Ministry of Education and Science of Ukraine
Dnipro University of Technology

Department of Electric Drive

«APPROVED»
Head of Department
Khudolii S.S. _____

«30» August 2022

WORK PROGRAM OF THE ACADEMIC DISCIPLINE

«Electrical systems and networks»

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..…………….	5,5 credits ECTS (165 hours)
Type of summative assessment	exam
Period of study ………………	5, 6 semesters (9-12 terms)
Language of study …………..	English

Lecturer: Assoc.Prof. Lysenko O.G.

Prolonged: for 20 __ / 20__ academic year _____ (_____) "__" ___ 20__.
(Signature, name, date)

for 20 __ / 20__ academic year _____ (_____) "__" ___ 20__.
(Signature, name, date)

Dnipro
DNIPROTECH
2022

Work program of the academic discipline «Electrical systems and networks» 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 Electric Drive. – D.: DNIPROTECH, 2022. – 14 p.

Author:

– Lysenko Oleksandra Gennadiivna – Associate Professor, Candidate of Technical Sciences, Associate Professor of the Department of Electric Drive.

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 Φ10 «Electrical systems and networks»:

PLO17	To solve complex specialized problems in the design and maintenance of electromechanical systems, electrical equipment of power plants, substations, systems and networks
PLO19	To apply suitable empirical and theoretical methods to reduce electricity losses during its production, transportation, distribution and use

The aim of the discipline – development of higher education students' competencies in the calculation and analysis of power grid modes, practical skills in selecting electrical equipment to meet the requirements of efficiency, reliability and quality of electricity.

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 of PLO	Disciplinary learning outcomes (DLO)	
	Code of DLO	**content**
PLO 17	PLO17.1-Φ10	Know and understand the principles of electrical systems and networks
	PLO17.2-Φ10	Solve complex specialized problems in the design and maintenance of systems and networks
PLO 19	PLO19.1-Φ10	Apply suitable empirical and theoretical methods to reduce electricity losses during its production, transportation, distribution and use

3 BASIC DISCIPLINES

Title of the discipline	Achieved learning outcomes
Φ5 «Basics of electricity production, distribution and consumption»	PLO01 To know and understand the principles of operation of electrical systems and networks, power equipment of power plants and substations, protective earthing and lightning protection devices and be able to use them to solve practical problems in professional activities. PLO04 To know the principles of bioenergy, wind, hydro and solar power plants. PLO13 To understand the importance of traditional and renewable energy for successful economic development of the country. PLO19-Φ5 Apply relevant methods for calculating electrical loads of consumers, analyze actual electricity consumption schedules with the development of effective solutions to reduce electricity losses during its production, transportation, distribution and use, while implementing rational solutions for the selection of nominal parameters of electrical equipment.

Б5 «Theoretical foundations of electrical engineering»	PLO05 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

Type of classes	Workload *hours*	Distribution by forms of study, *hours*					
		Full-time		Part-time		Extramural	
		Class work	Individual work	Class work	Individual work	Class work	Individual work
lectures	110	60	50	-	-	10	100
practical	55	39	16	-	-	8	47
laboratory	-	-	-	-	-	-	-
seminars	-	-	-	-	-	-	-
TOTAL	165	99	66	-	-	18	147

5 DISCIPLINE PROGRAM BY TYPES OF CLASSES

Code of DLO	Types and topics of classes	Volume of components, *hours*
	LECTURES	**110**
DLO17.1-Ф10, DLO17.2-Ф10	PREFACE	6
	Features of production and consumption of electricity	
	The role of electrical networks in the power industry	
	Classification of electrical networks	
	Characteristics of calculations of electrical networks	
DLO17.1-Ф10, DLO17.2-Ф10	1. ELEMENTS AND CONSTRUCTION OF ELECTRICAL NETWORKS	10
	1.1. Wires and cables of overhead power lines	
	1.2. Supports and insulators of overhead power lines	
	1.3. Fittings for suspension of wires and garlands of insulators	
	1.4. Cables for electric networks	
	1.5. Laying of cable power lines	
	1.6. Power lines	
	1.7. Insulated wires and internal wiring	
DLO17.1-Ф10, DLO17.2-Ф10	2. FORMATION OF ELECTRIC LOAD OF ELECTRICAL NETWORKS	10
	2.1. Electricity consumers and their characteristics	
	2.2. Load schedules for consumers, networks and energy systems	
	2.3. Determination of network load and amount of transmitted energy	
DLO17.1-Ф10, DLO17.2-Ф10	3. SCHEMES OF REPLACEMENT OF ELECTRICAL NETWORKS	14
	3.1. Replacement schemes for overhead transmission lines of district and local significance	
	3.2. Replacement schemes for cable transmission lines	
	3.3. Schemes of replacement of transformers and autotransformers	
	3.4. Schemes of replacement of networks with several nominal voltages	

Code of DLO	Types and topics of classes	Volume of components, *hours*
DLO17.1-Ф10, DLO17.2-Ф10 DLO19.1-Ф10	4. LOSS OF POWER AND ELECTRICITY IN NETWORKS	10
	4.1. Power losses in transmission lines of local and district significance	
	4.2. Power losses in transformers	
	4.3. Characteristics of methods for calculating electricity losses	
	4.4. Measures to reduce power and energy losses	
DLO17.1-Ф10, DLO17.2-Ф10, DLO19.1-Ф10	5. CALCULATIONS OF MODES OF ELECTRICAL NETWORKS WITH ONE-SIDED POWER SUPPLY	12
	5.1. Calculations of power and voltage under different conditions of the source data	
	5.2. Simplification of calculations for local networks	
DLO17.1-Ф10, DLO17.2-Ф10, DLO19.1-Ф10	6. TECHNICAL AND ECONOMIC CALCULATIONS OF ELECTRICAL NETWORKS	10
	6.1. Capital investment and operating costs. Total costs on networks	
	6.2. Calculations of the area of intersection according to economic criteria	
	6.3. Heating wires and cables. Permissible heating. Selection or check for allowable heating	
	6.4. Permissible voltage loss. Calculation of the cross section for the allowable voltage loss	
	6.5. Choice of rated voltage	
	6.6. Reliability of electrical networks. Choice of schemes of electric networks taking into account reliability of networks	
DLO17.1-Ф10, DLO17.2-Ф10, DLO19.1-Ф10	7. CALCULATIONS OF CLOSED ELECTRICAL NETWORKS	14
	7.1. General characteristics of closed networks	
	7.2. Two-way power supply networks	
	7.3. Characteristics of capacity distribution calculations in complex-closed networks	
	7.4. Matrix methods of power distribution calculations	
DLO17.1-Ф10, DLO17.2-Ф10, DLO19.1-Ф10	8. QUALITY OF ELECTRICITY AND ITS REGULATION IN POWER GRIDS	10
	8.1. Quality indicators and the impact of power grids on them	
	8.2. Methods and means of voltage regulation in networks	
	8.3. Selection of the desired branch in transformers with PBV	
	8.4. Checking the control capacity of transformers with on-load tap-changers	
	8.5. Calculation of parameters of compensating devices according to the value of the desired voltage at the transverse and longitudinal compensations	
	8.6. Technical and economic comparison of transverse and longitudinal compensations	
DLO17.1-Ф10, DLO17.2-Ф10, DLO19.1-Ф10	9. ENERGY SYSTEMS AND REGULATION OF THEIR MODES OF THEIR OPERATION	12
	9.1. Characteristics of energy systems	
	9.2. Balance of active and reactive capacities. Relationship between active power balance and frequency, reactive and	

Code of DLO	Types and topics of classes	Volume of components, *hours*
	voltage levels	
	9.3. Power of compensating devices under the conditions of reactive power balance for the load unit	
	9.4. Distribution of compensating devices in electrical networks	
	9.5. Checking compliance with the conditions of the balance of reactive power after the distribution of the network of compensating devices	
	PRACTICAL CLASSES	**55**
DLO17.1-Ф10	1 Calculation of parameters of substitution schemes of electric networks	8
DLO19.1-Ф10	2 Calculations of power and energy losses	6
DLO19.1-Ф10	3 Calculations of modes of electric networks	6
DLO19.1-Ф10	4 Technical and economic calculations of networks	4
DLO17.2-Ф10	5 Capacity distribution in two-way networks	6
DLO17.1-Ф10, DLO17.2-Ф10	6 Determination of cross-section of wires (cable cores) in networks with two-way power supply	6
DLO17.1-Ф10	7 Selection of branches in transformers with PBV	4
DLO17.1-Ф10	8 Checking the control capacity of transformers with on-load tap-changers	4
DLO17.2-Ф10	9 Determination of power of compensating devices from the conditions of reactive power balance	5
DLO17.1-Ф10, DLO19.1-Ф10	10 Location of compensating devices in network diagrams	6
	TOTAL	**165**

To implement a mixed form of student education, an electronic distance learning resource is used in the discipline at the following address: **https://do.nmu.org.ua/course/view.php?id=1364**

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 6th 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	
Educational class	diagnostic tools	procedures	diagnostic tools	procedures
lectures	control tasks for each topic	performing the task during lectures	complex control work (CCW)	determination of the average result of formative assessments; performing of CCW during the exam at the request of the student
practical	control tasks for each topic	performing the task during practical classes		
	an individual task	performing the task during individual work		

During the current control, lectures are evaluated by determining the quality of specific control tasks. Practical classes are assessed by the quality of the control and individual task.

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 during the exam testing has the right to perform the CCW, which contains tasks covering key disciplinary learning outcomes.

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 practical 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 decision 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	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

Description of qualification level	Requirements for knowledge, proficiency/skills, communication, autonomy and responsibility	Indicator evaluation
professional activity and / or training	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
	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	Fluency in industry issues. Clarity of the answer (report). Language: - correct; - clean; - clear; - accurate; - logical; - expressive; - concise.	95-100

Description of qualification level	Requirements for knowledge, proficiency/skills, communication, autonomy and responsibility	Indicator evaluation
application ♦ communication on professional issues, including in a foreign language, orally and in writing	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;	
	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
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	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;	95-100

Description of qualification level	Requirements for knowledge, proficiency/skills, communication, autonomy and responsibility	Indicator evaluation
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	- 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	
	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

Technical training tools.
MOODLE e-learning platform, MS Teams.

8. RECOMMENDED SOURCES OF INFORMATION

1. Півняк Г.Г., Волотковська Н.С., Кігель Г.А. Розрахунки електричних мереж систем електропостачання. – НГУ, 2011. / Pivnyak G.G., Volotkovskaya N.S., Kigel G.A. Calculations of electrical networks of power supply systems. - NMU, 2011.

2. Кігель Г.А, Півняк Г.Г. Електричні мережі систем електропостачання. – НГУ, 2011. / Kigel G.A., Pivnyak G.G. Electrical networks of power supply systems. - NMU, 2011.

3. Експлуатація електроустановок: Навч. посібник / Г.Г. Півняк, А.В. Журахівський, Г.А. Кігель, Б.М. Кінаш, А.Я Рибалко, Ф.П. Шкрабець, З.М. Бахор; За ред. академіка НАН України Г.Г. Півняка. –Дніпропетровськ, НГУ, 2005. / Operation of electrical installations: Navch. help / G.G. Pivnyak, A.V. Zhurakhivsky, G.A. Kigel, B.M. Kinash, A.Ya Ribalko, F.P. Shkrabets,

Z.M. Bakhor; For red. Academician of the National Academy of Sciences of Ukraine G.G. Pivnyak. – Dnipropetrovsk, NMU, 2005.

4. Сулейманов В.М., Кацадзе Т.Л. Електричні мережі та системи. – К.: НТУУ «КПІ», 2008. / Suleimanov V.M., Katsadze T.L. Electrical networks and systems. - K .: NTUU "KPI", 2008.

5. Зорін В.В., Штогрин Є.А., Буйний Р.О. Електричні мережі та системи (окремі розділи): навчальний посібник для студентів вищ. техн. навч. закл. – Ніжин: ТОВ «Видавництво «Аспект-Поліграф», 2011. – 248 с. іл./ Zorin V.V., Shtogrin E.A., Buinyi R.O. Electrical networks and systems (separate sections): study guide for university students. technical education closing - Nizhyn: LLC "Aspect-Polygraph Publishing House", 2011. - 248 p. fig.

8. Pivnyak G. G. Transients in Electric Power Supply Systems. Textbook for institutions of higher education/ G. G. Pivnyak, I.V. Zhezhelenko, Y.A. Papaika; under the editorship of G.G. Pivnyak; Ministry of Education and Science of Ukraine, National Mining University – 5th edition, revised and expanded: Translation from Ukrainian. – Dnipropetrovsk: NMU – 2015. – 419 pp.

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Editorial by the author