



## Syllabus of the educational component

Program of educational discipline

# Fundamentals Of Scientific Research

### Code and name of specialty

141 – Power engineering, electrical engineering and electromechanics

### Educational program

Electric drive, mechatronics and robotics

### Educational level

Master's degree

### Semester

1

### Institute

Educational and Scientific Institute of Energy, Electronics and Electromechanics

### Department

Automated electromechanical systems (129)

### Type of discipline

Special (professional), Mandatory

### Language of teaching

English

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## Lecturers and course developers



### Bohdan Vorobiov

[bohdan.vorobiov@khpi.edu.ua](mailto:bohdan.vorobiov@khpi.edu.ua)

Doctor of Philosophy (Ph.D), head of the department of automated electromechanical systems of NTU "KhPI". Work experience - 6 years. Author of more than 30 scientific works. Leading lecturer in the disciplines: "Fundamentals of scientific research", "Modelling of Mechatronic Systems", "Design of power supply systems in mechatronics".

<http://web.kpi.kharkov.ua/aems/uk/staff-uk/>

## General information

### Abstract

The discipline is aimed at providing students with theoretical knowledge about the laws, methods and means of scientific and technical research, solving real problems of identification and modeling of electromechanical objects and systems (EMCs) using personal computers (PCs).

### Purpose and objectives of the disciplines

The discipline is aimed at providing students with theoretical knowledge about the laws, methods and means of scientific and technical research, solving real problems of identification and modeling of electromechanical objects and systems (EMCs) using personal computers (PCs).

### Format of classes

Lectures, practical classes, calculation tasks, consultations. Final control - credit.

## Competences

Аналіз та обробка даних: Здатність використовувати комп'ютер для аналізу та обробки даних експериментальних досліджень.

Математичне моделювання: Вміння побудовувати математичні моделі об'єктів та систем з використанням різних методів, включаючи ряди Тейлора та розкладання Пуассона.

Експериментальна ідентифікація систем: Навички розробки та впровадження алгоритмів для експериментальної ідентифікації динамічних об'єктів і систем.

Оптимізація параметрів систем: Здатність визначати оптимальні параметри апроксимуючих структур передатної функції з використанням методів аналізу даних.

Моделювання та аналіз процесів: Вміння проводити моделювання та аналіз перехідних процесів в системах з метою оцінки їхньої ефективності та функціонування.

Комп'ютерне програмування та використання спеціалізованих програм: Знання та навички роботи з комп'ютерними програмами, необхідними для виконання аналізу та моделювання в мехатроніці та робототехніці.

## Learning outcomes

To be able to use a PC to determine the time (impulse) moments of the weight function of the object (system) in the form of the so-called Taylor coefficients and Poisson's coefficients of the first and second orders according to experimental data. To be able to find with the help of a PC the relationship between the time moments of the weight function and the coefficients of the expansion of the transfer function in the Taylor series. To be able to calculate with the help of a PC the time moments of the weight function according to the experimental curves of transient processes. To be able to calculate the modulus of inertia with the help of a PC, as a criterion for the optimality of the approximating structures of the transfer function of the object (system) under study. Know the methods of developing a scheme for constructing algorithms for the experimental identification of dynamic objects and systems by methods of time characteristics. Be able to determine the optimal structure of the approximating transfer function of the studied object (system) based on the results of identification and modeling on a PC.

## Scope of the discipline

The total volume of the discipline is 120 hours. (4 ECTS credits): lectures – 16 hours, practical classes – 32 hours, independent work – 72 hours.

## Prerequisites for studying the discipline (prerequisites)

To successfully complete the course, you must have knowledge and practical skills in the following disciplines: "Fundamentals of metrology and electrical measurements", "Electric machines", "Fundamentals of electric power engineering", "Theoretical foundations of electrical engineering. Part 1 and Part 2".

## Features of the discipline, methods and technologies of education

The learning process in this discipline involves lectures, practical work, performance of calculation tasks, independent work and consultations.

When conducting lectures, the text of lectures prepared and distributed to students in advance is used. At the same time, there is an opportunity to examine some sections of the lecture material in more detail and to carry out ongoing control.

Complex use of various methods of organization and implementation of educational and cognitive activities of students (lectures, practical classes, computer tasks, etc.) and methods of stimulating and motivating their learning, which contribute to the development of the creative foundations of the personality of the future specialist, taking into account the individual characteristics of the participants of the educational process and communication.

In order to form the professional competence of the future scientist-researcher, the topological analysis of language units and phenomena is carried out within each micro-level using comparative, component and cognitive methods.

During independent work, the student must study sections, topics according to the recommended literature, specified by the work program of the academic discipline..

## Program of educational discipline

### Topics of lectures

#### Topic 1. Necessary concepts and definitions.

Goals and objectives of the discipline. The problem and task of identification of technical objects. The structure and stages of the identification process. Experimental method of identification. Characteristics of identification objects. Definition of an ordinary differential equation as the main type of mathematical model (MM) of a linear stationary object. Other types of MM.

#### Topic 2. Identification by the method of time characteristics.

Types of signals. Test input influences. The relationship between the functions and . Transient and impulse transient (weight) functions of the object. Definition of transition function and impulse transition or weight function. The relationship between the functions.

#### Topic 3. Frequency methods of identification.

Types of mathematical models of objects in the frequency domain. Setting up an identification experiment using frequency methods. Identification by experimental LACCH. Rough estimation of model parameters according to frequency characteristics Matching of output functions in frequency identification methods. Advantages and disadvantages of frequency identification methods.

#### Topic 4. Concept of parametric identification.

Basic concepts of parametric identification. Linear and quadratic integral estimates as quality criteria. Types of deviation function. Parametric identification by the method of least squares.

#### Topic 5. Basics of the theory of experimental research planning.

Terms and concepts. Methods of experimental research. Statistical methods of evaluation of experimental studies. Determination and analysis of experimental errors. Methods of finding empirical formulas. Formation, recording and analysis of equations of statistical dynamics. The method of least squares. Formation of plans of experiments of the first order. Orthogonal plan of the second order. Evaluation of factorial experiments. Formation of plans for experiments of the second order.

#### Topic 6. Theoretical foundations of construction and solution of the identification system of linear equations.

Obtaining an unlimited identification system of linear equations. Representation of the identification system in vector-matrix form: . Definition of identification matrix, identification vector and vector of sought coefficients.

#### Topic 7. Practical aspects of building and using computer software for identification and modeling of EMC based on experimental data.

The reasons for the need to use Poisson's ratios in the identification of high-order objects and objects under the influence of noise disturbances. Limiting integrand weight factor and selection of its coefficient.

#### Topic 8. Identification of EMC with a given structure not higher than the 3rd order.

Determination of the parameters of the oscillating object of the 2nd order according to the transition process curve. Determination of integration constants, roots and coefficients of equations based on experimental data. Determination of the parameters of the dynamic object of the 3rd order according to the PP curve.

### Topics of practical classes

#### Topic 1. An example of building an identification system of linear equations.

#### Topic 2. Determination of dimensionless normalized time moments of the weight function.

#### Topic 3. Obtaining a ratio for determining the normalized time moments of the weight function based on discrete values of the normalized experimental transient process.

## Topics of laboratory works

Laboratory works within the discipline are not provided

## Independent work

The course involves performing a calculation task on the topic: "Graphic identification by transition functions. Smoothing of transition functions. Determination of mathematical expectation by a set. Structural and parametric identification by transition functions."

## Literature and educational materials

1. Hryshchuk Yu.S. Fundamentals of scientific research / Yu.S. Hryshchuk - Kh.: NTU "KhPI", 2008.
2. Gabovych O., Kuznetsov V., Semenova N. Ukrainian fundamental science and European values / O. Gabovych, V. Kuznetsov, N. Semenova. - Kyiv: Ed. house "Kyiv-Mohyla Academy", 2016. - 284 p.
3. B. I. Mokin, O. B. Methodology and organization of scientific research: study guide / Mokin. – 2nd ed., changes. and additional – Vinnytsia: VNTU, 2015. – 317 p.
4. V.S. Marcyn, N.G. Mitsenko, O.A. Danylenko. etc. / Fundamentals of scientific research: study guide / L.: Romus-Polygraph, 2002.- 128 c.
5. F.O. Chmylenko, L.P. Beetle. / Chmylenko, F.O. Guide to studying the discipline "Methodology and organization of scientific research" / - D.: RVVDNU, 2014. - 48 p.

## Evaluation system

### Criteria for evaluating student performance Rating scale and distribution of points

100% of the final grade consists of the current grade (100%).

A calculation task (40%), practical classes (40%) and test papers (30%).

Total points	National assessment	ECTS
90–100	Perfectly	A
82–89	Fine	B
75–81	Fine	C
64–74	Satisfactorily	D
60–63	Satisfactorily	E
35–59	Unsatisfactorily (further study required)	FX
1–34	Unsatisfactorily (re-study required)	F

## Norms of academic ethics and policy of the course

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": show discipline, education, benevolence, honesty, responsibility.

Conflict situations should be openly discussed in study groups with the teacher, and if it is impossible to resolve the conflict, it should be brought to the attention of the employees of the institute's directorate.

Regulatory and legal support for the implementation of the principles of academic integrity of NTU "KhPI" is posted on the website: <http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/>

## Coordination

Syllabus approved

21/09/2023

Head of Department  
Bohdan VOROBYOV

2109/2023

Guarantor of EP  
Vera SHAMARDINA

