MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL TECHNICAL UNIVERSITY
«KHARKIV POLYTECHNICAL INSTITUTE»

Department of Electrical machines

« **APPROVE** »
Head of the Department "Electrical machines" _____ Vladimir MILIKH
(signature)

September 24, 2020

WORKING PROGRAM OF THE DISCIPLINE

Electrical machines

(name of the discipline)

level of higher education _____first (bachelor's)_____
first (bachelor's)/second (master's)

field of knowledge _____14 – Electrical engineering _____
(code and name)

specialty __141 – Power engineering, electrical engineering and electromechanics
(code and name)

educational program – «Electromechanics»

type of discipline – professional training

form of study – full-time course

Kharkiv – 2020

APPROVAL LETTER

Working program of the discipline

ELECTRICAL MACHINES

Developer:

Professor of the Electrical Machines Department,
cand. tech. Sciences, Associate Professor Valentina SHEVCHENKO

The work program was considered and approved at the meeting of the department "Electrical Machines "

September 24, 2020, protocol № 3

Head of the Department "Electrical Machines" _____ Vladimir MILIKH

LETTER OF RE-APPROVAL OF THE WORKING CURRICULUM

Date of the meeting of the department-developer of RPND	Protocol number	Signature of the head of the department	Heads of specialty support groups

PURPOSE, COMPETENCIES, LEARNING OUTCOMES AND STRUCTURAL AND LOGICAL SCHEME OF STUDYING THE DISCIPLINE

The purpose of the working program of the discipline is to prepare bachelors in the specialty 141 "Electricity, Electrical Engineering and Electromechanics", involving the formation of a base of theoretical knowledge of future specialists, theoretical and practical knowledge in the field of manufacture, installation, operation of electric machines, methods and means of measuring the electric machines and transformers parameters of both in the production process and in operation. Know the electric machines principle of operation and basic characteristics; to choose the electric machines necessary for the enterprise, to carry out check of their working capacity, to know how electric machines to carry out start, braking, adjustment and reverse, to form students' knowledge about modern methods of diagnostics and testing of electric machines and transformers.

Competences. Ability to identify, pose and solve problems. Ability to adhere to international standards, norms and technical conditions in projects of electric power, electrotechnical and electromechanical equipment. Ability to use modern methods of calculation, modeling and analysis of modes of operation of electrical, electrical and electromechanical equipment and design of electrical and electromechanical systems. Ability to determine and ensure optimal, energy efficient and economical modes of electric machines and transformers operation. In the process of studying this discipline, graduates should be able to distinguish between technological schemes of different types of power plants and substations; ability to distinguish certain types of energy equipment and analyze the modes of their operation; ability and skills to perform diagnostics and testing of electrical equipment, to know the features of the layout and placement of equipment on the territory of power plants and substations; be able to choose new types of modern electric machines and transformers of power systems, evaluate its characteristics.

ZK-1-ZK3, ZK-5, PK-1, PK-5, PK-8, PK-10 - PK-13; PKs6-1, PKs6-2, PKs6-5

Learning outcomes.

The student must know the transformers and electrical machines (EM) purpose, types, classification, areas of use. Have fundamental theoretical and practical knowledge and skills in the field of electrical engineering, be able to conduct experimental research of EM and transformers, develop a program of EM research and analyze the obtained experimental data, present them in graphical, tabular and other forms, draw conclusions about the obtained EM and transformers parameters and characteristics. RNp-1, RNp-3, RNp-5, RNp-13, RNs3-1, RNs6-12

Structural and logical scheme of studying the discipline

Previous disciplines:	The following disciplines:
1. Physics	1. Power plants
2. Higher mathematics	2. International Economics
3. Introduction to the specialty	3. Electromagnetic transients
4. Informatics, computer engineering and programming	4. Operation and modes of operation of power plants electrical equipment
5. Theoretical mechanics	5. Electrical transients
6. Theoretical foundations of electrical engineering	6. Reliability and technical diagnostics of power equipment
7. Electrical materials	
8. Fundamentals of metrology and electrical measurements	7. Execution of diploma projects of bachelor and master
9. Fundamentals of electronics	
10. Electrical devices	
11. Computer Graphics	
12. Foreign language by profession	
13. Theory of automatic control	
14. Theory of electric drive	

DESCRIPTION OF THE COURSE

(distribution of study time by semesters and types of classes)

Semester	The total amount (hours)/ credits ECTS	Of them		By types of classes (hours)			Individual tasks of students (KP, KW, RG, R, RE)	Current control	Semester control	
		Classes (hours)	Independent work (hours)	Lectures	Laboratory works	Practical classes, seminars		Tests work (number of works)	Test	Exam
5	180/6	80	100	48	16	16	KW	2	-	+

The ratio of the number of hours of classroom classes to the total is 44.4 %.

STRUCTURE OF THE COURSE

№ in order	Types of training sessions (Lec, LW, PE)	Number of hours	Semester number (if the discipline is taught in several semesters). Names of content modules. Names of topics and questions of each lesson. Tasks for independent work.	Recommended literature (basic, auxiliary)
1	2	3	4	5
Content module № 1. T**ransformers**				
1	Lec, PE	4	***Topic 1***. Basic laws of electromechanics. Law of electromagnetic induction. The law of total current. Electrical materials used in electrical engineering. Classes of heat resistance of insulating materials. Electrical machines (EM). EM reversibility principle. Losses in electrical equipment and efficiency.	1-3, 10
	Lec	2	***Topic 2.*** Purpose of transformers. The principle of operation and design of transformer. Classification of transformers. Wiring diagrams of windings of three-phase transformers.	
	Lec, LW	4	***Topic* 3**. Reduced transformer. Modes of transformers operation. Transformer idle and laboratory short circuit modes. Transformer operation at rated load. Transformer winding connection groups.	
	Lec	2	***Topic* 4**. Calculation of the transformer nominal parameters based on the results of modes idling and laboratory short-circuit Transformer idling experiment. Experiment of laboratory short circuit of transformer.	
	Lec, PE	4	***Topic* 5.** Parallel operation of transformers. The transformer losses and coefficient of performance in the nominal mode. Transformer characteristics. External characteristics of the transformer.	
	Lec, LW	4	***Topic* 6**. Overvoltage in transformers. Operation of power transformers.	
Content module № 2. **General Questions of the Theory of Alternating Current Machines**				
2	Lec PE	4	***Topic* 7.** Classification of electric machines. Types of AC machines. Areas of use of asynchronous and synchronous machines in engine and generator modes. Stator design of AC machines. Designs of rotors of asynchronous and synchronous machines.	1-3, 9
	Lec	2	***Topic* 8**. Obtaining a rotating magnetic field. AC stator windings. EMF and MRS AC windings. Shortening and distribution of the stator winding of AC machines.	

1	2	3	4	5
Content module № 3. **Asynchronous machines**				
3	Lec, LW	4	***Topic* 9.** Design and principle of operation of an asynchronous machine in generator mode and in engine mode Operation of an asynchronous machine with a fixed and moving rotor. Equation and replacement scheme of an induction motor.	1-3,6
	Lec, PE	4	***Topic* 10.** Speed control of an asynchronous motor. Starting of asynchronous motor. The design of the phase rotor of an asynchronous motor	
	Lec, LW	4	***Topic* 11.** Power diagram of an induction motor. The asynchronous motor electromagnetic moment and performance characteristics.	
	Lec, PE	4	***Topic* 12.** Methods of asynchronous motors frequency of rotation regulating. Reverse. Operation of an asynchronous machine in generator mode	7-9, 13
	Lec, LW	4	***Topic* 13.** Single-phase asynchronous motors and asynchronous motors with current displacement in the rotor. Deep-sea asynchronous motors. Two-cell asynchronous motors	
Content module № 4. **Synchronous machines**				
4	Lec	2	***Topic* 14**. Synchronous generator. Design and principle of operation of a synchronous generator. Designs of synchronous generators rotors. Methods of excitation of synchronous generators.	1,2,7
	Lec, PE	4	***Topic* 15**. The hydro generators construction. Cooling systems of synchronous generators Vector charts of synchronous generators. The reaction of synchronous generator anchor.	5-7
	Lec, LW	4	***Topic* 16.** Characteristics of a synchronous generator taking into account the design of the rotor: idling, short circuit, external characteristics, loading and adjusting. Angular characteristics of synchronous turbo- and hydro generators. U-shaped characteristics of the synchronous generator	
	Lec	2	***Topic* 17**. Parallel operation of a synchronous generator with the network. Activation of a synchronous generator for parallel operation with the network with precise synchronization. Rough synchronization of a synchronous generator.	
	Lec, PE	4	***Topic* 18**. Adjusting the reactive power of a synchronous generator in parallel operation. Adjusting the active power of the synchronous generator in parallel operation: U-similar characteristics of the synchronous generator. Static stability of a synchronous generator.	

1	2	3	4	5
4	Lec, LW	4	***Topic* 19.** The principle of synchronous motor operation. Design and principle of operation of a synchronous motor. Ways to start a synchronous motor. Voltage equation and vector diagram of synchronous motor. Synchronous motor performance. Synchronous compensator.	1-3, 5-7
	Lec	2	***Topic* 20**. Transients in synchronous machines. Oscillations of synchronous machines. Ways to reduce the swing of synchronous machines.	
Content module № 5. **DC machines**				
5	Lec	2	***Topic* 21**. Design and principle of operation of DC machines (DCM). The principle of operation of the DC generator. Schemes of excitation windings inclusion of DCM. EMF of the winding of the DCM anchor. Electromagnetic moment of DCM	1-3, 6,7
	Lec, PE	4	***Topic* 22**. Commutation in DC machines, ways to improve commutation. Anchor reaction in DC machines	2-4, 6,7
	Lec, LW	4	***Topic* 23**. Characteristics of a DC generator. Features of operation of the generator with parallel excitation. Features of operation of the generator of a direct current of the mixed excitation.	
	Lec	2	***Topic* 24**. Characteristics of DC motors. Methods of starting DC motors. Mechanical characteristics of a DC motor. Operating characteristics of DC motors taking into account the excitation winding circuit. Means of the DC motors speed regulating. Methods of braking DC engines	
Total (hours)		80		

INDEPENDENT WORK

№ in order	Name of independent work types	Number of hours
1	Elaboration of lecture material	24
2	Preparation for practical and laboratory classes	16
3	Independent study of topics and issues that are not taught in lectures	10
4	Preparation and writing of tests	50
	Together	100

INDIVIDUAL TASKS

«Calculation of characteristics of transformers and electric machines»
Calculation task according to methodical instructions [11]

№ in order	The name of the individual task and (or) its sections	Deadlines (in which week)
1	Issuance-receipt of the task	1-2
2	Execution of theoretical and calculation parts	3-14
3	Registration of an individual task	15
4	Protection of individual task	16

TEACHING METHODS

Educational technologies used by teachers in lectures and laboratory classes are used in accordance with the content of the work program and in order to enhance the educational and cognitive activities of students in the study of the discipline. Teaching methods are used (active forms of classes, methods of interaction between teacher and students): lecture, lecture-dialogue, lecture survey, laboratory classes, engineering seminar, interview, consultation.

METHODS OF CONTROL

The current control is realized in the form of interrogation at lectures and consultations, at protection of laboratory works, carrying out of entrance control, control of performance of individual tasks (WG), carrying out of control (modular) works. The control of the component of the work program, which is mastered during the independent work of the student, is carried out by checking the abstracts. The semester control is carried out in the form of an exam whit using the examination tickets in accordance with the curriculum in the amount of educational material defined by the curriculum and in the terms established by the curriculum taking into account the results of current success.

The student is considered admitted to the examination in the discipline subject to the defense of all laboratory work and individual tasks provided by the curriculum in the discipline.

DISTRIBUTION OF SCORES RECEIVED BY STUDENTS AND SCALE FOR EVALUATION OF KNOWLEDGE AND SKILLS (NATIONAL AND ECTS)

Table 1 – Distribution of points to assess student performance

Work at lectures	Practical/ Laboratory work	Execution of an individual task	Interviews on topics of independent student work	Exam	Sum
10	10/10	30	10	30	100

Table 2 – Scale of assessment of knowledge and skills: national and ECTS

The sum of points for all types of educational activities	Rating ECTS	Score on a national scale
90 ... 100	A	excellent
82 … 89	B	good
74 … 81	C	
64 … 73	D	satisfactorily
60 … 63	E	
35 … 59	FX	unsatisfactory with the possibility of reassembly
0 … 34	F	unsatisfactory with mandatory re-study of the discipline

EDUCATIONAL AND METHODOLOGICAL SUPPORT EDUCATIONAL DISCIPLINE

Components of the complex of educational and methodical support of the discipline: lecture plan, methodical support for laboratory and practical works, other methodical materials are published on the official website of the university http://web.kpi.kharkov.ua/elmash/pro-kafedru/

1. Synopsis of lectures on the subject "Electrical Machines".
2. **Calculation of characteristics of transformers and electric machines**.

Methodical instructions for performing calculation tasks for full-time foreign students of specialty 141 – Electric power, electrical engineering and electromechanics specialty on the discipline "Electric machines" / Compilers V.V. Shevchenko, L.V. Domochka – Kharkiv: NTU "KhPI", 2021. – 28 p.

RECOMMENDED BOOKS

Basic literature

1	Charles A. Gross. Electric Machines. – Series: Electric Power Engineering Series. – CRC Press – 2006 – 466 p. ISBN 9780849385810 - CAT# 8581.

2	Jacek F. Gieras. Electrical Machines: Fundamentals of Electromechanical Energy Conversion. – CRC Press Textbook – 2016. – 434 p. ISBN 9781498708838 - CAT# K24957
3	Hamid A. Toliyat, Subhasis Nandi, Seungdeog Choi. Electric Machines: Modeling, Condition Monitoring, and Fault Diagnosis. – CRC Press Reference – 2012. –272 p. ISBN 9780849370274 - CAT# 7027
4	Lessons in Electric Circuits. Vol. I - Direct Current (DC). Vol. II – Alternating Current (AC). URL: https://www.allaboutcircuits.com/textbook/
5	Jacek F. Gieras. Electrical Machines. Fundamentals of Electromechanical Energy Conversion. – Published December 18, 2020 by CRC Press. – Copyright Year 2017. – 450 p. URL: https://www.routledge.com/Electrical-Machines-Fundamentals-of-Electromechanical-Energy-Conversion/Gieras/p/book/9780367736941. ISBN 9780367736941
6	Janusz Turowski, Marek Turowski. Engineering Electrodynamics: Electric Machine, Transformer, and Power Equipment Design 1st Edition. URL: https://www.amazon.com/Engineering-Electrodynamics-Electric-Transformer-Equipment/dp/1466589310
7	Shaahin Filizadeh. Electric Machines and Drives: Principles, Control, Modeling, and Simulation. – 2013 by CRC Press Reference. – 237 p. ISBN 9781439858073 - CAT# K12709
8	Kothari D. P., Nagrath I. J. Electric Machines. – Tata McGraw-Hill Education, 2004. – 834 p. ISBN 9780849370274 - CAT# 7027
9	A. Husain and H. Ashfaq. Electric Machines. – CRC Press Reference. – 2016. – 490 p.
10	J.B. Gupta. Theory & Performance of Electrical Machines. – Published by S.K. Kataria & Sons. – 2016. – 775 p.

Supporting literature

11	Calculation of characteristics of transformers and electric machines. Methodical instructions for performing calculation tasks for full-time foreign students of specialty 141 – Electric power, electrical engineering and electromechanics specialty on the discipline "Electric machines" / Compilers V.V. Shevchenko, L.V. Domochka – Kharkiv: NTU "KhPI", 2021. – 28 p. (in English). http://repository.kpi.kharkov.ua/handle/KhPI-Press/41796

INFORMATION RESOURCES ON THE INTERNET

(List of information resources)

1. Service of electrical equipment. URL: http://www.ra-nn.ru/customer_service/
2. Maintenance of electrical installations and electrical equipment. URL: https://ukn-servis.ru/uslugi/tehnicheskoe-obsluzhivanie-elektroustanovok/
3. Electricity quality and its provision – Balance of active and reactive power. URL: https://forca.ru/knigi/arhivy/kachestvo-elektroenergii-i-ego-obespechenie-7.html