Vinnytsia National Technical University
Department of Power Plants and Systems
Faculty of Power Engineering and Electromechanics

MODERN PROBLEMS OF ELECTRIC POWER, ELECTRIC ENGINEERING AND ELECTROMECHANICS

(Compulsory)
Professional

Master's level of higher education

Educational program: Power plants
Specialty: 141 – electrical engineering and electromechanics
Lecturer: Yuliia MALOHULKO
ECTS credits – 4.5 (135 hours)
Lectures – 27 hours
Practical lessons – 18 hours
Laboratory lessons – 18 hours
Self-support work – 72 hours
The course is given in **English**

Course content

The course aims to provide advanced knowledge about formation of systematized knowledge of students of analysis methods and improvement of technological process of production, transmission, distribution and consumption power energy.
The main tasks of studying the discipline «Modern problems of electric power, electric engineering and electromechanics» are: improvement of the technological process of generation, transmission, distribution and consumption of electrical energy in electrical power systems and electromechanical systems in accordance with current standards, rules and regulations;
analysis of the technological process during the production, transmission, distribution and supply of electricity in the power network; finding out the reasons for the suboptimal technological process during the production, transfer, distribution and consumption of electrical energy;
development and implementation of measures to improve the technological process of production, transportation, distribution and consumption of electrical energy.

Competencies that the applicant must master as a result of studying the discipline

The study of an academic discipline involves the formation and development of students' competencies:

Integral: The ability to solve complex problems and tACSs during professional activity in the field of electric power, electrical engineering and electromechanics or in the learning process, which involves conducting research and/or implementing innovations and is characterized by uncertainty of conditions and requirements.

General:

GC03. Ability to use information and communication technologies.

Special (professional):

SK11. The ability to evaluate indicators of reliability and efficiency of the functioning of electric power systems, electrotechnical and electromechanical objects.

SK15. The ability to publish the results of their research in specialized scientific publications.

SK16. The ability to solve complex specialized tasks and practical problems related to the operation of information systems in electric power engineering, electrical engineering and electromechanics.

SK17. The ability to solve complex specialized tasks and practical problems related to the optimal development of electrical energy transmission and distribution systems.

Program results of studying the discipline

PR4. Outline a plan of measures to increase the reliability, safety of operation and prolong the resource of electric power, electrotechnical and electromechanical equipment and relevant complexes and systems.

PR 5. Analyze processes in electric power, electrotechnical and electromechanical equipment and corresponding complexes and systems.

PR. Reconstruct existing electrical networks, stations and substations, electrotechnical and electromechanical complexes and systems in order to increase their reliability, efficiency of operation and extension of the resource.

PR 12. To participate in international scientific conferences and seminars devoted to modern problems in the field of electric power engineering, electrical engineering and electromechanics.

PR 13. Choose the direction of scientific research taking into account modern problems in the field of power engineering, electrical engineering and electromechanics.

PR 17. To adhere to the principles and directions of the energy security development strategy of Ukraine.

PR 18. To combine various forms of research work and practical activities in order to overcome the gap between theory and practice, scientific achievements and their practical implementation.

Description of the academic discipline

<table>
<tr><td rowspan="2">Name of indicators</td><td rowspan="2">Field of knowledge, specialty, educational programs, level of higher education</td><td colspan="2">Characteristics of the academic discipline</td></tr>
<tr><td>full-time education</td><td>external form of education</td></tr>
<tr><td>The number of credits is 4.5</td><td>Branch of knowledge
14 Electrical engineering</td><td colspan="2">Compulsory professional</td></tr>
<tr><td>Modules - 2</td><td rowspan="4">Specialty
141 Power engineering, electrical engineering and electromechanics

Educational program:</td><td colspan="2">Year of training (course):</td></tr>
<tr><td>Content modules – 2</td><td>1</td><td>1</td></tr>
<tr><td rowspan="2">Individual scientific and research task — course work and reports at the annual scientific and technical conference of VNTU divisions</td><td colspan="2" rowspan="2">Semester</td></tr>
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<table>
<tr><td rowspan="2">The total number of hours is 135</td><td rowspan="2">Power plants</td><td>2nd</td><td>2nd</td></tr>
<tr><td colspan="2">Lectures</td></tr>
<tr><td rowspan="10">Weekly hours for full-time education:

classrooms – 3.5

student's independent work – 6.5</td><td rowspan="10">Level of higher education:

second (master's)</td><td>27</td><td>10</td></tr>
<tr><td colspan="2">Practical, seminar</td></tr>
<tr><td>18</td><td>5</td></tr>
<tr><td colspan="2">Laboratory</td></tr>
<tr><td>18</td><td>5</td></tr>
<tr><td colspan="2">Independent work</td></tr>
<tr><td>72</td><td>115</td></tr>
<tr><td colspan="2">Type of control</td></tr>
<tr><td colspan="2">Type of control: exam</td></tr>
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Program of educational discipline

Content module 1.*Problems and tasks of the improving production technology, transportation and electrical energy consumption.*

Task 1. *Problems and tasks of the improving production technology, transportation and electrical energy consumption.* Characteristics of the modern state of generator sets, power lines and equipment. National energy program tasks for generating capacities reconstruction, power networks, power energy saving technologies.

Task 2. *Alternative and renewable energy sources.* Fuel and energy resources of the country. Typical load schedules of electricity generation and consumption. Solar power plants. Wind power plants. Small hydropower plants. Integrated use of renewable energy sources. Automation of the renewable energy sources generation process.

Content module 2. Organizational and technical measures to reduce power losses.

Task 3. *Physical bases of power losses in elements of electrical engineering, electric power engineering and electromechanics (EEE).* The main causes of power losses increased in the power system and ways to reduce it. Element with equivalent resistance. Transformers and autotransformers. Active power losses associated with reactive power transmission and consumption. Static load characteristics to determine power losses. Power loss calculation methods. Principles of power and electrical energy losses control in electrical equipment. Cost-effective level of power losses in electrical equipment. Power and energy losses control tasks in the power energy systems. Information support of the of power systems optimization and its analysis

Task 4. *Organizational and technical means of energy efficiency increasing.* Optimization of power networks operating modes and main equipment. Reactive power compensation. Voltage levels optimization in power networks. The ensuring optimal voltage in power centers. Counter voltage

regulation. Software voltage regulation. The determination of the optimal voltage control laws by transformers and compensating equipment. Optimization of transformer operation modes. Automation of transformers transformation coefficients regulation. Ranking of transformers in accordance with their reliability, residual life and sensitivity of losses to changes in transformation coefficients. Computer diagnostics of electrical equipment for more efficient use in optimal control tasks.

Content module 3. SMART Grid technologies for improving technological processes in EEE.

Task 5. *The concept and main provisions of the concept SMART GRID.* The main prerequisites for the formation of a new (innovative) concept of EEE development. Principles of developing the Smart Grid concept abroad, IEEE standards. Comparison of characteristics and properties of EPS before and after the introduction of Smart Grid technologies. Energy and communication connections of power sources in Smart Grid.

Task 6. *Creation and improvement of the automatic control system in EEE.* Block diagram of the automatic control system of normal modes of EPS. Operational information and control complex in automated control systems. The automatic control system of power and voltage flows in the power system and increase the efficiency of its functioning. The improvement of power metering systems. Consumption methods detecting of unaccounted electricity in the industrial and municipal spheres. Automated power metering systems. Planning and financing measures to reduce power and electricity losses. Calculation of technical and economic efficiency from measures to reduce power and electricity losses.

Content module 4. Functioning of the electric power industry in the conditions of the energy market.

Task 7. *Balancing in the electric power system modes with renewable energy sources.* Functions of NPS «Ukrenergo», Guaranteed buyer and operators of power transmission and distribution systems. Hourly forecast of the power balance of the UPS of Ukraine for the next day. RES in the process of balancing power and electricity. The ways to reserve the RES generation instability.

Task 8. *Review of the Ministry of Energy of Ukraine regulatory documents and features of functioning with the European power system.* The law about power energy, Power networks codex, The concept of "smart" (intelectual) networks. Tasks for connection and operation of the UES of Ukraine in parallel with the European energy system.

Topics of laboratory classes

№	Topic
1	Calculation of the steady-state mode of the electric network
2	Comparative analysis of methods for determining power losses in electrical networks
3	Construction of the dependence of EES heterogeneity on the inductance of the transmission line, determination of the optimal inductance of the transmission line from the point of view of the influence on the heterogeneity of the system. Studying the feasibility of installing longitudinal compensation devices in power lines

4	Research on the effectiveness of using transformers to reduce power losses. Construction of dependences of power losses on transformation coefficients. Analysis of the sensitivity of these dependencies and ranking of transformers
5	Study of efficiency and expediency of reactive power compensation. Calculation of modes when installing sources of reactive power in different nodes of the network.
6	Analysis and assessment of the sensitivity of optimal solutions
7	Study of the influence of the completeness of the information support on the accuracy of the calculation of electricity losses
8	Study of the impact of RES on the technical and economic indicators of the electric network

Topics of practical classes

№	Topic
1	Power and electricity losses in transformers and power lines
2	Determination and assessment of power and electricity losses
3	Formation of calculation schemes and information support
4	Technical and economic assessment of measures to reduce electricity losses
5	Features of synchronous and asynchronous machines at small hydroelectric power stations
6	Comparison of characteristics and properties of the power system before and after the introduction of Smart Grid technologies

Individual tasks

№	Topic
1	Problems and tasks of improving the technology of production, transportation, distribution and transformation of electricity.
2	The main tasks of optimization. Problems of optimal design. Problems of optimal planning.
3	Unconditional extremum of smooth functions. Conditional 6 9 extremum of smooth functions.
4	Golden ratio method. Fibonacci method. Dichotomy method. Bisection method. Quadratic interpolation method.
5	Criterion of optimality. The Kuhn-Tucker theorem. Classes of optimization problems. One-dimensional minimization methods.
6	Passive and sequential search. Sequential search methods. Methods of polynomial approximation.
7	Minimization of convex functions. Convex sets. Convex functions. Differentiated convex functions. Strongly convex functions.
8	Examples of minimization of quadratic functions. Numerical methods of unconditional minimization. Relaxation sequence.

9	Methods of descent. Gradient descent method. Minimization of the quadratic function. Conjugate directions of descent. Algorithms of the gradient descent method. Method of conjugate directions.
10	Newton's method. Modifications of Newton's method. Quasi-Newton methods. Features of the direct search for the minimum.
11	Using the regular simplex. Search using an irregular simplex. Cyclic coordinate descent. Analytical methods of nonlinear programming
12	Minimization of the objective function on a given set. Minimization under equality type constraints. General problem of nonlinear programming. The saddle point of the Lagrange function. Lagrange's problem. Numerical methods of nonlinear programming
13	Conditional gradient method. Antigradient projection method. The method of projecting a point onto a set.
14	Methods of successive unconditional minimization. Multidimensional unconditional optimization. Optimization without limits.
15	Gradient algorithms. The method of conjugate gradients.
16	The method of uncertain Lagrange multipliers. Problems with inequality constraints.
17	Organizational and technical means of increasing energy efficiency.
18	Concepts and basic provisions of the Smart Grid concept. Creation and improvement of the automatic control system in the power system.
	Essay for correspondence students

Individual tasks

The working curriculum provides for course work by full-time and part-time students.

The task of the course work is to consolidate knowledge and practical skills in determining the optimal distribution of active power between aggregates and power plants; construction of equivalent characteristics of an electric station.

According to the decision of the department, students prepare essays on separate topics of the discipline and reports for the annual scientific and technical conference of the VNTU divisions.

Teaching methods

The main teaching methods are: lecture-visualization; story-explanation; briefing; illustrating; demonstration, in particular, using multimedia learning tools; oral survey; testing; educational discussion; conversation-dialogue; performance of laboratory work; group work; a report on topics assigned to independent study; solution of practical tasks; consultations; independent work at home; individual assignments (course work, abstracts, essays, etc.), preparation of reports of a scientific and research nature, in particular, for the annual scientific and technical conference of VNTU divisions.

Control methods

Current control is carried out during practical and laboratory classes and is aimed at checking the level of the student's readiness to perform specific work. Current control can be carried out with the help of electronic tests in the local network or in the global network (JetIQ, Google) and conducting an oral or written survey.

Distribution of points received by students

Table 1 – Distribution of points for mastering content modules during the 2nd semester for full-time students

Current testing and independent work				Final test (exam)	Total
Module 1		Module 2			
Content module 1	*Content module* 2	*Content module* 3	*Content module* 4	25 points	100
16 points	20 points	19 points	20 points		

Table 2 – Evaluation of students' knowledge, abilities and skills in certain types of work and in general by modules (in points)

Module	Credits	Lectures (hours)	Laboratory works (hours)	Practical classes (tasks/hours)	Control work	Colloquium
I	2,25	13	9	9	1	1
II	2,25	14	9	9	1	1

Table 3 – Evaluation of the results of the coursework defense

Type of work	Module 1	Module 2
1. Practical classes (PC 1, 2, 6 2 points each: 3×2=6 points; PC 3, 4, 5 each 4 points 4×3=12 points)	8	10
2. Control works	10	9
3. Laboratory works (LW 1, 2, 3, 4, 5, 6, 7 each 2 points: 7×2=14 points, LW 8 – 4 points)	8	10
4. Colloquium	10	10
In total	36	39

Methodical support

1. Work program of the educational discipline "Modern problems of electric power, electric engineering and electromechanics".
2. Work plan of the discipline for the current trimester.
3. A set of examination tickets.
4. A set of complex control works.
5. Current knowledge control tests.
6. Questions for colloquiums.

Course policy

Applicants and teachers must adhere to the norms of ensuring honor, dignity, mutual respect and trust, equality and tolerance of all participants in the educational process by observing the principles of academic integrity set forth in the "Regulations on Academic Integrity **at VNTU"**.

In order to prevent and detect plagiarism in academic works, to develop the skills of correct work with sources of information and to implement the practice of proper citation, compliance with the requirements of scientific ethics and respect for intellectual property, and activation of independence and individuality when creating an author's work and responsibility for violations of generally accepted rules of citation should be observed of norms **"Regulations on the prevention of academic plagiarism and the procedure for its detection in educational, scientific, qualification and scientific-methodological works at VNTU".**

In order to recognize the learning results obtained during non-formal and/or informal education (which was obtained according to educational programs and did not involve the awarding of state-recognized educational qualifications by education level, but could end with the awarding of professional and/or partial educational qualifications, as well as education that was carried out in the manner of self-education), applicants can use the relevant procedures specified in the **"Regulations on the procedure for recognizing learning results obtained through informal and/or informal education at VNTU".**

Applicants have the right to appeal the results of intermediate and final control measures, but only on the basis of reasoned explanations, in accordance with the **"Procedure for the organization and conduct of assessments, differentiated assessments, examinations at VNTU"**, as well as by directly contacting the educational ombudsman, according to the **"Regulations on the educational ombudsman on the rights of VNTU students"**.

In order to resolve conflict situations that may arise between applicants and other participants of the educational process and/or to prevent the occurrence of conflict situations, one should be familiar with the norms of the **"Code of Ethics of VNTU".**

VNTU applicants must be guided by the principle of "zero tolerance" to any manifestations of corruption and must take all measures provided by law to prevent, detect and counter corruption and related actions (practices), in accordance with the VNTU Anti-Corruption Program **.**

These documents are published on the VNTU website: https://vntu.edu.ua/uk/public-info/zag.html .

Recommended literature

1. Оптимізація режимів електричних мереж з відновлюваними джерелами електроенергії: монографія / П. Д. Лежнюк, О. Є. Рубаненко, І. О. Гунько – Вінниця : ВНТУ, 2017. – 164 с.

2. Добровольська Л.Н., Кулик В.В., Лежнюк П.Д. Електроощадні технології в електроенергетичних системах. –Луцьк: Вежа-Друк, 2018.– 328 с

4. Балансова надійність електричної мережі з фотоелектричними станціями: монографія // Лежнюк П.Д., Комар В.О., Кравчук С.В., Лесько В.О., Нетребський В.В. – Вінниця: ВНТУ, 2018. – 136 с.

5. Інтелектуальні електричні мережі: елементи та мережі. – За ред. Кириленка О.В. – К.: Ін-т електродинаміки НАН України, 2016. – 400 с.

7. Malogulko, J. Influence of dispersed generation on reliability of electric network / Malogulko, J., Vyshnevsky, S., Kotylko , I., Sobchuk, N. // Przeglad Elektrotechniczny, 2020, 96(10), pp. 119-123.

8. Komar, V., Lezhniuk, P., Lesko, V., Malogulko, Yu., Netrebskyi, V., Sikorska, O. (2022). Electricity consumption and renewable energy sources generation schedules coordination in electric networks for balance reliability increasing. Energy facilities: management and design and technological innovations. Kharkiv: PC TECHNOLOGY CENTER, 42–75. doi: https://doi.org/10.15587/978-617-7319-63-3.ch2

9. Optimization of the functioning of the renewable energy sources in the local electrical systems [Text] : monograph / O. B. Burykin, P. D. Lezhniuk, V. V. Kulyk [etc.]. – Vinnitsa : VNTU, 2018. – 124 p. – ISBN 978-966-641-719-3.

10. Лежнюк П.Д., Ковальчук О.А., Нікіторович О.В., Кулик В.В. Відновлювані джерела в розподільних електричних мережах: Монографія. – Вінниця: ВНТУ, 2014. – 204 с.

11. Лежнюк П.Д., Нікіторович О.В., Кулик В.В. Малі гідроелектростанції з асинхронними генераторами: Монографія. – Вінниця: УНІВЕРСУМ-Вінниця, 2010. – 136 с.

12. Лежнюк П.Д., Кулик В.В., Нетребський В.В., Тептя В.В. Принцип найменшої дії в електротехніці та електроенергетиці: Монографія. – Вінниця: ВНТУ, 2014. – 212 с.

13. Oleksandr Burykin, Petro Lezhniuk, Volodymyr Kulyk, Oleksandr Rubanenko, Yuliia Malohulko. Optimization of the renewable energy sources in the local electrical systems: monograph. – Vinnytsia: VNTU, 2018. – 124 p.

14. Petro Lezhniuk, Oleksandr Burykin, Yuliia Malogulko. Distributed energy sources in the local electrical systems. – LAP LAMBERT Academic Publishing, 2018. – 140 p.

15. Petro Lezhniuk, Vyacheslav Komar, Serhii Kravchuk, Volodymyr Netrebskiy, Vladyslav Lesko. Optimal Integration of Photoelectric Stations in Electric Networks. – LAP LAMBERT Academic Publishing, 2019. – 210 p.

16. Буславець О.А., Лежнюк П.Д., Черемісін М.М. Інформаційне забезпечення задач зменшення втрат електроенергії в електричних мережах: монографія. – Вінниця: ВНТУ, 2020. – 184 с.

17. Petro Lezhniuk, Olena Rubanenko. Optimal Solutions Sensitivity Analysis in Complex Systems in Relative Units. – Collective Monograph: “Scientific Research of the XXI Century”, volume 2. – Sherman Oaks, California (USA). – 2021. – p. 111–118. doi: 10.51587/9781-7364-13302-2021-002-111-118.