MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

Dnipro University of Technology

Department of Electrical Engineering

« APPROVED »
Head of Department
Tsyplenkov D.V. _____
31,08.2021 year

EDUCATIONAL DISCIPLINE WORK PROGRAM

« Fundamentals of metrology and electrical measurements »

Knowledge area ……..…	14 Electrical Engineering
Specialty ……...	141 Electric Power Engineering, Electrical Engineering and Electromechanics
Level of higher education …….	First (bachelor)
Degree ……	bachelor
Educational and professional program	Electric Power Engineering, Electrical Engineering and Electromechanics
Status ……	compulsory
Total of hours (credits)..…….	3 credits ECTS (90 hours)
Form of final control ……..	Graded credit
Term of teaching …….	3 semester
Language of instruction …….	English

Lecturer: Doctor of Technical Sciences, Professor Khilov V.S.

Prolonged:
to 20__/20__ s.y. _____ (_____) «__»____ 20__y.
(підпис, ПІБ, дата)
to 20__/20__ s.y. _____ (_____) «__»____ 20__y.
(підпис, ПІБ, дата)
to 20__/20__ s.y. _____ (_____) «__»____ 20__y.
(підпис, ПІБ, дата)

DNIPRO
DUT
2021

Working program of the normative educational discipline "Fundamentals of metrology and electrical measurements" for bachelors speciality in 141 "Electric power engineering, electrical engineering and electromechanics" (cycle of special training: basic disciplines in the field of knowledge) / Dnipro University of Technology, Department of Electrical Engineering. - D.: DUT, 2021. - 13 p.

Developer – Doctor of Technical Sciences, Professor Khilov V.S.

The work program regulates:

– the purpose of the discipline;
– disciplinary learning outcomes formed on the basis of the transformation of the expected learning outcomes of the educational program;
– basic disciplines;
– the amount and distribution of forms of organization of the educational process and types of training sessions;
– program of the discipline (thematic plan by types of classes);
– algorithm for assessing the level of achievement of disciplinary learning outcomes (scales, tools, procedures and evaluation criteria);
– tools, equipment and software;
– recommended sources of information.

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

The work program will be useful for the formation of the content of professional development of research and teaching staff of university departments.

Approved by the decision of the Scientific-Methodical Commission of specialty 141 «Electrical Power Engineering, electrical engineering and electromechanics» at the request of the Department of Higher Mathematics (protocol № 21\22-01 dated 30.08.2021).

CONTENT

1 The purpose of the education discipline

In the educational-professional program of the Dnipro University of Technology specialty 141 " Electric Power Engineering, Electrical Engineering and Electromechanics" the distribution of program learning outcomes by organizational forms of educational process.

Code ПРН	Learning outcomes
ПР02	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.
ПР18	To be able to learn independently, to master new knowledge and to improve skills of work with the modern equipment, measuring technics and the applied software.

The purpose of the discipline is to form in future professional's competencies in the field of normative-basic discipline Ф3 "Fundamentals of metrology and electrical measurements".

Achieving the goal requires the transformation of program learning outcomes into disciplinary and adequate selection of the content of the discipline according to this criterion.

2 EXPECTED DISCIPLINARY LEARNING OUTCOMES

Code ПРН	Disciplinary learning outcomes (DLO)	
	Code ДРН	content
ПР02	ПР02.1-Ф3	Fundamentals of metrology - issues of practical application of developments in theoretical metrology and issues of metrological support
ПР18	ПР18.1-Ф3	Electrical measurement - finding (by experimental methods) the value of a physical quantity, expressed in appropriate units.

3 BASIC DISCIPLINES

Discipline name	Learning outcomes obtained
Foreign Language	ПР11 Communicate freely on professional issues in state and foreign languages orally and in writing, discuss the results of professional activities with specialists and non-specialists, argue their position on debatable issues
General Physics	ПР08.2-Б2 Formulate physical ideas, solve problems, make estimates of quantities, operate with physical models and understand the limits of their applications
	ПР8.4-Б2 Apply knowledge of the basic fundamental laws of classical and modern physics to solve electrical problems
Higher mathematics	ПР07.2-Б1 Be able to use a mathematical apparatus for objective analysis of processes in electromechanical

Discipline name	Learning outcomes obtained
	equipment;
	ПР08.1-Б1 Know the principles of solving technical problems based on mathematical analysis, construction and solution of differential equations.
Computer science	Use application software, microcontrollers and microprocessor technology to solve practical problems in professional activities
	Be able to learn independently, master new knowledge and improve skills with modern equipment, measuring equipment and application software.
Electrical materials	ПР07.1-Б6 Analyze the processes in electrical, electrical and electromechanical equipment, relevant complexes and systems, taking into account the properties of dielectric, conductive and magnetic materials ПР07.2-Б6 Calculate the parameters of dielectric, conductive and magnetic materials used in the elements of electric power, electrical electromechanical complexes and systems.
Fundamentals of electric engineering	Know the basics of electromagnetic field theory, methods of calculating electric circuits and be able to use them to solve practical problems in professional activities.

4 AMOUNT AND DISTRIBUTION BY FORMS OF ORGANIZATION OF THE EDUCATIONAL PROCESS AND TYPES OF EDUCATIONAL CLASSES

Type of training	**Amount,** *hours*	**Distribution by forms of education**, *hours*			
		full-time form of study		**extramural form of study**	
		Classroom studies	independent work	Classroom studies	independent work
lectures	54	21	33		
practical	-	-			
laboratory	36	14	22		
seminars	-	-	-		
Total	90	35	55		

5 DISCIPLINE PROGRAM BY TYPES OF EDUCATIONAL CLASSES

Code ДРН	**Types and topics of training sessions**	**Volume of components, hours**
ПР02.1-Ф3	**Lectures**	**54**
	1. 1. Science of metrology. Tasks of measurements.	12
	1.1. International system of units of physical quantities SI	
	1.2. Types of measurements	
	1.3. Methods of realization of direct measurements	
	1.4. Measuring instruments	

	2. Measurement errors and measuring instruments	12
	2.1. The main types of measurement errors	
	2.2. Taking into account the random error in the measurement results	
	2.3. Determination of errors in indirect measurements	
	2.4. Accuracy classes of measuring instruments	
	3. Scale measuring transducers	12
	3.1. Shunts	
	3.2. Additional resistors	
	3.4. Voltage dividers	
	3.5. Measuring current and voltage transformers	
	4. Principles of construction of electromechanical measuring devices	25
	4.1. Magnetoelectric system devices	
	4.2. Electromagnetic system devices	
	4.3. Devices of electrodynamic and ferrodynamic systems	
	4.4. Induction system devices.	
	4.5. Electrostatic system devices	
	4.6. Electronic and digital measuring devices	
	5. Measurement of power and energy	11
	5.1. Measurement of power in a direct current circuit and active power in a single-phase alternating current circuit	
	5.2. Measurement of active power in three-phase circuits	
	5.3. Measurement of reactive power in three-phase circuits	
	5.4. Energy measurement in a three-phase circuit	
	6. Measurement of non-electric quantities	11
	6.1. Resistive measuring transducers	
	6.2. Electromagnetic measuring transducers	
	6.3. Induction measuring transducers	
	6.4. Electrostatic measuring transducers	
	6.5. Thermal measuring transducers	
ПР18.1-Ф3	**Laboratory classes**	**36**
	MFEM 1. Ammeter and Voltmeter Calibration	5
	EB 2. Power measurement in three-phase circuits	5
	MFEM 3. Direct, indirect and multiple measurements accuracy assessment	5
	MFEM 4. Voltage transformer measurement errors study.	5
	MFEM 5. Electrical parameters measurement by cathode-ray oscilloscope.	5
	MFEM 6. Study of measurement errors of electronic and digital devices.	5
	MFEM 7. Research of errors of measuring current transformer.	6
	TOTAL	**90**

6 EVALUATION OF LEARNING OUTCOMES

Certification of student achievement is carried out through transparent procedures based on objective criteria in accordance with the Regulations of the University "On the evaluation of learning outcomes of higher education."

The achieved level of competencies relative to the expected ones, which is identified during the control activities, reflects the real result of the student's study in the discipline.

6.1 Scales

Assessment of academic achievements of students of DNIPROTECH is carried out on a rating (100-point) and conversion scales. The latter is necessary (in the official absence of a national scale) for the conversion (translation) of grades of higher education students of different institutions.

Scales for assessing the academic achievements of DNIPROTECH students

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

Credits of the discipline is accounted if the student received a final mark of at least 60 points. The lower mark 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 Dnipro University of Technology.

6.2 Means and procedures

The content of diagnostic tools is aimed at controlling the level of knowledge, skills, communication, autonomy and responsibility of the student according to the requirements of the НРК to the 7th qualification level during the demonstration of learning outcomes regulated by the work program.

The student in the control activities must perform tasks focused solely on the demonstration of disciplinary learning outcomes (Section 2).

Diagnostic tools provided to students at control activities in the form of tasks for current and final control, are formed by specifying the initial data and the method of demonstrating disciplinary learning outcomes.

Diagnostic tools (control tasks) for the current and final control of the discipline are approved by the department.

The types of diagnostic tools and assessment procedures for the current and final control of the discipline are given below.

Diagnostic tools and assessment procedures

CURRENT CONTROL			FINAL CONTROL	
training session	**diagnostic tools**	**procedures**	**diagnostic tools**	**procedures**
Lectures	control tasks for each topic	performing the task during lectures	complex control work (CCW)	determination of the weighted average result of current controls; performing CCW during the exam at the request of the student
Laboratory	control tasks for each topic or individual task	performing tasks during independent work		

During the current control, lectures are evaluated by determining the quality of control specific tasks. Laboratory classes are evaluated by the quality of the control or individual task.

If the content of a certain type of classes is subject to several descriptors, the integral value of the assessment can be determined taking into account the weights set by the teacher.

If the level of results of current controls in all types of classes is not less than 60 points, the final control is carried out without the participation of the student by determining the weighted average of current assessments.

Regardless of the results of the current control, each student during the exam has the right to perform the CCW, which contains tasks that cover key disciplinary learning outcomes.

The number of specified tasks CCW should correspond to the allotted time for performance. The number of CCW options should provide individualization of the task.

The value of the assessment for the implementation of the CCW is determined by the average assessment of the components (specified tasks) and is final.

The integral value of the assessment of the performance of CCW can be determined taking into account the weights set by the department for each descriptor HPK.

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 current control role of lectures and practical classes as a criterion is used the coefficient of mastering, which automatically adapts the assessment indicator to the rating scale:

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

where a is the 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 tests are evaluated 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 НРУ for the bachelor's degree (higher below).

General criteria for achieving learning outcomes for the 6th qualification level for НРК

	Requirements for knowledge, skills, communication, autonomy and responsibility	Indicator evaluation
	Skills	
♦ specialized conceptual knowledge acquired in the process of learning and / or professional activity at the level of the latest achievements, which are the basis for original thinking and innovation, in particular in the context of research; ♦ critical understanding of problems in teaching and / or professional activities and at the boundaries of subject areas	The answer is excellent - correct, wrapped, meaningful. Characterizes the provision of: - specialized conceptual knowledge at the levels of new and previous achievements; - critical understanding of the problem in teaching and / or professional activities and at the border of subject areas	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
	Skills	
♦ solving complex problems and problems that require updating and integration of knowledge, often in conditions of incomplete / insufficient information and conflicting requirements; ♦ conducting research and / or innovation activities	The answer characterizes the ability to: - identify problems; - formulate hypotheses; - solve problems; - update knowledge; - integrate knowledge; - to carry out innovative activity; - to carry out scientific activity	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	70-73

	Requirements for knowledge, skills, communication, autonomy and responsibility	Indicator evaluation
	practice, but has some inaccuracies in the implementation of the four requirements	
	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	
♦ clear and unambiguous communication of own conclusions, as well as knowledge and explanations that substantiate them, to specialists and non-specialists, in particular to students; ♦ use of foreign languages in professional activities	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; - relevant 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; - - use of foreign languages in professional activities	95-100
	Sufficient clarity of the answer (report) and appropriate communication strategy with minor flaws	90-94
	Good clarity of the answer (report) and appropriate communication strategy (three requirements in total are not realized)	85-89
	Good clarity of response (report) and appropriate communication strategy (four requirements not implemented in total)	80-84
	Good comprehensibility of the answer (report) and appropriate communication strategy (five requirements in total are not fulfilled)	74-79
	Satisfactory clarity of response (report) and appropriate communication strategy (seven requirements not implemented in total)	70-73
	Satisfactory comprehensibility of the answer (report) and communication strategy with errors (a total of nine requirements are not implemented)	65-69
	Satisfactory comprehensibility 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	
♦ responsibility for the development of professional knowledge	Excellent competence: - use of principles and methods of organizing team activities;	95-100

	Requirements for knowledge, skills, communication, autonomy and responsibility	Indicator evaluation
and practices, assessment of the strategic development of the team; ♦ ability to further study, which is largely autonomous and independent	- effective distribution of powers in the team structure; - maintaining a balanced relationship with team members (responsibility for the relationship); - stress resistance; - self-regulation; - work activity in extreme situations; - high level of personal attitude to the case; - mastery of all types of educational activities; - appropriate level of fundamental knowledge; - - the appropriate level of formation of general educational skills and abilities	
	Confident mastery of the competencies of autonomy and responsibility with minor flaws	90-94
	Good mastery of autonomy and responsibility competencies (two requirements not met)	85-89
	Good mastery of autonomy and responsibility competencies (three requirements not met)	80-84
	Good mastery of autonomy and responsibility competencies (four requirements not met)	74-79
	Satisfactory mastery of autonomy and responsibility competencies (five requirements not met)	70-73
	Satisfactory ownership of autonomy and responsibility competencies (six requirements not met)	65-69
	Satisfactory mastery of autonomy and responsibility competencies (fragmentary level)	60-64
	The level of autonomy and responsibility is unsatisfactory	<60

7 TOOLS, EQUIPMENT AND SOFTWARE

№ works (code)	Work title	Tools, equipment and software used in the work
MFEM 1	Ammeter and Voltmeter Calibration	Study-research laboratory stand, multimeter, oscilloscope
MFEM 2	Power measurement in three-phase circuits	Study-research laboratory stand, multimeter, oscilloscope
MFEM 3	Direct, indirect and multiple measurements accuracy assessment	Study-research laboratory stand, multimeter, oscilloscope
MFEM 4	Voltage transformer measurement errors study.	Study-research laboratory stand, multimeter, oscilloscope
MFEM 5	Electrical parameters measurement by cathode-ray oscilloscope.	Study-research laboratory stand, multimeter, oscilloscope
MFEM 6	Study of measurement errors of electronic and digital devices.	Study-research laboratory stand, multimeter, oscilloscope
MFEM 7	Research of errors of measuring current transformer.	Study-research laboratory stand, multimeter, oscilloscope

8. RECOMMENDED SOURCES OF INFORMATION

1. Електричні вимірювання / За ред. В.М. Малиновського. – К.: Вища шк., 1984.–327 с.

2. Ціделко В.Д., Яремчук Н.А. Невизначеність вимірювань. Обробка даних і подання результату вимірювання: Монографія. – К.:ВЦ “Видавництво «Політехніка»”,2002.–176 с.

3. Головко Д.Б. та ін. Основи метрології та вимірювань / Головко Д.Б., Рего К.Г., Скрипник Ю.О. – К.: Либідь, 2001. – 408 с.

4. Поліщук Є. С. Метрологія та вимірювальна техніка [Текст]: підручник . С. Поліщук; Львів: Новий світ, 2003. – 460 с.

5. Шкрабець Ф.П., Ципленков Д.В., Куваєв Ю.В. та ін. Електротехніка, основи електроніки та мікропроцесорної техніки: Навчальний посібник – Дніпропетровськ, Національний гірничий університет, 2004. – 515 с.

6. Дорожовець М. та ін. Основи метрології та вимірювальної техніки: Підручник: У 2 т. / М. Дорожовець В. Мотало, Б. Стадник, В.Василюк, Р. Борек, А.ковальчик; За ред. Б. Стадника. – Львів: Видавництво Національного університету "Львівська політехніка", 2005. – Т.2. Вимірювальна техніка. – 656 с.

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для бакалаврів спеціальності 141 «Електроенергетика, електротехніка та електромеханіка»

Розробник:
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В редакції автора

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