.1. Construction of DC machines	
	5.2. Principle of operation	
	5.3. Armature windings. Equations of motors and generators armature winding circuit, armature current	
	5.4. Electromechanical energy conversion in DC machines	
	5.5. Rotational induced voltage in armature circuit; electromagnetic torque	
	5.6. Magnetic field of DC machine	
	5.7. Armature reaction of DC machine	
	5.8. Methods of weakening armature reaction in DC machines. Compensating winding	

Code DLO	Types and topics of training sessions	Volume of components, *hours*
	5.9. Commutation of armature current in DC machines	
	5.10. Generators with separate excitation	
	5.11. Generators with self-excitation	
	5.12. DC generators parallel operation	
	5.13. Circuitry of DC motors	
	5.14. Motors with separate and parallel excitation	
	5.15. Motors with series excitation	
	5.16. Compound motors	
	6. Special electric machines	**15**
	6.1. Single-phase AC motors	
	6.2. Special induction machines	
	6.3. Asynchronous electrical machine automation devices	
	6.4. Special synchronous machines	
	6.5. Special types of DC machines	
	6.6. Commutator AC machines	
	LABORATORY LESSONS	**60**
ПР03.2-Ф1 ПР03.5-Ф1	Determination of transformer ratings and its testing	4
	Testing of transformer under conditions of open circuit and short-cir cuit operation	4
	Transformers parallel operation	4
	Study of induction motors construction and principle	6
	Investigation of three-phase induction motor using data of no-load and short-circuit tests	6
	Investigation of induction motor working properties using method o direct loading	6
	Investigation of cage induction motors starting methods	6
	Investigation of parallel operation of synchronous generator con-nected to grid	6
	Asynchronous starting and investigation of synchronous motor at field current adjustment	6
	Investigation of dc generators	6
	Investigation of dc motors with shunt and compound excitation	6
	РАЗОМ	**180**

For the implementation of the mixed form of education of students, the electronic resources of the e-learning platform in the discipline are used: **https://do.nmu.org.ua/course/view.php?id=189**

6 KNOWLEDGE PROGRESS TESTING

Certification of student achievement is accomplished through transparent procedures based on objective criteria in accordance with the University Regulations “On Evaluation of Higher Education Applicants' Learning Outcomes”.

The level of competencies achieved in relation to the expectations, identified

during the control activities, reflects the real result of the student's study of the discipline.

6.1 Grading scales

Assessment of academic achievement of students of the Dnipro University of Technology is carried out based on a rating (100-point) and institutional grading scales. The latter is necessary (in the official absence of a national scale) to convert (transfer) grades for mobile students.

The scales of assessment of learning outcomes of the DNIPROTECH students

Rating	Institutional
90 ... 100	відмінно / Excellent
74 ... 89	добре / Good
60 ... 73	задовільно / Satisfactory
0 ... 59	незадовільно / Fail

Discipline credits are scored if the student has a final grade of at least 60 points. A lower grade is considered to be an academic debt that is subject to liquidation in accordance with the Regulations on the Organization of the Educational Process of DNIPROTECH.

6.2 Tools and procedures

The content of diagnostic tools is aimed at controlling the level of knowledge, proficiency/skills, communication, autonomy, and responsibility of the student according to the requirements of the National Qualifications Framework (NQF) up to the 6^{th} qualification level during the demonstration of the learning outcomes regulated by the work program.

During the control activities, the student should perform tasks focused solely on the demonstration of disciplinary learning outcomes (Section 2).

Diagnostic tools provided to students at the control activities in the form of tasks for the formative and summative knowledge progress testing are formed by specifying the initial data and a way of demonstrating disciplinary learning outcomes.

Diagnostic tools (control tasks) for the formative and summative knowledge progress testing are approved by the department.

Types of diagnostic tools and procedures for evaluating the formative and summative knowledge progress testing are given below.

Diagnostic and assessment procedures

FORMATIVE ASSESSMENT			**SUMMATIVE ASSESSMENT**	
training session	**diagnostic tools**	**procedures**	**diagnostic tools**	**procedures**
Lectures	Control task for each the topic	completing the assignment during the lecture	comprehensive control work (CCW)	determining the average results of formative assessments;

Laboratory lessons	verification and protection	performance of laboratory work		CCW performance during the differentiated test (6 term), exam (8 term) at the request of the student

During the formative assessment, lecture classes are evaluated by determining the quality of performance of specific control tasks. Laboratory classes are assessed by the quality of performance and defense of laboratory work.

If the content of a certain type of classes is subordinated to several components of the description of the qualification level according to the NQF, the integral value of the grade can be determined taking into account the weighting coefficients set by the lecturer.

Provided that the level of results of the formative assessments of all types of training at least 60 points, the summative assessment can be carried out without the student's immediate participation by determining the weighted average value of the obtained grades.

Regardless of the results of the formative assessments, every student has the right to perform the CCW, which contains tasks covering key disciplinary learning outcomes, during the differentiated test and exam.

The number of specific tasks of the CCW should be consistent with the allotted time for completion. The number of CCW options should ensure that the task is individualized.

The value of the mark for the implementation of the CCW is determined by the average evaluation of the components (specific tasks) and is final.

The integral value of the assessment of the implementation of the CCW can be determined taking into account the weighting coefficients established by the department for each component of the description of the qualification level of the NQF.

6.3 Criteria

Actual student learning outcomes are identified and measured relative to what is expected during the control activities using criteria that describe the student's actions to demonstrate the achievement of learning outcomes.

To assess the performance of control tasks during the formative assessment on lectures and laboratory classes the coefficient of mastery is used as a criterion, which automatically adapts the assessment indicator to the rating scale:

$$O_i = 100\ a/m,$$

where a is a number of correct answers or significant operations performed in accordance with the solution standard; m is the total number of questions or significant operations of the standard.

Individual tasks and complex control works are assessed expertly using criteria that characterize the ratio of requirements to the level of competencies and indicators of assessment on a rating scale.

The content of the criteria is based on the competency characteristics defined by the NQF for the bachelor's level of higher education (given below).

General criteria for achieving learning outcomes for the 6th qualification level of NQF (bachelor)

Description of qualification level	**Requirements for knowledge, proficiency/skills, communication, autonomy and responsibility**	**Indicator evaluation**
	Knowleges	
Conceptual scientific and practical knowledge, critical understanding of theories, principles, methods and concepts in the field of professional activity and / or training	The answer is excellent - correct, reasonable, meaningful. Characterizes the presence of: - conceptual knowledge; - high degree of knowledge of the state of the art; - critical understanding of the basic theories, principles, methods and concepts in education and professional activity	95-100
	The answer contains minor errors or omissions	90-94
	The answer is correct, but has some inaccuracies	85-89
	The answer is correct, but has some inaccuracies and is insufficiently substantiated	80-84
	The answer is correct, but has some inaccuracies, insufficiently substantiated and meaningful	74-79
	The answer is fragmentary	70-73
	The answer shows the student's vague ideas about the object of study	65-69
	The level of knowledge is minimally satisfactory	60-64
	The level of knowledge is unsatisfactory	<60
	Proficiency/Skills	
In-depth cognitive and practical skills, mastery and innovation at the level required to solve complex specialized tasks and practical problems in the field of professional activity or training	The answer characterizes the ability to: - identify problems; - formulate hypotheses; - solve problems; - choose appropriate methods and tools; - collect and interpret information logically and clearly; - use innovative approaches to solving problems	95-100
	The answer characterizes the ability to apply knowledge in practice with minor errors	90-94
	The answer characterizes the ability to apply knowledge in practice, but has some inaccuracies in the implementation of one requirement	85-89
	The answer characterizes the ability to apply knowledge in practice, but has some inaccuracies in the implementation of the two requirements	80-84
	The answer characterizes the ability to apply knowledge in practice, but has some inaccuracies in the implementation of the three requirements	74-79
	The answer characterizes the ability to apply knowledge in practice, but has some inaccuracies in the implementation of the four requirements	70-73
	The answer characterizes the ability to apply knowledge in practice when performing tasks on the model	65-69

Description of qualification level	Requirements for knowledge, proficiency/skills, communication, autonomy and responsibility	Indicator evaluation
	The answer characterizes the ability to apply knowledge in performing tasks on the model, but with inaccuracies	60-64
	The level of skills is unsatisfactory	<60
	Communication	
♦ reporting to specialists and non-specialists information, ideas, problems, solutions, own experience and argumentation ♦ data collection, interpretation and application ♦ communication on professional issues, including in a foreign language, orally and in writing	Fluency in industry issues. Clarity of the answer (report). Language: - correct; - clean; - clear; - accurate; - logical; - expressive; - concise. Communication strategy: - consistent and consistent development of thought; - the presence of logical own judgments; - appropriate reasoning and its compliance with the defended provisions; - correct structure of the answer (report); - correct answers to questions; - appropriate technique for answering questions; - ability to draw conclusions and formulate proposals;	95-100
	Sufficient knowledge of industry issues with minor flaws. Sufficient clarity of the answer (report) with minor flaws. Relevant communication strategy with minor flaws.	90-94
	Good knowledge of industry issues. Good clarity of the answer (report) and appropriate communication strategy (three requirements in total are not realized)	85-89
	Good knowledge of industry issues. Good clarity of the answer (report) and appropriate communication strategy (four requirements not implemented in total)	80-84
	Good knowledge of industry issues. Good clarity of the answer (report) and appropriate communication strategy (five requirements not implemented in total)	74-79
	Satisfactory knowledge of industry issues. Satisfactory clarity of the answer (report) and appropriate communication strategy (a total of seven requirements have not been implemented)	70-73
	Partial knowledge of industry issues. Satisfactory clarity of the answer (report) and communication strategy with errors (a total of nine requirements are not implemented)	65-69
	Partial knowledge of industry issues. Satisfactory clarity of the answer (report) and communication strategy with errors (a total of 10 requirements are not implemented)	60-64
	The level of communication is unsatisfactory	<60

Description of qualification level	Requirements for knowledge, proficiency/skills, communication, autonomy and responsibility	Indicator evaluation
	Autonomy and responsibility	
• managing complex technical or professional activities or projects • ability to take responsibility for making and making decisions in unpredictable work and / or learning contexts • formation of judgments that take into account social, scientific and ethical aspects • organization and management of professional development of individuals and groups • ability to continue studies with a significant degree of autonomy	Excellent command of personal management competencies focused on: 1) management of complex projects, which involves: - research nature of educational activities, marked by the ability to independently assess various life situations, phenomena, facts, identify and defend a personal position; - ability to work in a team; - control of own actions; 2) responsibility for decision-making in unpredictable conditions, including: - justification of own decisions by the provisions of the regulatory framework of the industry and state levels; - independence in the performance of tasks; - initiative in discussing problems; - responsibility for relationships; 3) responsibility for the professional development of individuals and/or groups of individuals, which involves - use of professionally oriented skills; - use of evidence with independent and correct argumentation; - mastery of all types of learning activities; 4) the ability to continue learning with a high level of autonomy, which includes - the degree of mastery of fundamental knowledge; - independence of evaluative judgments; - a high level of general learning skills; - - independent search and analysis of information sources	95-100
	Good mastery of personality management competencies (two requirements not met)	90-94
	Good mastery of personality management competencies (three requirements not met)	85-89
	Good mastery of personality management competencies (four requirements not met)	80-84
	Good mastery of personality management competencies (six requirements not met)	74-79
	Satisfactory mastery of personality management competencies (seven requirements not met)	70-73
	Satisfactory mastery of personality management competencies (eight requirements not met)	65-69
	The level of responsibility and autonomy is fragmentary	60-64
	The level of autonomy and responsibility is unsatisfactory	<60

7 TOOLS, EQUIPMENT AND SOFTWARE

# of work (code)	Work name	Tools, equipment, and software used in the work
EM-2/1	Determination of transformer ratings and its testing	TCO-2.5 transformer Incandescent lamp

		Probes Switch Measuring devices: • megohmmeter • AC voltmeter,15 V • AC voltmeter, 250 V
EM-2/2	Testing of transformer under conditions of open circuit and short-circuit operation	TCO-2.5 transformer Probes Switch Additional resistance of 5 kOhm - 2 pieces. Measuring devices: • ammeter 2.5… 5 A - 3 pcs • voltmeter 75… 600 V • wattmeter 5/150 - 2 pcs
EM-2/4	Transformers parallel operation	TSO-2,5 transformer - 2 pieces Probes Switch 50 A - 1 pc Switch 20 A - 4 pcs Panel for connection- 2 pieces Measuring devices: • AC ammeter, 10 A - 2 pcs • AC ammeter, 20 A - 1 pc. • voltmeter change e.g. 250 V - 2 pcs
EM-3/1	Study of induction motors construction and principle	Asynchronous motor Incandescent lamp Probes Switch Measuring devices: • AC voltmeter, 15 V - 1 pc • megohmmeter
EM-3/2	Investigation of three-phase induction motor using data of no-load and short-circuit tests	Asynchronous motor Switch Resistance 12.5 Ohms Additional resistance of 5 kOhm - 2 pieces Current transformer 15; 50/5 - 2 pcs Measuring devices: • DC voltmeter, 1… 150 V • voltmeter, 75… 600 V • ammeter 2,5… 5 A - 2 pcs • wattmeter 5A / 150V - 2 pcs
EM-3/3	Investigation of induction motor working properties using method of direct loading	The test bench with measuring instruments, starting equipment and amotor Additional resistance of 5 kOhm Tachometer Desktop measuring instruments: • voltmeter 75… 600 V • ammeter 2.5… 5 A • wattmeter 5A / 150V
EM-3/4	Investigation of cage induction motors starting methods	Asynchronous motor TCO-2.5 transformer Switch 50 A - 3 pcs

		Switch for Y/D commutation Measuring devices: • AC ammeter 100 A • AC ammeter 50 A • AC ammeter 10 A • AC voltmeter 250 V - 2 pcs
EM-4/2	Investigation of parallel operation of synchronous generator connected to grid	Synchronous generator DC motor Switch - 4 pcs Adjusting rheostat - 2 pcs Synchronization console Current transformer - 2 pcs Measuring devices: • AC ammeter 20 A • AC ammeter 3 A - 2 pcs • AC ammeter 30 A - 1 pc • DC voltmeter 300 V - 1 pc • three-phase kilo-wattmeter - 1 piece
EM-4/3	Asynchronous starting and investigation of synchronous motor at field current adjustment	Synchronous motor DC generator Equipment and devices for starting and research of synchronous motor
EM-1/2	Investigation of dc generators	Asynchronous motor DC generator Switch - 3 pcs Loading rheostat Adjusting rheostat of 1000 Ohms Measuring devices: • AC ammeter, 100 A • AC voltmeter, 250 V. • DC ammeter, 3 A • DC ammeter, 30 A • DC voltmeter, 300 V

8 RECOMMENDED SOURCES OF INFORMATION

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2. Ivanov, O.B., Shkrabets, F.P., Zawilak, Jan. (2011)."Electrical generators driven by renewable energy systems", Wroclaw University of Technology, Wroclaw – 169 p.
3. Іванов О.Б., Ципленков Д. В. Проектування трифазних асинхронних двигунів: Навчальний посібник для студентів, що навчаються за спеціальністю 141 «Електроенергетика, електротехніка та електромеханіка» (англійською мовою). – Д.: Національний технічний університет «Дніпровська політехніка», 2020. – 111с. іл.
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6. Яцун Я.А. Електричні машини: Підручник. – Львів: Видавництво Львівської політехніки, 2011. – 464 с.

7. Collection of methodical materials for laboratory work on discipline "Electric machines" (section "DC Machines") for students studying specialty 141 “Electrical Power Engineering, Electrical Engineering and Electromechanics” / O.B. Ivanov, D.V. Tsyplenkov; Dnipro University of Technology – D.: DniproTech, 2021. – 40 p.

8. Collection of methodical materials for laboratory work on discipline "Electric machines" (section "Transformers") for students studying specialty 141 “Electrical Power Engineering, Electrical Engineering and Electromechanics” / O.B. Ivanov, D.V. Tsyplenkov; Dnipro University of Technology – D.: DniproTech, 2021. – 32 p.

9. Collection of methodical materials for laboratory work on discipline "Electric machines" (section "Induction machines") for students studying specialty 141 “Electrical Power Engineering, Electrical Engineering and Electromechanics” / O.B. Ivanov, D.V. Tsyplenkov; Dnipro University of Technology – D.: DniproTech, 2021. – 20 p.

10. Collection of methodical materials for laboratory work on discipline "Electric machines" (section "Synchronous Machines") for students studying specialty 141 “Electrical Power Engineering, Electrical Engineering and Electromechanics” / O.B. Ivanov, D.V. Tsyplenkov; Dnipro University of Technology – D.: DniproTech, 2021. – 20 p.

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«Electric Machines» for bachelors of the educational and professional program «Electrical energetics, electrical engineering and electromechanics» of the specialty 141 Electrical energetics, electrical engineering and electromechanics

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Editorial by the author

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