MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL TECHNICAL UNIVERSITY
KHARKIVPOLYTECHNIC INSTITUTE

Department **of Electric Stations**
(title)

«**ЗАТВЕРДЖУЮ**»
Chairman of the Scientific and Methodological Commission of NTU ***"KhPI" 141 – Electricpower engineering, electrical engineering and electromechanics***
(name of commission)

Lazurenko O.P.
(signature) (initials and last name)

" 20 years

WORK PROGRAM OF THE ACADEMIC DISCIPLINE

« Energy Storage Systems and Maneuvering at the Power Grid »

(name of the academic discipline)

level of higher ***education second (master's)***
first (bachelor's) / second (master's degree)

Field of ***knowledge 14Electric engineering***
(cipher and name)

specialty ***141 Electric power engineering, electrical engineering and electromechanics***
(cipher and title)

specialization ***141-01Electric stations***
(cipher and title)

type of ***discipline professional training***
(profecional / selective)

educational form ***full-time education form***
(full-time / part-time)

Kharkiv – 2021 years

APPROVAL LETTER

Work program on the discipline Energy Storage Systems and Maneuvering at the Power Grid
(name of the discipline)

Developer Assistant _____ A.V. Ivahnov
(title, scientific degree and academic rank) (signature) (initials and surname)

The working program was reviewed and approved at the meeting of the Department

Electric stations
(name of the department)

Protocol of 20___ year No._____

Zav. Department *of Electric Stations*
(name of the department)

_____ *P. Lazurenco.*
(signature) (initials and last name)

LETTER OF APPROVAL

Name of the graduating department ***Electric stations***

Head of ***the Department of Electric Stations***

_____ *O.P.Lazurenko*
(signature) (initials and last name)

"___" _____ 20__

WORK CURRICULUM OVERRRIZATION LETTER

Date of the meeting of the department - developer of the RPND	Protocol Number	Signature of the head of the department	Signature of the Chairman of the NMC (for disciplines of general training and disciplines of vocational training in the specialty) or the head of the graduating department (for disciplines of professional training, if the RND is not developed by the graduating department)

PURPOSE, COMPETENCE, RESULTS OF TRAINING AND STRUCTURAL AND LOGICAL SCHEME OF STUDYING ACADEMIC DISCIPLINE

The purpose of the discipline: the formation of an idea of physical processes occuring in electrical systems when changing the modes of their work; the formation of the ability to mathematically describe and analyze these processes; the formation of skills of using computer technology for modeling and detailed study of short-circuit currents.

Competence:

Cipher	Content
FC 3	Ability to use basic knowledge in general physics, higher mathematics, theoretical bases of electrical engineering and electrical materials to solve practical problems in the field of electric power engineering, electrical engineering and electromechanics.
FC 6	Ability to use knowledge on the basics of electromechanics: theories of electric machines, devices and an automated electric drive to solve practical problems in the field of electric power engineering, electrical engineering and electromechanics.
FC 8	Ability to use modern methods of calculation, modeling and analysis of modes of operation of electric, electrotechnical and electromechanical equipment and design of electric and electromechanical systems.
FC 12	Ability to study and analyze scientific and technical information in the field of electric power engineering, electrical engineering and electromechanics.
FC 13	Ability to perform experimental (model) studies of modes of operation of electric power, electrotechnical and electromechanical equipment.
FX 16	Obtaining and using professional knowledge and understands related to the processes of transmission, distribution of electricity and electricity in compliance with the specified parameters of technological processes and the quality of electricity.

Learning outcomes:

Cipher	Content
PRN 12	Know and use methods of fundamental sciences to solve general engineering and professional problems
PRN 16	Determine the principles of construction and normal functioning of elements of electric power, electrotechnical electromechanical complexes and systems
PRN-18	Evaluate the parameters of the operation of electrotechnical, electric and electromechanical equipment and the relevant complexes and systems and develop measures to improve their energy efficiency and reliability
PRN-20	Analyze processes in electrical, electrical and electromechanical equipment and related complexes and systems
PRN-21	Collect and analyze information about abnormal modes and emergencies in the electrical industry to prevent their recurrence in the future
PRN-22	Possess methods of synthesis of electric power, electrotechnical and electromechanical installations and systems with specified indicators
PRN-24	Evaluate the reliability of the operation of electric power, electrotechnical and electromechanical systems.

Structural and logical scheme of academic discipline

Previous disciplines:	The following disciplines:
Bachelor's level training disciplines	

DESCRIPTION OF THE DISCIPLINE

(distribution of study time by semester and types of training)

Semester	Total volume (hours) / ECTS credits	Of these,		By type of classroom classes (hours)			Individual tasks of students (CP, KR, WP, R, RE)	Current control	Semester control	
		Classroom classes (hours)	Independent work (hours)	Lecture	Laboratory classes	Practical classes, seminars		Control papers (number of works)	Credit	Exam
1	2	3	4	5	6	7	8	9	10	11
9	**120 / 4**	**64**	**56**	**32**	**16**	**16**	**D**	**2**		**+**

The ratio of the number of hours of classroom classes to the total amount **is 54 %**:

STRUCTURE OF THE DISCIPLINE

No.	Types of training sessions (L, drugs, CP)	Number of hours	Semester number (if the discipline is taught in several semestra). Names of content modules. Names of topics and questions of each lesson. Tasks for independent work.	Recommended Literature (Base, Secondary)
1.	L1	4	Goals of the discipline. The value of this academic discipline to provide other professional disciplines. The amount of educational material, types of classes and the organization of work for its assimilation. Maneuvering in the electric power system	B 1,4,9-12 D 16
2.	Pr1	2	Aspects of maneuvering in the power system	-
3.	LR1	4	Investigation of the peculiarities of the technological cycle of the thermal power plant (TPP)	Ministry of Home
4.	L2	2	Maneuvering at traditional power plants (TPPs, NPPs, hydroelectric power plants)	B 1,4,9-12 D 16
5.	L3	2	Maneuvering – Gas turbine units	B 1,4,9-12 D 16
6.	Pr2	2	Features of gas turbine plants.	-
7.	Lr2	4	Research of the effectiveness of using a photovoltaic power plant	Ministry of Home
8.	Pr3	2	Photovoltaic power plants, calculation of the efficiency of their use.	-
9.	L4	2	Technologies of oculation, their varieties.	B 2,3,5,8 D 15,18,19
10.	Pr4	2	Comparison of network power drives.	-
11.	L5	2	Mechanical drives – IPP	B 6 D 18
12.	L6	2	Mechanical drives –Pneumatic accumulator	B 6 D 18
13.	L7	2	Mechanical drives – Supermahos.	B 6 D 18
14.	Pr5	2	Calculation of supermahos.	-
15.		2	Modular control No1	
16.	Pr6	2	Calculation of PSP indicators.	-

No.	Types of training sessions (L, drugs, CP)	Number of hours	Semester number (if the discipline is taught in several semestra). Names of content modules. Names of topics and questions of each lesson. Tasks for independent work.	Recommended Literature (Base, Secondary)
17.	L8	2	Electromagnetic drives – Inductive superconducting drives	B 8 D 18
18.	L9, 10	4	Electrochemical Drives – Rechargeable Batteries	B 13 D 18
19.	Lr3	4	Study of the structure of lead and alkaline batteries. Set the battery to charge mode to restore its capacity	
20.	LR4	4	Research of Lithium Batteries	
21.	L11	2	Electrochemical drives - Supercoons	B 13 D 18
22.	L12	2	Electrochemical storages – Fuel cells	B 13 D 18
23.	Pr7	2	Investigation of the installation of lead batteries in charge mode to restore its capacity.	-
24.	L13	2	Electrochemical drives – Flow-through redox batteries	B 13 D 18
25.	Pr8	2	Investigation of flowing redox batteries.	-
26.		2	Modular control No2	
Together		120		

INDEPENDENT WORK

№ S/p	Name of types of independent work	Number of hours
1	Processing of lecture material	24
2	Preparation for practical classes	16
3	Performing an individual task:	16
	Together	56

INDIVIDUAL TASKS

ABSTRACT

(type of individual task)

№ S/p	Name of the individual task and/or its sections	Deadlines (in what week)
1	Abstract on a given topic. The student should understand in depth on the topic of the abstract: 1) To investigate the relevance of the issue; 2) Give the basic principles of operation of the devices specified in the topic; 3) Give examples of the use of existing (if any) devices specified in the topic; 4) To independently conclude the expediency of using the devices specified in the topic, with the indication of advantages and disadvantages; 5) At the end, issue, according to the VAC, the list of used sources of information The work is presented in the form of an explanatory note on 10-30 pages: 1) Cover sheet; 2) Table of contents; 3) List of conditional designations and abbreviations; 4) Introduction; 5) The main part; 6) Conclusions; 7) List of sources of information.	10

TEACHING METHODS

The course is focused on the formation of students' ideas about technologies of storage and maneuvering in the power system of Ukraine and other countries, the formation of the ability to describe and analyze these technologies and devices, instill in students the skills of modeling and the use of computer technology in the study and calculations of technologies of storage and maneuvering.

The *problematic method* and reproductive methods of teaching with reliance on active teachingmethods are used.

The main recommendation is to ensure uniform active work of students on the course during the academic semester. They must produce the material of listened lectures, master specialized software, prepare for practical classes to solve problems, perform individual tasks.

Most of the tasks for practical classes involves the presence of an individual task. *Instructive-practical and problematic* teaching *methods are* used.

The student's independent work involves an incentive method of study. It includes the study of lecture material, preparation for practical classes, the implementation of an individual task, the study of additional material.

CONTROL METHODS

The current control is implemented in the form of modular control works and the implementation of an individual task, final examination work.

All lectures of the discipline end with repetition questions to answer. Practical classes involve solving problems. Control is carried out during the survey at lectures, conducting practical classes, protecting the individual task, the current control of the content modules. The assessment takes into account the knowledge of theoretical material, the scope of study of additional literature, the completeness of answers to control questions and the correctness of the individual practical task.

Control of the component of the work program, which is mastered during the independent work of the student, is carried out:

- from lecture material – by modular control works;
- individual tasks – by evaluating an individual task, protecting it and participating in practical classes.

Final control – exam (with an assessment on a 100-point scale) in the amount of educational material determined by the curriculum and within the terms established by the curriculum and schedule of the educational process.

The priority is the rating assessment based on the results of the current control and the success of the individual task.

List of questions for preparing for the exam:

•The concept of balance in the electricity system, to give all components.

• The concept of maneuvering in the electric power system, to give maneuvering characteristics of different types of power plants.

• Maneuvering capabilities of TPP and NPPs, to give similar and distinctive features.

•The maneuvering capabilities of the hydroelectric power complex and the GTU to give similar and distinctive features.

•Features of GTU.

•Types of storage technologies.

•Mechanical power drives.

•Electrochemical power storages.

•Electromagnetic power drives.

•Principles of hybrid combination of electricity storages.

• Application of electricity storages in the power system.

•Causes of balance violation in the electricity system.

Criteria for assessing the quality of students' knowledge:

Excellent evaluate student, who deeply and reliably assimilated software material, exhaustive, consistent, competent and logical coherently laid it out, in response linked the theory with practice, showed familiarity with monographic literature, software and correctly justified the solution of the problem (the number of points received 90-100).

A study that firmly knows the program material, competent and essentially teachesit is wellevaluated, does not assume significant inaccuracies in answering

questions, correctly applies theoretical provisions in solving practical questions and tasks: C (the number of points received is 82-89), C (the number of points received is 75-81).

The study, which knows only the main material, but has not learned its details satisfactorily, suggestsinaccuracies, does not correctly formulate basic laws andrules, has complications in the implementation of practical tasks: D (the number of points received is 64-74), E (the number of points received is 60-63).

Poorly evaluated studio, who does not know a significant part of the program material, makes significant mistakes, with complications performs practical tasks FX (the number of points received 35-59), unsatisfactory with the mandatory re-study of discipline F (the number of points received 0-34).

DISTRIBUTION OF POINTS RECEIVED BY STUDENTS AND THE SCALE OF KNOWLEDGE AND SKILLS ASSESSMENT (NATIONAL AND ECTS)

Table 1: Table 1 Use the < Distribution Points for assessment of the student's current performance

Ongoing testing and independent work		Individual task	Exam	Amount
T1-T7	T8-T13			
30	30	25	15	100

Individual task

Explanatory notes	Ilustrativeparticle	Zahistroboti	Amount
10	-	15	25

Table 2: Use the Knowledge and skills assessment scale: national and ESTS

Amount of points for all types of educational activities	ECTS score	Score national scale
90 – 100	A	Perfectly
82 – 89	B	well
75 – 81	C	
64 – 74	D	Satisfactory
60 – 63	And	
35 – 59	FX	unsatisfactory with the possibility of re-assembly
0 – 34	F	unsatisfactory with the obligatory re-study of the discipline

EDUCATIONAL AND METHODOLOGICAL SUPPORT OF ACADEMIC DISCIPLINE

1. MV to the implementation of l/r in the discipline "Technologies of oculation and maneuvering in the power system" for full-time students special. 008, 601, 615. Ivakhnov A.V., Bulgakov O.V., Fedorchuk S.O., Lazurenko O.P. – 2021

Components of educational and methodological support

discipline are located on the site:

http://sites.kpi.kharkov.ua/es/ManualsU#GuidsEl

RECOMMENDED LITERATURE

Basic literature

1.Advanced Power Generation Systems - 1st Edition [Electronic resource]. URL: https://www.elsevier.com/books/advanced-power-generation-systems/dincer/978-0-12-383860-5 (accessed: 27.08.2021).

2.Electrochemical Energy Conversion and Storage Systems for Future Susta [Electronic resource]. URL: https://www.routledge.com/Electrochemical-Energy-Conversion-and-Storage-Systems-for-Future-Sustainability/Samantara-Ratha/p/book/9781771888851?utm_source=cjaffiliates&utm_medium=affiliates&cjevent=3fee33a2072511ec801f7db80a180514 (accessed: 27.08.2021).

3.Energy Storage for Power System Planning and Operation | Wiley [Electronic resource] // Wiley.com. URL: https://www.wiley.com/en-al/Energy+Storage+for+Power+System+Planning+and+Operation-p-9781119189084 (accessed: 27.08.2021).

4.Fundamentals of Thermal and Nuclear Power Generation - 1st Edition [Electronic resource]. URL: https://www.elsevier.com/books/fundamentals-of-thermal-and-nuclear-power-generation/koizumi/978-0-12-820733-8 (accessed: 27.08.2021).

5.Handbook of Energy Storage - Demand, Technologies, Integration | Michael Sterner | Springer [Electronic resource]. URL: https://www.springer.com/gp/book/9783662555033 (accessed: 27.08.2021).

6.Mechanical Energy Storage for Renewable and Sustainable Energy Resources | SpringerLink [Electronic resource]. URL: https://link.springer.com/book/10.1007/978-3-030-33788-9 (accessed: 27.08.2021).

7.Mechanical Energy Storage Technologies - 1st Edition [Electronic resource]. URL: https://www.elsevier.com/books/mechanical-energy-storage-technologies/arabkoohsar/978-0-12-820023-0 (accessed: 27.08.2021).

8.Novel Electrochemical Energy Storage Devices: Materials, Architectures, and Future Trends | Wiley [Electronic resource] // Wiley.com. URL: https://www.wiley.com/en-ae/Novel+Electrochemical+Energy+Storage+Devices%3A+Materials%2C+Architectures%2C+and+Future+Trends-p-9783527821068 (accessed: 27.08.2021).

9.Sallam A.A., Malik O.P. Power Grids with Renewable Energy: Storage, integration and digitalization. IET Digital Library, 2020.

10.Renewable energy conversion systems - 1st Edition [Electronic resource]. URL: https://www.elsevier.com/books/renewable-energy-conversion-systems/kamran/978-0-12-823538-6 (accessed: 27.08.2021).

11.Renewable-Energy-Driven Future - 1st Edition [Electronic resource]. URL: https://www.elsevier.com/books/renewable-energy-driven-future/ren/978-0-12-820539-6 (accessed: 27.08.2021).

12.Smart Energy Grid Engineering - 1st Edition [Electronic resource]. URL: https://www.elsevier.com/books/smart-energy-grid-engineering/gabbar/978-0-12-805343-0 (accessed: 27.08.2021).

13.Thermal, Mechanical, and Hybrid Chemical Energy Storage Systems - 1st Edition [Electronic resource]. URL: https://www.elsevier.com/books/thermal-mechanical-and-hybrid-chemical-energy-storage-systems/brun/978-0-12-819892-6 (accessed: 27.08.2021).

Supporting literature

14. Fedorchuk S.O. et al. Modeling of distributed energy systems based on renewable energy sources // Energy management: state and prospects of development - PEMS'17. 2017.
15. Ivakhnov A.V., Lazurenko O.P., Fedorchuk S.O. Modeling of the system of accumulation of electricity as highly maneuvering power with the use of various power grid units // Modelling of energy storage systems as highly maneuvering power by using it in various nodes of power grid. Private Entrepreneur Panov A.M., 2018. № 195.
16. Ivakhnov A.V., Lazurenko A.P. Increase of reserves of balancing capacities of the power system through the use of electric batteries. National Technical University "Harkowski Polythechnich-est", 2017. Vol. Part 2.
17. Lazurenko A.P., Krugol N.M., Ivakhnov A.V. Increasing the reserves of balancing capacities of the energy system of Ukraine through the use of electric batteries. National Technical University "Kharkiv Polytechnic Institute," 2017.
18. Ivakhnov A.V., Fedorchuk S.O., Lazurenko O.P. Systems of energy storage, analysis of capabilities and their combination for use in the power system // Power storage systems, opportunities analysis and their combinations for use in the power system. National Technical University "Kharkiv Polytechnic Institute", 2018. № №10(1286).
19. Fedorchuk S. et al. Optimization of Storage Systems According to the Criterion of Minimizing the Cost of Electricity for Balancing Renewable Energy Sources // 2020 IEEE KhPI Week on Advanced Technology (KhPIWeek). 2020. P. 519–525.

INFORMATION RESOURCES ON THE INTERNET

1. http://scilab.org
2. http://mathworks.com