Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Department of Automation
of Electrical and
Mechatronic Complexes

Reliability of electrical and mechatronic systems

Working program of educational discipline (syllabus)

Requisites of educational discipline

Higher education level ***Second (master)***

Knoweledge domain	**14 Electrical Engineering**
Specialty	**141 Electric Power Engineering, Electrotechnics and Electromechanics**
Educational program	**EPP, ESP "Engineering of intelligent electrical and mechatronic complexes"**
Status of the discipline	*Normative*
Form of education	*Full-time (day-time)*
Year of study**, semester**	*I course, autumn semester*
Teaching hours	*120 hours / 4 credits ECTS (lections – 36 hours, seminars – 18 hours, self students studying – 66 hours)*
Semester control / control activities	*Exam, modular test*
Schedule	*http://rozklad.kpi.ua/*
Language of study	*English*
Інформація про керівника курсу / викладачів	Lections and seminars are given by: *PhD, assoc. prof., , assoc. prof. of Department of AEMC Viktor Gorodetskyi, v.gorodetskyi@ukr.net*
Розміщення курсу	Googleclassroom, oltnw7u

Program of educational discipline

1. Description of the discipline, its purpose, subject of study and learning outcomes

The discipline considers the main approaches to assessing the reliability of electrical and mechatronic systems used in energy-intensive industries. The basis of the course is not only the mathematical apparatus for calculating the reliability of these systems, but also the physical basis of operation of such equipment, which affects its reliability.

The **purpose** of the discipline is to form a system of basic knowledge to solve professional problems of reliable operation of specific electromechanical equipment of these industries, the design of such equipment taking into account the reliability factor.

The **subject** of study of the discipline is a set of questions on the theoretical basis of calculating the reliability and methods of improving the reliability of equipment at different stages. As a result of studying the discipline "Reliability of electrical and mechatronic systems" students receive the following **competencies**:

General competencies (GC) :

- Ability to abstract thinking, analysis and synthesis (GC1).
- Ability to search, process and analyze information from various sources (GC2).
- Ability to use information and communication technologies (GC3).
- Ability to apply knowledge in practical situations (GC4) .
- Ability to use a foreign language to carry out scientific and technical activities (GC5)

Professional competencies (PC):

- Ability to apply the acquired theoretical knowledge, scientific and technical methods to solve scientific and technical problems and problems of power engineering, electrical engineering and electromechanics (PC1).
- Ability to apply existing and develop new methods, techniques, technologies and procedures to solve engineering problems of power engineering, electrical engineering and electromechanics (PC2).
- Ability to plan, organize and conduct research in the field of power engineering, electrical engineering and electromechanics (PC3).
- Ability to develop and implement measures to improve the reliability, efficiency and safety in the design and operation of equipment and facilities of electricity, electrical engineering and electromechanics (PC4).
- Ability to analyze technical and economic indicators and examination of design decisions in the field of power engineering, electrical engineering and electromechanics (PC5).

Program learning outcomes (PLO):

- Know the basic principles of sustainable development of society, taking into account the social, technological, economic and environmental aspects of human activity (PLO4).
- Know a foreign language at a level that provides free discussion with foreign scientists on current scientific and technical problems of power engineering, electrical engineering and electromechanics and the opportunity to speak at foreign conferences and symposia (PLO5).
- Know and understand the rules of safe operation of electrical, electrical and electromechanical equipment (PLO7).
- Know the main effective methods and approaches aimed at improving energy efficiency and reliability of electrical, electrical and electromechanical equipment and related complexes and systems (PLO9).
- Knowledge, understanding and practical application of experimental theory, methods of experiment planning, evaluation of experimental results, methods of analysis of experimental data and construction of mathematical models based on them, including the use of new methods based on the use of modern information technologies (PLO20).

2. Prerequisites and post requisites of the discipline (place in the structural and logical scheme of education according to the relevant educational program)

The study of the discipline is based on the material of the disciplines studied before: "Higher Mathematics", "Physics", "Electrical Materials", "Pump, fan and pneumatic systems". "Electricity supply systems for energy-intensive industries". Related disciplines are: "Technical risks", "Complexes, machines and equipment of electromechanical systems", "Systems of technical diagnostics".

3. The content of the discipline

The discipline consists of 3 sections:
Section 1. Mathematical foundations of reliability
Topic1.1. Basic concepts of reliability theory
Topic 1.2. The main quantitative characteristics of the reliability of elements and systems
Topic 1.3. Mathematical apparatus of reliability theory
Topic 1.4. Methods for calculating the reliability for the main connection of elements
Topic 1.5. Analysis of the reliability characteristics of equipment with redundancy
Section 2. Physico-chemical bases of reliability
Topic 2.1. Physico-chemical processes of materials destruction
Topic 2.2. Physical and chemical nature of failures of electromechanical systems
Section 3. Reliability of equipment in various industries
Topic 3.1. Methods of calculating reliability for complex systems
Topic 3.2. Reliability of equipment for power supply systems
Topic 3.3. Reliability of mine equipment
Topic 3.4. Reliability of quarry electromechanical equipment
Topic 3.5. Reliability of equipment of oil pumping stations
Topic 3.6. Reliability of control systems
Topic 3.7. Methods to increase reliability

4. Training materials and resources

Basic literature

1. V.G. Gorodetsky, S.V. Zaichenko. The reliability of electro-mechanical equipment. - K .: NTUU "KPI", 2010.
2. Trukhanov V.M. Reliability in technology. - M .: Mechanical Engineering, 1999.
3. Trukhanov V.M. Reliability of mechanical engineering products. - M .: Mechanical Engineering, 1996.
4. Trukhanov V.M. Methods for ensuring the reliability of mechanical engineering products - M .: Mechanical engineering, 1995
5. Pereverzev E.S., Daniev Yu.F. Testing and reliability of technical systems. - Dnipro: Inst. Tech. Mech. NASU, 1999.
6. Kanarchuk V.E. Fundamentals of machine reliability. - K .: Naukova Dumka, 1982.
7. Kubarev A.I. Reliability in mechanical engineering. - M .: Publishing house of standards, 1989.

Additional literature

1. Reliability of engineering products. - M .: Publishing house of standards, 1990.
2. Reinschke K., Ushakov I.A. Assessment of the reliability of systems using graphs - M .: Radio and communication, 1988.
3. Henley EJ, Kumamoto H. Reliability of technical systems and risk assessment. - M .; Mechanical engineering, 1984.
4. Polovko A.M., Gurov S.V. Foundations of the theory of reliability. - SP .: BHV-Petersburg, 2006.
5. Zorin V.V. and other. Reliability of power supply systems. - K .: Vyshcha school, 1984.
6. Topchiev A.V. and other. Reliability of mining machines and complexes. - M .: Nedra, 1968.
7. Koh P.I. Reliability of the mechanical equipment of the quarries. - M .: Nedra, 1978.
8. Gumerov A.G., Gumerov R.S., Akberdin A.M. Operation of equipment for oil pumping stations. - M .: LLC "Nedra-Business Center", 2001.
9. Polovko AM, Fundamentals of reliability theory. - M .: Nauka, 1964.
10. Polovko A.M. Collection of problems on the theory of reliability. - M .: Sov. Radio, 1972.
11. DSTU 2860-94. Reliability for technology. Terms and conditions.
12. DSTU 2864-94. Reliability for technology. Experimental assessment and control of reliability

Information resources

http://emoev.kpi.ua

Educational content

5. Methods of mastering the discipline (educational component)

- **Distribution of study time**

Titles of sections and topics	Number of hours			
	Total	Including		
		Lectures	Practical	SSS*
1	2	3	4	5
Section 1. Mathematical foundations of reliability				
Topic1.1. Basic concepts of reliability theory	4	2	-	2
Topic 1.2. The main quantitative characteristics of the reliability of elements and systems	8	4	2	2
Topic 1.3. Mathematical apparatus of reliability theory	6	4	2	-
Topic 1.4. Methods for calculating the reliability for the main connection of elements	12	6	4	2

Topic 1.5. Analysis of the reliability characteristics of equipment with redundancy	10	4	4	2
Total for section 1	40	20	12	8
Section 2. Physico-chemical bases of reliability				
Topic 2.1. Physico-chemical processes of materials destruction	4	2	-	2
Topic 2.2. Physical and chemical nature of failures of electromechanical systems	4	2	-	2
Modular test (part 1)	4	1		3
Total for section 2	12	5		7
Section 3. Reliability of equipment in various industries				
Topic 3.1. Methods of calculating reliability for complex systems	4	-	4	-
Topic 3.2. Reliability of equipment for power supply systems	6	2	2	2
Topic 3.3. Reliability of mine equipment	4	2	-	2
Topic 3.4. Reliability of quarry electromechanical equipment	4	2	-	2
Topic 3.5. Reliability of equipment of oil pumping stations	2	2	-	-
Topic 3.6. Reliability of control systems	2	-	-	2
Topic 3.7. Methods to increase reliability	4	2	-	2
Modular test (part 2)	4	1		3
Total for section 3	30	11	4	13
Calculation work	8			8
Exam	30			30
Total	120	36	18	66

*) SSS - self students studying

- **Practical lessons**

The main task of the series of practical classes is to consolidate the knowledge gained in lectures

Назва теми заняття та перелік основних питань
Practical lesson 1. Quantitative characteristics of the reliability of non-repairable systems.
Practical lesson 2. Calculation of system reliability at different distributions.
Practical lesson 3. Calculation of system reliability at the main (series) connection of elements. Exponential distribution.
Practical lesson 4. Calculation of system reliability at the main (series) connection of elements. Types and stages of calculations.
Practical lesson 5. Calculation of reliability of systems with redundancy.
Practical lesson 6. Calculation of reliability of systems with redundancy.
Practical lesson 7. Calculation of reliability of complex systems. The method of minimum paths and minimum cross sections.
Practical lesson 8. Calculation of reliability of complex systems. Decomposition method in relation to a special element.
Practical lesson 9. Reliability of power supply equipment.

- **Calculation work**

During the semester, students perform calculation work on the topic "Calculation of the reliability of complex systems." To perform this work, students are required to study topic 3.1.

6. Self students studying

The self students studying includes preparation for surveys, preparation for practical work, performance and defense of calculation work, as well as preparation for modular control work and exam.

Policy and control

7. Policy of academic discipline (educational component)

Attending classes. Absence does not result in penalty points. The final rating score of the student is formed solely based on evaluation of learning outcomes. At the same time, the work in practical lessons, results of modular test, calculation work and exam will be evaluated during the classroom sessions. To actively participate in the practical lesson, the student prepares for a particular practical lesson using the literature recommended by the lecturer.

Calendar control is carried out to improve the quality of student learning and monitor student compliance with syllabus requirements.

Criterion		*First calendar control*	*Second calendar control*
Term of calendar control		Week 8	Week 14
Conditions for obtaining a positive assessment	Current rating	≥ 19 points	≥ 34 points

Academic integrity. The policy and principles of academic integrity are defined in Section 3 of the Code of Honour of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Details: https://kpi.ua/code.

Norms of ethical behaviour. Norms of ethical behaviour of students and employees are defined in Section 2 of the Code of Honour of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Details: https://kpi.ua/code.

Inclusive education. The acquisition of knowledge and skills during the study of the discipline "Foundations of Sustainable Development" may be available to most people with special educational needs, except for students with severe visual impairments who do not allow to perform tasks with personal computers, laptops, and/or other technical means.

Learning a foreign language. During the assignments, students may be encouraged to refer to Ukrainian-language sources.

8. Types of control and rating system for assessing learning outcomes (RSA)

Semester certification is conducted in the form of exam. A 100-point rating system and a university scale are used to assess learning outcomes.

Current control: participation in practical lessons, modular test, calculation work.

Calendar control is conducted twice a semester for monitoring of the current state of compliance with the requirements of the syllabus.

Semester control: exam.

Modular control work. Each of the two parts of the module test contains seven questions of the test, which are evaluated in two points. The student receives 2 point for the correct answer to the question, incorrect - 0 points.

Types of work	Timely passing the test	The 1st re-taking the test (within two weeks of initial control)	The 2nd re-taking the test (without meeting deadlines)
1. Modular control work			
- completely done work	14	12	8
- the work is done with minor errors	12	10	6
- work is not credited	0	0	0
2. Answers to practical classes:			
- the answer demonstrates excellent mastery of the material	4		
- the answer indicates minor gaps in material ownership	3		
- the answer indicates the unpreparedness of the student	0		
3. Виконання розрахункової роботи:			

- the task is defended with excellent mastery of the material	8	6	4
- the task is defended with minor errors	6	4	2
- the task is not completed	0	0	0

Calculation of the rating scale during semester (RS)

RS (max)=6*4+1*8+14*2=60 points
RC(min)= 36 points

At the exam, students perform a written test. Each task contains two theoretical questions and one problem. Each theoretical question is evaluated at 15 points, the problem - at 10 points

Theoretical questions evaluation system:
- "excellent", complete answer (not less than 90% of the required information) - 15 points;
- "good", a sufficiently complete answer (at least 75% of the required information), or a complete answer with minor inaccuracies - 12 points;
- "satisfactory", incomplete answer (not less than 60% of the required information) and minor errors - 9 points;
- "unsatisfactory", unsatisfactory answer (does not meet the requirements for "satisfactory") - 0 points.

Rating score scale and exam evaluation criteria (RE):

	Points
- Completely correct answer	40...38
- Answer with minor errors	37...30
- Answer with errors	29...20
- Answer is not credited	19-0

The rating scale of the discipline is R=RS+RE=60+40=100 points

Translation of rating points to grades on a university scale

Rating points, RP	*A mark on a university scale*
$95 \leq RP \leq 100$	Exellent
$85 \leq RP \leq 94$	Very good
$75 \leq RP \leq 84$	Good
$65 \leq RP \leq 74$	Satisfactory
$60 \leq RP \leq 64$	Sufficient
$RP < 60$	Unsatisfactorily

A necessary condition for admission to the exam is the full implementation of the curriculum, as well as a preliminary rating of at least 36 points.

Students who complete additional tasks and show creative initiative receive incentive points from 1 to 10.

9. Additional information on the discipline (educational component)

Control questions in the discipline "Reliability of electrical and mechatronic systems"

1. Definition of reliability and the concept of failure
2. The concept of service life, limit state and maintainability
3. The concept of the probability of failure
4. The concept of failure rate
5. The concept of failure rate. The relationship between the main quantitative characteristics of the reliability of non-renewable systems in the general case
6. The concept of average uptime

7. The concept of average failure time, coefficients of readiness and coefficients of forced downtime
8. Exponential distribution
9. Normal distribution
10. Weibull distribution
11. Ratios for calculation for the main connection of elements
12. The concept of estimated calculation of reliability
13. The concept of approximate calculation of reliability
14. The concept of the final calculation of reliability
15. The sequence of reliability calculation
16. Structural, functional, time, load and information redundancy
17. Multiplicity of redundancy, redundancy with integer and fractional multiplicity
18. General and element-by-element reservation, permanent reservation and reservation with replacement
19. Analysis of reliability characteristics with a permanently included reserve in the case of general redundancy
20. Analysis of reliability characteristics with a permanently included reserve in the case of element-by-element redundancy
21. Analysis of the characteristics of reliability in general and element-by-element redundancy
22. Internal defects of materials
23. The concept of diffusion and sorption
24. Destruction of materials under mechanical stress
25. Destruction of materials during their aging
26. Electrical destruction of materials
27. Failures in terms of strength
28. Tribological failures
29. Failures on corrosion parameters
30. Reliability of overhead power lines in EPS
31. Reliability of cable power lines in EPS
32. Reliability of power lines with SIW (Self-supporting insulated wire)
33. Reliability of power transformers and switching devices in EPS
34. The method of minimum paths and minimum cross sections
35. Using graphs to assess the reliability of systems
36. Using algebra of logic to evaluate the reliability of systems
37. Kolmogorov-Chapman equation
38. The method of decomposition of a relatively special element
39. The rule of determining the minimum cross sections of complex systems

Work program of the discipline (syllabus):
Compiled by Ph.D., Assoc. Prof. Gorodetskyi Viktor G.
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(Protocol № 18 of 25.05.2021)
Approved by the Methodical Commission of the IEE Institute (Protocol № 6 of 26.05.2021)