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

**Department of automation of electrotechnical and mechatronic complexes**

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

### Details of the academic discipline

| | |
|---|---|
| **Level of higher education** | ***Second (Master)*** |
| **Branch of knowledge** | *14 Electrical engineering*[1] |
| **Specialty** | *141 Power engineering, electrical engineering and electromechanics* |
| **Educational program** | *Engineering of intelligent electrotechnical and mechatronic complexes* |
| **Discipline status** | *Selective* |
| **Form of education** | *full-time/remote* |
| **Year of training, semester** | *1 course* |
| **Scope of the discipline** | *4 credits of 120 hours(36 hours of lectures, 18 hours of practical, 66 hours of IWS)* |
| **Semester control/ control measures** | *Test,MKW* |
| **Lessons schedule** | *https://schedule.kpi.ua* |
| **Language of teaching** | *Ukrainian* |
| **Information about the course leader / teachers** | *Lecturer: Doctor of Technical Sciences, Professor, Stefan Volodymyrovych Zaichenko, tel. 067-165-37-48, email: zstefv@gmail.com*[2] |
| **Placement of the course** | http://emoev.kpi.ua/author/Zstefan |

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.

[2] E-mail of the teacher afor 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.

## 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,

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:

- Ability to abstract thinking, analysis and synthesis (K01);
- Ability to make informed decisions. (K02).
- Ability to make informed decisions. (K06)
- The ability to identify feedback and adjust your actions taking them into account. (K10).

professionals:

- Ability to apply acquired theoretical knowledge, scientific and technical methods to solve scientific and technical problems and tasks of electric power, electrical engineering and electromechanics. (K11).
- The ability to develop and implement measures to increase reliability, efficiency and safety in the design and operation of equipment and objects of the power industry, electrical engineering and electromechanics. (K14);
- The ability to evaluate the indicators of reliability and efficiency of the functioning of electric power, electrotechnical and electromechanical objects and systems (K21);
- The ability to create new effective methods and methods of designing, manufacturing, diagnosing and repairing energy-intensive electrical equipment. (K31);

and program learning outcomes:

- Know and understand the rules of safe operation of electric power, electrotechnical and electromechanical equipment. (PR7);
- Master new versions or new software designed for computer modeling of objects and processes in electric power, electrotechnical and electromechanical systems (PR12);
- Apply methods of engineering activity in the field of creation of modern electrical engineering complexes. (PR15);
- To create universal, most effective algorithms for modeling the processes of electrotechnical complexes and to conduct their research on modern equipment with modern software. (PRN17).
- Identify problems and identify limitations related to issues of environmental protection, sustainable development, human health and safety and risk assessments in the field of electric power, electrical engineering and electromechanics (PR26).

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

**Chapter 3. Design of technical means of diagnosing electromechanical equipment**

**Topic 3.1**Design of technical means of diagnosis
**Topic 3.2**Algorithms of functioning of technical means of diagnosis

**Chapter 4.**Methods and means of diagnosing electromechanical systems and equipment
**Topic 4.1**Justification of the choice of method and means of technical diagnosis of electromechanical equipment
**Topic 4.2**Methods 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

## Educational content

### 5. Methods of mastering an educational discipline (educational component)

| No. z/p | The name of the topic of the lecture and a list of main questions |
|---|---|
| 1 | **Introduction to the subject**<br>*Lecture 1.* **Introduction**<br>Terms and definitions. The task of technical diagnostics. Organization of technical diagnostics. Types of technical diagnostics. Methods of technical diagnostics.<br>***Didactic tools:***SD slides<br>***Recommended reading: 1, 2***<br>***IWS:***Methods of technical diagnostics |
| 2 | **Topic 1.1**Organization of maintenance work and technical diagnostics of electromechanical systems<br>*Lecture 2.*Definition and main tasks of diagnosis.<br>Methodical foundations of electrical equipment diagnostics developments. Wear and damage of parts and assemblies of electrical equipment during operation. Methods, devices and schemes for diagnosing electrical equipment.<br>***Didactic tools:***SD slides<br>***Recommended Books****: 2, 4*<br>**IWS:**Methods, devices and schemes for diagnosing electrical equipment. |
| 3 | **Topic 1.2**Basic theories and types of technical diagnostics<br>*Lecture 3.* Basic theories and types of technical diagnostics<br>Basic concepts and definitions. Quantitative characteristics of the reliability of technical means of diagnosis. Technical diagnosis and forecasting. Connection of technical diagnostics with reliability and quality. Types of technical diagnostics. Test diagnostics. Functional diagnostics. Mathematical modeling during functional diagnosis of analog objects.<br>***Didactic tools:***SD slides<br>***Recommended reading: 3, 4***<br>***IWS:***Mathematical modeling during functional diagnosis of analog objects. |
| 4 | **Topic 2.1 Diagnostic parameters of electromechanical equipment**<br>*Lecture 3.*Diagnostic parameters of electromechanical equipment<br>Diagnostic parameters of electromechanical equipment. Measurement of diagnostic parameters of electrical quantities. Defetoscopy..<br>***Didactic tools:***SD slides<br>***Recommended reading: 1, 3***<br>***IWS:***Defetoscopy. |
| 5 | **Topic 2.2 Measurement of diagnostic parameters** |

| | |
|---|---|
| | *Lecture 5.*Diagnostic parameters of electromechanical equipment<br>Electrical quantities. Mass and force. Dimensions and location of objects. Pressure, level and flow of liquid and gas. Temperature. Time. Moisture, viscosity, density and structure of the material. Vibration, noise, shock..<br>***Didactic tools:***SD slides<br>***Recommended reading: 4, 7***<br>***IWS:***Vibration, noise, impact |
| 6 | **Topic 3.1 Design of technical means of diagnosis**<br>*Lecture 6.*Stages of designing diagnostic tools. Preliminary design stage. TSD functioning algorithms. The depth of the search for defects and the reliability of the results.<br>***Didactic tools:***SD slides<br>***Recommended reading: 4, 6***<br>***IWS:***The depth of the search for defects and the reliability of the results. |
| 7 | **Topic 4.1 Justification of the choice of method and means of technical diagnosis of electromechanical equipment.**<br>*Lecture 7.*Diagnostics of electric machines.<br>Diagnosis of asynchronous electric motors. Diagnostics of DC machines. Grounding check. Diagnosis of transformers<br>***Didactic tools:***SD slides<br>***Recommended reading: 1, 4***<br>***IWS:***Diagnosis of transformers |
| 8 | **Topic 4.2 Methods and technical means of diagnosing electric machines**<br>*Lecture 8.*Methods and technical means of diagnosing electric machines<br>Basic diagnostic parameters of electrical equipment. Types of control. Method of diagnosing electrical equipment. Methods of measuring the parameters of electrical equipment diagnostics. Measurement methods and technical means of diagnosing electrical equipment insulation.<br>***Didactic tools:***SD slides<br>***Recommended reading: 4, 8***<br>***IWS:***Measurement methods and technical means of diagnosing electrical equipment insulation. |

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

| No. z/p | Name of the subject of the lesson and list of main questions |
|---|---|
| 1 | **Topic 1.1**Organization of maintenance work and technical diagnostics of electromechanical systems<br>*Practical lesson 1.*Study of the Bayesian method for diagnosing the technical condition of the investigated systems and objects<br>Posterior probability of diagnosis. Diagnostic matrix in the Bayesian method<br>***Didactic tools:*** Bayes method slides<br>***Recommended literature: 1***<br>***IWS:***Bayes' formula for a set of features. |
| 2 | **Topic 2.1 Basic theories and types of technical diagnostics**<br>*Practical lesson 3.*Methods of logical analysis when diagnosing the technical condition of the investigated systems and objects<br>Logical model of the system, graph of cause-and-effect relationships, tables of state functions.<br>***Didactic tools:*** Plaques functional models of EMC<br>***Recommended literature: 1***<br>***IWS:***Inverting the state function table. |

## 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 Sikorskyi 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:****tasks within the framework of a practical lesson (7 practical lessons × 10 points = 70 points), MKW (conducted directly in a practical lesson, in the presence of a teacher, 30 points).*

*Tasks within the framework of a practical lessonare evaluated out of 10 points according to the following criteria:*

- *"excellent" - a complete answer (at least 90% of the required information), relevant justifications and a personal opinion are provided - 10-9 points;*
- *"good" - a sufficiently complete answer (at least 75% of the required information), which is completed in accordance with the requirements for the "skills" level or contains minor inaccuracies - 8-7 points;*
- *"satisfactory" - an incomplete answer (at least 60% of the required information), completed in accordance with the requirements for the "stereotype" level and containing some errors - 6 points;*
- *"unsatisfactory" - unsatisfactory answer - 0 points.*

*MKW consists of test tasks of three levels of difficulty. The first difficulty level consists of twelve questions, each of which offers multiple answers, only one of which is correct. Each correct answer within the first level is valued at 1 point. The second level of difficulty is aimed at testing knowledge about the use of certain diagnostic schemes (equipment) and involves providing the correct answer based on the results of working with a graphic image of the diagnostic scheme or equipment. This level contains three tasks, each of which is valued at 4 points. The third level of difficulty involves solving the problem and, based on the results of the solution, choosing the correct answer, such a task is estimated at 6 points. MKW is considered passed if the student has scored 60% of the maximum possible points, i.e. 18 points. For those students who could not complete it on time.*

***Calendar control:****is held twice a semester as a monitoring of the current state of fulfillment of the syllabus requirements. 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.Conditions for admission to semester control:MKW completed and credited.*

*Students who have met all the admission requirements and have a rating of 60 or more points receive a rating corresponding to the rating without additional tests. The sum of the rating points received by the student during the semester is transferred to the final grade according to the table.*

*If the sum of points is less than 60, but the MKW is completed and credited, the student completes the credit control work. In this case, the sum of points for the MKW and for the final test is transferred to the final grade according to the table.*

*A student who received more than 60 points in the semester, but wants to improve his result, can take part in a credit test. In this case, the final result consists of the points obtained on the final test and the points for the MKW.*

*The credit control work is estimated at 70 points. The control task of this work consists of two theoretical questions from the list provided in the appendix to the syllabus and a task.*

*Each question is valued at 20 points according to the following criteria:*

- *"excellent" - a complete answer (at least 90% of the required information), relevant justifications and a personal opinion are provided - 20 - 18 points;*
- *"good" - a sufficiently complete answer (at least 75% of the required information), which is completed in accordance with the requirements for the "skills" level or contains minor inaccuracies - 17 - 15 points;*
- *"satisfactory" - an incomplete answer (at least 60% of the required information), completed in accordance with the requirements for the "stereotype" level and containing some errors - 14 - 12 points;*
- *"unsatisfactory" - unsatisfactory answer - 0 points.*

*The task is evaluated in 30 points according to the following criteria:*

- *"excellent" - a complete answer (at least 90% of the required information), relevant justifications and a personal opinion are provided - 30 - 27 points;*
- *"good" - a sufficiently complete answer (at least 75% of the required information), which is completed in accordance with the requirements for the "skills" level or contains minor inaccuracies - 26 - 23 points;*
- *"satisfactory" - an incomplete answer (at least 60% of the required information), completed in accordance with the requirements for the "stereotype" level and containing some errors -22 - 18 points;*

*"unsatisfactory" - unsatisfactory answer - 0 points.*

For correspondence education

***Current control:****MKW (30 points). The structure of MKW, its requirements and evaluation criteria are similar to those for full-time education and are listed above.*

***Semester control:****test.Conditions for admission to semester control:MKW completed and credited.*

*Students who have fulfilled the conditions for admission to the credit, perform the credit control work. The sum of points for the MKW and for the credit control work is transferred to the final grade according to the table.*

*Credit control work is estimated at 70 points as for full-time education. The evaluation criteria are given above.*

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

| *Scores* | *Rating* |
|---|---|
| 100-95 | Perfectly |
| 94-85 | Very good |
| 84-75 | Fine |
| 74-65 | Satisfactorily |
| 64-60 | Enough |
| Less than 60 | Unsatisfactorily |

| | |
|---|---|
| Admission conditions not met | 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):**

**Folded**Zaichenko S.V.

**Approved**department of automation of electrotechnical and mechatronic complexes. Protocol No. 17 dated May 31, 2023.