



Basics of the theory of technical diagnostics
**Working program of the academic discipline (Syllabus) Details of the
academic discipline**

Level of higher *Second (Master) education*

Branch of knowledge	<i>G Engineering, Manufacturing and Construction</i>
Specialty	<i>G3 Electrical Engineering</i>
Educational program	<i>Engineering of intelligent electrotechnical and mechatronic complexes</i>
Discipline status	<i>Selective</i>
Form of education	<i>full-time/remote</i>
Year of training, semester	<i>1 year, spring semester</i>
Scope of the discipline	<i>4 credits of 120 hours</i>
Semester control/ control measures	<i>Test</i>
Lessons schedule	<i>https://schedule.kpi.ua</i>
Language of teaching	<i>Ukrainian</i>
Information about the course leader / teachers	<i>Lecturer: Doctor of Technical Sciences, Professor, Stefan Volodymyrovych Zaichenko, tel. 067-165-37-48, email: zstefv@gmail.com¹</i>
Placement of the course	<i>ClassRoom</i>

¹In fields Field of knowledge/Specialty/Educational program:

For the disciplines of professional and practical training, information is noted in accordance with the curriculum.

For social and humanitarian disciplines, a list of branches, specialties, or "for all" is indicated.

Program of educational discipline

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

The successful solution of problems related to the improvement of production efficiency is achieved, first of all, by increasing the reliability of the technical means in use. The growing requirements for safety, reliability and durability in the power supply systems of enterprises and electrotechnical complexes make it very important to assess the technical condition of various devices. Striving to increase the competitiveness of the enterprise, organization of a system for collecting and processing statistical information on the reliability of electrical equipment taking into account operating conditions, calculation and use of reliability indicators to ensure the efficiency of the power supply of enterprises and electrotechnical complexes, their improvement during operation,

¹ E-mail of the teacher for other contacts for feedback, it is possible to indicate reception hours or hours for communication in case of specifying contact telephone numbers. For the syllabus of a discipline taught by many teachers (for example, history, philosophy, etc.), you can refer to the site page where the contact information of teachers for the relevant groups, faculties, institutes is presented.

The purpose of teaching the course "Fundamentals of the theory of technical diagnostics" is to train specialists who have knowledge in the field of general concepts of technical diagnostics, areas of its application, possibilities and features of the construction of modern diagnostic systems, the formation of students' holistic ideas about the place and role of the problem of reliability and diagnostics in the improvement efficiency of system operation when transitioning to a qualitatively new principle of organizing their maintenance - according to the actual technical condition.

The subject of study of the educational discipline "Fundamentals of the theory of technical diagnostics" is the main directions and methods of technical diagnostics, their areas of application and peculiarities of use; to know the main diagnostic parameters and methods of their control, organization of maintenance work and technical diagnostics of electromechanical systems. basics of theories and types of technical diagnostics, parameters of electromechanical equipment diagnostics, measurement of diagnostics parameters, design of technical means of diagnostics, justification of the choice of method and means of technical diagnostics of electrotechnical complexes.

As a result of studying the discipline "Fundamentals of the Theory of Technical Diagnostics", students acquire the following competencies: general:

- (PC01) Ability to apply existing and develop new methods, techniques, technologies, and procedures to solve engineering problems of Electric Power Engineering, Electrotechnics and Electromechanics; (PC09) Ability to use software for computer modeling, computeraided design, computer-aided manufacturing, and computer-aided development or design of elements of electric power, electrotechnical, and electromechanical systems.; (PC12) Ability to develop intelligent solutions to increase the efficiency of electrical and mechatronic systems.

- Ability:

- (PLO13) To master new versions or new software designed for computer modeling of objects and processes in electric power, electrical and electro-mechanical systems; (PLO16) Select and integrate the element base of intelligent solutions for electromechanical and mechatronic systems, including intelligent technologies for controlling electric and hydraulic drives, protection and automation of technological processes; (PLO17) to create intelligent technologies for automated control and monitoring of electromechanical equipment's technical condition based on programmable logic controllers.

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

The educational discipline "Fundamentals of the theory of technical diagnostics" is taught on the basis of knowledge and skills acquired by students during the study of such disciplines as "Technical mechanics", "Electric machines", etc.

The knowledge and skills acquired in the process of studying the credit module "Fundamentals of the theory of technical diagnostics" are necessary for every specialist of this specialty who solve engineering tasks in the field of electrical engineering and when studying the following disciplines: "Automated electric drive of machines and installations", "Fundamentals of automated design electrical installations and complexes", "Fundamentals of electromechatronics", etc.

3. Content of the academic discipline

Academic discipline "Fundamentals of the theory of technical diagnostics" consists of 4 sections:

Chapter 1 Basics of theories of technical diagnostics

Topic 1.1 Organization of maintenance work and technical diagnostics of electromechanical systems

Topic 1.2 Basics of theory and types of technical diagnostics

Section 2. Methods of measuring diagnostic parameters

Topic 2.1Diagnostic parameters of electromechanical equipment **Topic**
2.2Measurement of diagnostic parameters

Chapter 3. Design of technical means of diagnosing electromechanical equipment

Topic 3.1Design of technical means of diagnosis

Topic 3.2Algorithms of functioning of technical means of diagnosis

Chapter 4.Methods and means of diagnosing electromechanical systems and equipment **Topic**

4.1Justification of the choice of method and means of technical diagnosis of electromechanical equipment

Topic 4.2Methods and technical means of diagnosing electric machines

4. Educational materials and resources

Basic literature:

1. Cherny O.P., Zachepa Y.V., Tityuk V.K., Chorna O.A. Monitoring and diagnostics of electromechanical objects: study guide. Kremenchuk: PP Shcherbatykh A.V., 2019. 122 p.
2. Vyshnivskyi V.V., Vasylenko V.V., Hnidenko M.P., Zvenigorodskyi O.S., Zinchenko O.V., Ishcheryakov S.M. Basics of reliability and diagnostics of information systems. The study guide is prepared for the independent work of students and postgraduates of higher educational institutions. Kyiv: FOP Gulyaeva V.M., 2020. – 188 p.
3. Vyshnivskyi V.V., Zherdev M.K., Kredentser B.P. etc. Physical foundations of reliability theory. Textbook / Ed. M.K. Zherdev. - K.: Kyiv University Publishing and Printing Center, 2008. - 215 p.
4. Kredentser B.P., Vyshnivskyi V.V., Zherdev M.K., Mogilevich D.I., Stoykova L.S. Reliability assessment of redundant systems with limited initial information / Monograph / Under the scientific editorship of Doctor of Technical Sciences, Professor B.P. Credenza. - K.: "Fenix", 2013. - 335 p.

Supporting literature:

1. Methodological instructions for laboratory work from the course "Systems of technical diagnosis of electromechanical equipment" for students of the specialty "Electromechanical equipment of energy-intensive industries". of all forms of education \compiled by S.P. Shevchuk, L.K. letter writer - K.: NTUU KPI, 2002- p.40.
2. DSTU 2860-94. Reliability of equipment. Terms and definitions. - Valid since January 1, 1996. - Kyiv: State Standard of Ukraine, 1994. - 88p.
3. DSTU V 3577-97. Types of maintenance. Replacement of components. Terms. – Valid from 1998.07.01. - K.: Derzhstandard of Ukraine, 1998. - 10 p.
4. DSTU 2389-94. Technical diagnostics and control of the technical condition. - Valid since January 1, 1995. - Kyiv: State Standard of Ukraine, 1994. - 88p.
5. DSTU 3-29-150-96. Calculation of sets of spare parts. Valid since July 1, 1997. - Kyiv: Minmashprom of Ukraine, 1996. - 20 p. **Information resources**

<https://www.library.kpi.ua/>- Scientific and technical library named after G.I. Denisenko <https://sci-hub.st/>- the first resource in the world that opened public and mass access to tens of millions of scientific articles

#	Lecture Title & Core Topics	Educational Aids	Recommended Reading	Self-Study (SRS)
1	Lecture 1. Introduction to Technical Diagnostics of Electromechanical Equipment Terms and definitions. Objectives, organization, and types of technical diagnostics. Key classical and modern diagnostic methods.	STM MO Slides	1, 2	Classification of modern technical diagnostic methods.
2	Lecture 2. Maintenance Organization and Diagnostics of Electromechanical Systems Methodological foundations for diagnosing electrical equipment. Wear processes and types of component/node damage during operation.	STM MO Slides	2, 4	Patterns and types of wear in electromechanical system components.
3	Lecture 3. Fundamentals of Reliability Theory and Technical Diagnostics Core concepts of reliability theory. Quantitative reliability metrics of technical diagnostic equipment (TDE). Link between diagnostics, reliability, and quality.	STM MO Slides	3, 4	Quantitative reliability indicators of TDE.
4	Lecture 4. Types of Technical Diagnostics and Condition Forecasting Test and functional diagnostics. Principles of residual life prediction. Mathematical modeling in functional diagnostics of analog objects.	STM MO Slides	3, 4	Mathematical modeling of functional diagnostics for analog objects.
5	Lecture 5. Diagnostic Parameters of Electromechanical Equipment Concept and classification of diagnostic parameters. Measurement and analysis of electrical values during diagnostic procedures.	STM MO Slides	1, 3	Primary electrical parameters serving as diagnostic information carriers.
6	Lecture 6. Defectoscopy Methods for Electromechanical Equipment Non-destructive testing (NDT) and flaw detection. Magnetic, ultrasonic, eddy current, and optical methods for hidden defect detection.	STM MO Slides	1, 3	Applications of ultrasonic and magnetic flaw detection in machine building.

7	Lecture 7. Measurement of Mechanical and Thermal Parameters Measuring mass, force, geometric dimensions, pressure, level, and fluid/gas flow. Temperature control and thermographic inspection.	STM MO Slides	4, 7	Methods and instruments for thermal imaging inspection of electrical equipment.
8	Lecture 8. Vibroacoustic Diagnostics and Physical-Chemical Control Vibration, noise, and shock load parameters. Monitoring humidity, viscosity, density, and material structure.	STM MO Slides	4, 7	Analysis of vibroacoustic characteristics in electric motors.
9	Lecture 9. Fundamentals of Designing Technical Diagnostic Equipment (TDE) Stages and techniques of diagnostic tool design. Preliminary design phase and baseline requirements engineering.	STM MO Slides	4, 6	Systematization of development stages for technical diagnostic equipment.
10	Lecture 10. Algorithmization and Defect Search Depth Functional operational algorithms of TDE. Fault localization depth, result reliability, and decision-making strategies.	STM MO Slides	4, 6	Evaluating the reliability of technical diagnostic results.
11	Lecture 11. Selection and Justification of Diagnostic Methods and Tools Criteria for selecting optimal diagnostic methods. Feasibility, technical parameters, and economic aspects of implementing diagnostic systems.	STM MO Slides	1, 4	Feasibility study and technical-economic justification of diagnostic tool selection.
12	Lecture 12. Diagnostics of Induction Motors Common fault modes of induction machines. Diagnostic techniques for stator, rotor, bearing assemblies, and air gap irregularities.	STM MO Slides	1, 4	Modern monitoring systems for induction motor stators and rotors.
13	Lecture 13. Diagnostics of DC Machines and Grounding Systems Diagnostic characteristics of DC machinery (commutator-brush assembly, windings). Inspection and testing of grounding loops.	STM MO Slides	1, 4	Methodologies for inspecting condition and resistance of grounding loops.
14	Lecture 14. Diagnostics of Power and Instrument Transformers	STM MO Slides	1, 4	Dissolved gas analysis (DGA)

	Key diagnostic parameters of transformers. Monitoring windings, magnetic cores, oil-filled equipment, and insulation.			techniques in transformer oil.
15	Lecture 15. Methods and Equipment for Electrical Insulation Diagnostics Types and methods of insulation testing. Measuring resistance, absorption ratio, and partial discharge. Instruments for insulation system testing.	STM MO Slides	4, 8	Partial discharge measurement methods and instruments for insulation testing.

The main tasks of the cycle of practical classes are devoted to consolidating the knowledge obtained at the lectures

1. Organization of Diagnostic Inspection of Electromechanical Systems and Primary Data Collection

- **Key Topics:** Structure of maintenance processes; methods for collecting diagnostic signs and generating baseline data for object condition analysis.
- **Didactic Aids:** Slides "Organization of EMS Diagnostics", technical condition logging cards.
- **Recommended Literature:** 1.
- **Independent Student Work (ISW):** Survey method and primary processing of diagnostic information.

2. Application of the Probabilistic Bayesian Method for Assessing the Technical Condition of Objects

- **Key Topics:** Theoretical foundations of the probabilistic approach; posterior probability of diagnosis; decision-making rules.
- **Didactic Aids:** Slides "Bayes' Method", calculation worksheets.
- **Recommended Literature:** 1.
- **Independent Student Work (ISW):** Bayes' formula for a set of diagnostic signs.

3. Construction and Analysis of Diagnostic Matrices in Bayes' Method

- **Key Topics:** Formation of diagnostic matrices; calculation of prior and posterior probabilities for various EMS conditions.
- **Didactic Aids:** Examples of filled diagnostic matrices, computational software/templates.
- **Recommended Literature:** 1.
- **Independent Student Work (ISW):** Probability update algorithm upon receiving new data.

4. Development and Analysis of Logical Models of Electromechanical Systems

- **Key Topics:** Principles of logical analysis; construction of structural-logical diagrams of the technical condition of systems and objects.
- **Didactic Aids:** Posters "Functional Models of EMS", schematic templates.
- **Recommended Literature:** 1.
- **Independent Student Work (ISW):** Construction of a logical model for an electromechanical system unit.

5. Construction of Cause-and-Effect Graphs for Troubleshooting

- **Key Topics:** Graphical modeling of failures; connection between causes, defects, and their external manifestations.
- **Didactic Aids:** Posters "Cause-and-Effect Graphs of EMS".
- **Recommended Literature:** 1.
- **Independent Student Work (ISW):** Failure graph synthesis for a typical electric motor or drive.

6. Compilation and Analysis of State Function Tables for Technical Objects

- **Key Topics:** Formation of state function tables; determination of operable, inoperable, and limit states of the system.
- **Didactic Aids:** Tabular guidelines, examples of functional tables.
- **Recommended Literature:** 1.
- **Independent Student Work (ISW):** Inversion of the state function table.

7. Defect Search Methods Based on Logical Minimization and Data Inversion

- **Key Topics:** Troubleshooting algorithms using inverted tables; optimization of the inspection sequence.
- **Didactic Aids:** Slides "Diagnostic Algorithms", study guidelines.
- **Recommended Literature:** 1.
- **Independent Student Work (ISW):** Diagnostic test minimization to detect single failures.

8. Comprehensive Assessment of EMS Technical Condition Using Probabilistic-Logical Methods

- **Key Topics:** Combined analysis using Bayes' method and logical models; selection of an optimal maintenance strategy.
- **Didactic Aids:** Comprehensive testing tasks, final report forms.
- **Recommended Literature:** 1.
- **Independent Student Work (ISW):** Preparation of a final diagnostic report based on analysis results.

6. Independent work of student

The hours allocated to the student's independent work are specified in clause 5. The method of mastering the academic discipline is preparation for the implementation and defense of practicals, as well as preparation for the modular test work of the exam.

Policy and control 7. Policy of academic discipline (educational component)

The policy of the educational discipline "Fundamentals of the theory of technical diagnostics" is based on the policy of KPI named after Igor Sikorsky.

KPI named after Igor Sikorsky is a free and autonomous center of education, which is called to give adequate answers to the challenges of modern times, to nurture and protect the spiritual freedom of a person, which makes him able to act according to his own conscience; its civil freedom, which is the basis of the formation of a socially responsible personality, and academic freedom and integrity, which are the main driving factors of scientific progress. The internal atmosphere of the University is built on the principles of openness, transparency, hospitality, and respect for the individual.

The study of the educational discipline "Fundamentals of the theory of technical diagnostics" requires: completion of an individual task according to the curriculum; elaboration of the recommended basic and additional literature.

Preparation for the implementation of an individual task involves: familiarization with the curriculum of the academic discipline and plans for practical classes; study of theoretical material; performance of tasks proposed for independent processing.

The result of preparation for the lesson should be the acquisition of skills and abilities to use modern measuring equipment. The applicant's answer must demonstrate signs of independent performance of assigned tasks, absence of signs of repetition and plagiarism.

The presence of students of higher education at practical classes is mandatory. Lessons missed for valid reasons must be made up.

A student of higher education must adhere to educational and academic ethics and the schedule of the educational process; to be considered, attentive.

8. Types of control and rating system for evaluating learning outcomes

Current control: MCW (modular control work) is carried out before the second calendar control at the lecture class in the presence of the lecturer (28 points), 9 practical classes (8 points per practical lesson = $9 \times 8 = 72$). MCW is performed in the form of an answer to a theoretical question from the lecture material and one practical work. At the end of the lesson, the work on the MCW ends and is not subject to rewriting. MCW is evaluated at 28 points according to the following criteria:

- "excellent" – a complete answer to the theoretical question (at least 90% of the required information), appropriate justifications and personal views are provided, and the problem is solved correctly – 28-23 points;

- "good" – a sufficiently complete answer to the theoretical question (at least 75% of the required information), which is made in accordance with the requirements for the level of "skills" or contains minor inaccuracies, the course of solving the problem is correct, but contains minor inaccuracies, mostly in the calculation – 22-17 points;

- "satisfactory" – an incomplete answer to a theoretical question (at least 60% of the required information), performed in accordance with the requirements for the "stereotyped" level and contains some errors, significant errors in solving problems are traced – 16-11 points;

- "unsatisfactory" – unsatisfactory answer and incorrectly solved problem – 0 points.

Tasks within the framework of the practical lesson are evaluated at 8 points according to the following criteria:

- "excellent" – fully completed work (at least 90% of the necessary information), appropriate justifications and personal opinion provided – 8 points;

- "good" – the work contains certain inaccuracies (at least 75% of the necessary information), the provided justifications are not complete enough – 7-6 points;

- "satisfactory" – the work contains significant inaccuracies (at least 60% of the required information), the work is performed in accordance with the requirements for the "stereotyped" level and contains significant errors – 5-5 points;

- "unsatisfactory" – the problem was solved incorrectly – 0 points.

Calendar control: is carried out twice a semester as a monitoring of the current state of fulfillment of the requirements of the syllabus. The condition for a positive first and second calendar control is to obtain at least 50% of the maximum possible rating at the time of the corresponding calendar control.

Semester control: test. A prerequisite for admission to the credit assessment is the writing of a modular test work and a starting rating of at least 30 points. $RC(max) = 28 + 72 = 100$ points $RC(min) = 30$ points.

Test assessment. Students who have fulfilled all the conditions for admission to the test and have a rating score of 60 or more points receive a grade corresponding to the rating scored without additional tests. The sum of rating points received by the student during the semester is converted to the final grade according to the table.

If the sum of points is less than 60, but the practical ones are completed and passed, the MCW, the student performs the test work. The test work is estimated at 100 points. The control task of this work consists of two theoretical questions from the list provided in the appendix to the syllabus and the problem. Each question is evaluated at 50 points according to the following criteria:

- "excellent" – complete answer (at least 95% of the required information), provided appropriate justifications and personal view – 47-50 points;

– "good" – a sufficiently complete answer (at least 75% of the required information) that has been completed according to the requirements for the level of "skills" or contains minor inaccuracies – 37-46 points;

– "satisfactory" – an incomplete answer (at least 60% of the required information) made in accordance with requirements for the "stereotyped" level and contains some errors – 30-36 points; – "unsatisfactory" – unsatisfactory answer – >30 points. Incentive points are set for:

Completing an individual semester assignment	depending on the complexity, but not more than 10 points
Report at relevant student conferences on the subject of the discipline and participation in competitions of works	up to 5 points
Preparation of an abstract work on the topic of the lesson missed by the student, or on the topic proposed by the lecturer (up to 10 sheets)	depending on the student's disclosure of the chosen topic, the validity of the conclusions, but not more than 3 points

Table of correspondence of rating points to grades on the university scale

<i>Rating Points, RD</i>	<i>University Scale Score</i>
$95 \leq RD \leq 100$	Perfectly
$85 \leq RD \leq 94$	Very good
$75 \leq RD \leq 84$	Well
$65 \leq RD \leq 74$	Satisfactory
$60 \leq RD \leq 64$	Enough
$RD < 60$	Disappointing
Failure to meet the conditions for admission to semester control	Not allowed

9. Additional information on the discipline (educational component)

Questions for credit from an academic discipline "Fundamentals of the theory of technical diagnostics"

Why is technical diagnostics called indiscriminate?

What is the main task of technical diagnostics?

What are the two main areas of technical diagnostics? Their structure.

Explain the definition of "technical diagnostics" What is a defect, defect detection and defect search?

What is the main purpose of technical diagnostics?

What stages of the "life" of a technical object do you know?

In what technical conditions can the object be.

What diagnostic systems do you know?

Is it possible to determine the correct functioning of the object with a diagnostic test system?

Is it possible to determine the proper functioning of the object by means of a functional diagnostic test?

Reveal the components of the structural diagram of technical diagnostics What is the task of forecasting.

What is the task of technical genetics.

What reliability indicators do you know?

What aspects of the reliability problem do you know?

Give examples of using the physical aspect to improve reliability?

Give examples of the use of majoring.

What is the diagnostic aspect of reliability.

What is the purpose of creating mathematical models when diagnosing technical objects.

What equations must be applied to the mathematical models of the system elements to create a mathematical model of the entire system?

What stages of creation of technical diagnostics tools do you know?

How does the value of the readiness indicator change from the coefficient of embeddedness of TZD.

How is it possible to raise the value of the readiness indicator?

How to determine the optimal value of the embedding factor?

Is the statement true: The higher the level of the structural unit, the more complicated the algorithm for finding a defect in it, and the higher the cost of TZD.

How is it possible to determine the optimal level of a structural unit for which it is necessary to create a TZD.

What does the construction of the algorithm for the operation of the TZ begin with?

What is the switching of diagnostic indicators?

By what criterion is the final set of diagnostic parameters selected from a set of fundamentally possible measurement parameters?

What groups are physical parameters divided into?

Name the physical parameters of the electrical group?

Name the physical parameters of the kinematic group?

Name the physical parameters of a geometric group?

Name the physical parameters of a static and dynamic group?

Name the main methods of measuring electrical quantities.

Name the device that uses the method of direct value estimation.

Name the device that uses the differential method of estimating a value.

What principles of operation of analog electrical measuring devices do you know?

What principle of action does a wattmeter use?

Describe the torsional measurement of the force of gravity.

Describe the inertial method of mass measurement.

Diagnostic parameters of electromechanical systems.

Types of control of electromechanical systems.

Causes of insulation aging.

Parameters for assessing the state of insulation.

Scheme and principle of operation of the bridge measuring device for diagnosing insulation.

Dielectric loss angle and its relationship with the state of elements of electromechanical systems.

Working program of the academic discipline (syllabus):

Compiled by: Associate Professor of the Department of Automation of Electrical and Mechatronic Complexes, Stefan Zaichenko

Approved by the Department of Automation of Electrical and Mechatronic Complexes. Protocol No. 15 of 04.06.25

Agreed: Methodological Commission of the IEE (Minutes No. 30 of 25.06.25)