National Technical University of Ukraine
"Ihor Sikorsky Kyiv Polytechnic Institute"

Department of automation electrical engineering and mechatronic complexes

Energy-saving intelligent machines and equipment of electromechanical and mechatronic systems
Working program of the academic discipline (Syllabus)

Details of the academic discipline	
Level of higher education	***Second (master's)***
Branch of knowledge	*14 – Electrical engineering*
Specialty	*141 – Electric Power Engineering, Electrotechnics and Electromechanics*
Educational program	*Engineering of Intellectual Electrotechnical and Mechatronic Complexes*
Discipline status	*Selective*
Form of education	*Full-time (daytime)/full-time (evening)/correspondence/distance/mixed*
Year of training, semester	*X -spring semester*
Scope of the discipline	*5 credits of ESTC (150 hours)*
Semester control/ control measures	*test, MCW*
Lessons schedule	*36 hours-lectures, 18 hours-practical*
Language of teaching	*Ukrainian*
Information about head of the course / teachers	Lecturer: *d.t.s., prof., Slidenko Viktor Mykhailovych , viktorslidenko@gmail.com* Practical: *d.t.s., prof., Slidenko Viktor Mykhailovych , viktorslidenko@gmail.com*
Placement of the course	Googleclassroom, t4io7nw *https://campus.kpi.ua/*

Program of educational discipline

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

The discipline considers methods of calculation and identification of complexes and their components, elements of energy-saving intelligent machines and equipment of electromechanical systems, methodologies of intelligent control of elements of complexes of mining and oil and gas industries, development of system and software of artificial neural networks.

The discipline lays the foundations for carrying out scientific research within the scope of the tasks facing the research university: modeling of electromechanics problems, conducting research and design works in the performance of computational and graphic works, preparing master's dissertations using mathematical modeling, CAD - technologies, information systems and databases, software, multimedia systems and Internet technologies, design methodologies and ADS.

The purpose of the educational discipline is to form students' engineering knowledge, skills and abilities from the main sections of the theory of adaptive complexes of electromechanical and mechatronic systems of mining and oil and gas industries, as well as to apply the acquired knowledge in the future - in scientific and industrial activities.

The subject of study of the discipline is: engineering basics, structure and functions of elements of adaptive complexes and their control systems using neural networks; system software for rational

functioning using C# and AutoLISP programming languages**;** ADS structural elements using AutoCAD, MathCAD shells.

Discipline "Energy-saving intelligent machines and equipment of electromechanical and mechatronic systems" refers to the cycle of professional and practical training, which provides knowledge and skills in the field of engineering calculations of elements of complexes of electromechanical systems, modeling of parameters and characteristics of complexes and equipment of electromechanical and mechatronic systems, knowledge in the field of information support for the functioning of complexes , the basics of intellectual control of executive bodies of complexes and is a continuation of the disciplines "Nonlinear problems and identification of electrotechnical and mechatronic systems", "Mathematical modeling and identification of electromechanical systems" with the formation and deepening of engineering knowledge of students and their expansion in the direction of specialization under the educational program "Engineering of intelligent electrotechnical and mechatronic complexes" through practical work with application ECM.

As a result of studying the discipline "Energy-saving intelligent machines and equipment of electromechanical and mechatronic systems" students receive the following competencies:

- *-are common*:

1) focus on abstract thinking, analysis and synthesis (ZK1),
2) focus on abstract thinking, analysis and synthesis (ZK2)
3) the origins of information and communication technologies (ZK3),
4) the importance of stagnating knowledge in practical situations (ZK4)
5) the building accepts lining solutions (ZK6),
6) the importance of understanding and enriching with current knowledge (ZK7).
7) the ability to identify and evaluate risks (ZK8),
8) the importance of identifying the gates and adjusting your actions from them (ZK10),

professionals:

1) the ability to apply the acquired theoretical knowledge, scientific and technical methods to solve scientific and technical problems and tasks of electric power, electrical engineering and electromechanics (FC1),
2) the ability to apply existing and develop new methods, techniques, technologies and procedures for solving engineering tasks of electric power, electrical engineering and electromechanics (FC2),
3) the ability to plan, organize and conduct scientific research in the field of electric power, electrical engineering and electromechanics (FC3),
4) the ability to demonstrate knowledge and understanding of mathematical principles and methods necessary for use in electric power, electrical engineering and electromechanics (FC6),
5) the ability to understand and take into account social, ecological, ethical, economic and commercial considerations that affect the implementation of technical solutions in electric power, electrical engineering and electromechanics (FC9),
6) the ability to evaluate indicators of reliability and efficiency of the functioning of electric power, electrotechnical and electromechanical objects and systems (FC11),
7) the ability to use methods of evaluating objects of intellectual property rights for their further commercialization, including for the sale of licenses and technology transfer. (FC14),здатність публікувати результати своїх досліджень у наукових фахових виданнях. (ФК15),
8) the ability to develop means, methods and methods of science and technology aimed at automating existing and creating new automated and automatic technologies and productions (FK17),
9) the ability to create universal, most effective process modeling algorithms in electrical engineering systems and conduct their research (FK18),
10) the ability, based on the analysis of static and dynamic loads, operating characteristics, to calculate and develop optimal equipment designs and operating modes of simple and complex electromechanical complexes using modern computer methods of mathematical modeling (FC20),
11) the ability to use basic mathematical optimization methods and statistical modeling methods in the development of modern electrical engineering complexes and systems (FK25),
12) the ability to solve complex scientific tasks of automation of technological processes using neural networks (FC26).

and *program learning outcomes:*

1) know and understand the main types of intellectual property rights and methods of its protection, methodological and legislative foundations for the creation of intellectual property objects. (PRN1),
2) to know the main effective methods and approaches aimed at increasing the energy efficiency and reliability of electric power, electrotechnical and electromechanical equipment and relevant complexes and systems (PRN9),
3) master new versions or new software designed for computer modeling of objects and processes in electric power, electrotechnical and electromechanical systems (PRN12),
4) use the method of intelligent management in the study and design of relevant complexes and systems (PRN14),
5) synthesize systems of automatic control of various objects based on the theory of fuzzy logic and using the theory of artificial neural networks (PRN16),
6) to create intelligent and adaptive systems of automated management and control of the technical condition of electromechanical equipment based on the use of programmable logic controllers (PRN18),
7) knowledge, understanding and practical application of experimental theory, experimental planning methods, assessment of the reliability of experimental results, methods of experimental data analysis and the construction of mathematical models based on them, in particular the use of the latest methods based on the use of modern information technologies (PRN20),
8) perform physical and mathematical modeling, static and dynamic analyzes of structures, mechanisms, materials and processes at the design stage using modern computer systems (PRN21),
9) to create intelligent and adaptive systems of automated management and control of the technical condition of electromechanical equipment based on the use of programmable logic controllers and on-board computers (PRN23),
10) calculate forces, stress-strain state, speeds, moments, power, static and dynamic properties of electromechanical equipment, perform power and hydraulic calculations of elements of hydraulic drives, electric drives, linear and non-linear elements, electric and magnetic circuits (PRN24),
11) Communicate freely orally and in writing in national and foreign languages on modern scientific and technical problems of electric power, electrical engineering and electromechanics (PRN25),
12) Knowledge of basic methods of mathematical optimization and methods of statistical modeling in the development of modern electrotechnical and mechatronic complexes and systems (PRN27).

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

Prerequisites: the discipline is based on students' knowledge of the basic concepts of physics, mathematics, economics, philosophy, sociology, ecology and professional training disciplines, aimed at acquiring the skills of a systematic approach to studying and solving the problems of rational use of energy resources and engineering and technological techniques in solving specific practical situations , as well as the ability to correctly assess the local and distant consequences of management and engineering decisions.

Post-requisites. Competences that will be acquired by students during the study of this discipline should be applied by them during the execution of the master's thesis, as well as future engineering tasks in the field of energy, in particular, electrical engineering, etc.

3. Content of the academic discipline

The educational discipline consists of 2 sections:

Chapter 1. Intelligent machines, working equipment and determination of their parameters.
Topic 1.1. Engineering support for the design of energy-saving intelligent machines and equipment of electromechanical systems.
Topic 1.2 Energy-saving machines and intelligent equipment of electromechanical systems in the fuel and energy complex.
Chapter 2. Application of neural networks in intelligent electromechanical systems
Topic 2.1 Elements of the theory of intelligent electromechanical systems based on neural networks.

4. Educational materials and resources

Basic literature

1. Ma, W., & Bai, L. (2018). Energy-Saving Principles and Technologies for Induction Motors. Hoboken, NJ, USA: Wiley..
2. Gieras, J. F. (2008). Advancements in electric machines. Springer Science & Business Media.

3. Energy Savings in Agricultural Machinery and Mechanization. Netherlands, Springer Netherlands, 2012.

4. Energy Efficiency in Electric Devices, Machines and Drives. Switzerland, Mdpi AG, 2020.

Additional literature

5. Vaez-Zadeh, S. (2018). Control of permanent magnet synchronous motors. Oxford University Press..

6. Mechatronics : an introduction / edited by Robert H. Bishop. CRC Press, 2006. – 285 p.

7. Kurinec, Santosh K., and Walia, Sumeet. Energy Efficient Computing & Electronics: Devices to Systems. United Kingdom, CRC Press, 2020.

ADS. Programming in the AutoLISP functional language...

https://cpsm.kpi.ua › knigi › Pidruchnuk_AutoLISP

Information resources

11. http://emoev.kpi.ua.

12. http://ela.kpi.ua/handle/123456789/7572

Literature, the bibliography of which is provided with a link, can be found on the Internet or in the electronic library of KPI named after Igor Sikorsky. Literature, the bibliography of which does not contain references, can be found in the library or on the Internet, or in the library of the department.

Basic literature [1-4, 6, 7] is mandatory for reading. All other literary sources are optional, it is recommended to familiarize yourself with them.

Educational content

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

The method of teaching the discipline combines visual teaching methods with explanation. Teaching is conducted in the form of lectures and practical classes.

Назви змістових модулів і тем	Number of hours								
	In total	including							
		Lectures	Practical	Laboratory work	Control work	CGW	Consultations	Independent work of students	Test
1	2	3	4	5	6	7	8	9	10
Chapter 1. **Intelligent machines, working equipment and determination of their parameters..**									
Topic 1.1. *Engineering support for the design of energy-saving intelligent machines and equipment of electromechanical systems.*	22	12	4		-	-	-	6	-

Topic 1.2 *Energy-saving machines and intelligent equipment of electromechanical systems in the fuel and energy complex.*	95	16	6		2		1	70	-
Разом за розділом 1	**117**	**28**	**10**		**2**		**1**	**76**	**-**
Chapter 2 **Application of neural networks in intelligent electromechanical systems**									
Topic 2.1 *Elements of the theory of intelligent electromechanical systems based on neural networks.*	31	8	8		1		1	13	-
Together by chapter 2	31	8	8		1		1	13	
Hours in general	**150**	**36**	**18**		**3**		**2**	**89**	**2**

Lecture classes

№ T/I	The name of the topic of the lecture and a list of main questions
1	Topic 1.1. ***Engineering support for the design of energy-saving intelligent machines and equipment of electromechanical systems.*** *Lecture 1*. Introduction to the subject "Energy-saving intelligent machines and equipment of electromechanical and mechatronic systems". General concepts and classifications. Determination of the main parameters of the machine with a manipulator. *The relevance of the subject "Energy-saving intelligent machines and equipment of electromechanical and mechatronic systems" is substantiated. The results of the analysis of the terms and definitions characteristic of these productions are presented. The main parameters of the kinematics of machines with manipulators (working equipment) - hydraulic excavators, mathematical models and the technique of analytically determining the coordinates of the executive body and the working area are given.* **Didactic tools:** *multimedia presentation, posters and drawings that explain individual points of the lecture .* **Recommended Books** *[1] c. 11-22; [3] c.31-39;* **IWS:** *Information from the Internet by topic, a summary of the lecture with an analysis of the tasks and problems.* *Lecture 2*. Stability parameters of electromechanical complexes *The main requirements and methods for determining the stability parameters of basic machines with a manipulator are considered. The concept of dynamic stability is introduced. Ways to increase the stability of machines are proposed.* ***Didactic tools:*** *multimedia presentation, posters and drawings that explain individual points of the lecture .* ***Recommended Books:*** *[4] c. 18-37.* **IWS:** *Information from the Internet by topic, a summary of the lecture with an analysis of the tasks and problems .* *Lecture 3*. Structural analysis and synthesis of the kinematic system of a machine with a manipulator. *The elements of kinematic analysis with the determination of the degree of freedom of mechanisms according to Malyshev's formula are presented. The elements of the synthesis of kinematic systems with the definition of Assur groups are given. Calculation schemes typical for*

	manipulators of hydraulic excavators are considered ***Didactic tools:*** *multimedia presentation, posters and drawings that explain individual points of the lecture .* ***Recommended Books:*** *[1] c. 12-20; [4] c. 21-25.* **IWS*:*** *Information from the Internet by topic, a summary of the lecture with an analysis of the tasks and problems* *Lecture 4.* The method of superelements for determining the reactions in the hinges of the working equipment of the manipulator. *The technique of vector-analytical analysis using superelements is given. The method of determining reactions in the hinges of the working equipment of mechatronic complexes is given.* ***Didactic tools:*** *multimedia presentation, posters and drawings that explain individual points of the lecture .* ***Recommended Books:*** *[2] c. 12-20; [4] c. 21-25.* **IWS*:*** *Information from the Internet by topic, a summary of the lecture with an analysis of the tasks and problems* *Lecture 5.* Analysis of calculation schemes and construction of manipulator external load charts. *The method of constructing external load diagrams and determining dangerous cross-sections is considered. An analysis of differential dependencies during bending is carried out. Examples of calculation and construction of external load diagrams for the handle and boom are given.* ***Didactic tools:*** *multimedia presentation, posters and drawings that explain individual points of the lecture .* ***Recommended Books:*** *[4] c. 32-68.* **IWS*:*** *Information from the Internet by topic, a summary of the lecture with an analysis of the tasks and problems* *Lecture 6.* Identification of the stress-strain state in the structural elements of the manipulator. *A method for determining the stress-strain state of structural elements of the working equipment of the machine is given. Stress plots of asymmetric sections are analyzed. Features of the application of strength theories to determine equivalent stresses are given* ***Didactic tools:*** *multimedia presentation, posters and drawings that explain individual points of the lecture .* ***Recommended Books:*** *[3] c. 32-68.* **IWS*:*** *Information from the Internet by topic, a summary of the lecture with an analysis of the tasks and problems*
2	**Topic 1.2** ***Energy-saving machines and intelligent equipment of electromechanical systems in the fuel and energy complex*** *Lecture 7.* Shield tunneling complexes and complexes of equipment for the construction of tunnels. Basics of the theory and calculation of prokhodnykh shields. *Identified structure, field of application, and defined main element of the complex is the walker's shield. Defined equipment systems of shields. The elements of the calculation of the main parameters of tunneling shields based on their purpose, design and mining technical conditions are given. The main parameters include: performance; shield dimensions (outer diameter and length); coefficient of maneuverability; mass; the number of jacks needed to move the shield.* ***Didactic tools:*** *multimedia presentation, posters and drawings that explain individual points of the lecture .* ***Recommended Books:*** *[4] c. 25-31. [8] c. 49-59.* **IWS*:*** *Information from the Internet by topic, a summary of the lecture with an analysis of the*

	tasks and problems . *Lecture 8* Working equipment of manipulators with vibrating bucket and multiplier equipment. *Systematization of variable equipment of manipulators using vibrating buckets and pressure multipliers. Theory of calculation of basic parameters .* ***Didactic tools:*** *multimedia presentation, posters and drawings that explain individual points of the lecture .* ***Recommended Books:*** *[3] c. 25-31. [4] c. 49-59.* **IWS*:*** *Information from the Internet by topic, a summary of the lecture with an analysis of the tasks and problems* *Lecture 9*. Operation of oil and gas wells. *Reasonable methods of operating wells, which are divided into the following groups: fountain, when oil is extracted from wells by self-draining; with the help of compressed gas energy introduced into the well from the outside; pumping - oil extraction using pumps of various types. The choice of the method of operating oil wells depends on the amount of reservoir pressure and the depth of the reservoir. Some types of well repair are described****Didactic tools:*** *multimedia presentation, posters and drawings that explain individual points of the lecture .* ***Recommended Books:*** *[4] c.71-107; [9] c.71-96.* **IWS*:*** *Information from the Internet by topic, a summary of the lecture with an analysis of the tasks and problems* *Lecture 10*. Technological complexes were developed at NTUU "KPI named after Igor Sikorsky". *The system of increasing the productivity of wells using the "Impulse S" and "Impulse +" complex.* ***Didactic tools:*** *multimedia presentation, posters and drawings that explain individual points of the lecture .* ***Recommended Books:*** *[1] c.71-107; [3] c.71-96. [4] c.88-98.* **IWS*:*** *Information from the Internet by topic, a summary of the lecture with an analysis of the tasks and problems* *Lecture 11*. Intellectual wells . *The terms and definitions are presented, as well as the well-founded technology of the functioning of an intelligent well, which includes the following basic operations: descent of the device and recording of background parameters; assembling and pressing the electric motor; installation of a decentrator on the body (electric centrifugal pump) (EVN); descent of the installation (EVN) on pump-compressor pipes (NKT) with the attachment of protective decentrators; installation of a face washer with two cap inputs; research directly depending on the task.* ***Didactic tools:*** *multimedia presentation, posters and drawings that explain individual points of the lecture .* ***Recommended Books:*** *[4] c.71-107; [6] c.71-96.* **IWS*:*** *Information from the Internet by topic, a summary of the lecture with an analysis of the tasks and problems* *Lecture 12*. Adaptive hydropulse systems controlled by programmable logic controllers. *Information on adaptive hydroimpulse systems of adaptive stabilization is given and the main ways of their modernization are given.* ***Didactic tools:*** *multimedia presentation, posters and drawings that explain individual points of the lecture .* ***Recommended Books:*** *[3] c.35-45.* **IWS*:*** *Information from the Internet by topic, a summary of the lecture with an analysis of the tasks and problems* *Lecture 13*. Electrohydraulic systems controlled by a programmable logic controller.

	Information on the methods of controlling the programmable logic controller of the electrohydraulic system with a mechatronic complex is provided. ***Didactic tools:*** *multimedia presentation, posters and drawings that explain individual points of the lecture .* ***Recommended Books:*** *[5] c.35-45.* **IWS*:*** *Information from the Internet by topic, a summary of the lecture with an analysis of the tasks and problems* *Lecture 14*. Electrohydraulic systems were developed at KPI named after Igor Sikorskyi and their application in practice. *Information on methods of controlling electro-hydraulic systems developed at KPI named after Igor Sikorskyi and ways of their implementation in practice.* ***Didactic tools:*** *multimedia presentation, posters and drawings that explain individual points of the lecture .* ***Recommended Books:*** *[4] c.35-45.* **IWS*:*** *Information from the Internet by topic, a summary of the lecture with an analysis of the tasks and problems*
3	Topic 2.1 ***Elements of the theory of intelligent electromechanical systems based on neural networks.*** *Lecture 15.* A typical scheme of the operation of an intelligent system. Fuzzy knowledge, linguistic variable, elements of theory. Connectionist approach. Artificial neural network as a mechanism of intelligent control. *The analysis of technical systems from the point of view of fuzzy sets is given. The concept of "linguistic variable" and the definition from the theory of fuzzy sets are defined. Considered examples of the formation of fuzzy sets and operations with them, the structure of a fuzzy microcontroller.* *The main provisions of the connectionist approach are given as an attempt to directly model the mental activity of the human brain. The structure and functions of an artificial neuron and neural networks are considered, which are built according to the principles of organization and functioning of their biological counterparts and which are capable of solving a wide range of tasks of managing complex objects, pattern recognition, identification, forecasting, and optimization. The characteristics of the main activation functions are given.****Didactic tools:*** *multimedia presentation, posters and drawings that explain individual points of the lecture .* ***Recommended Books:*** *[6] c.48-69; [7] c.55-78.* **IWS*:*** *Information from the Internet by topic, a summary of the lecture with an analysis of the tasks and problems* .***Lecture 16.*** Types of neural networks and their functions. Unidirectional multilayer networks of the sigmoidal type. Neural network training. *The association of neurons with the formation of a system - an artificial neural network is substantiated. Depending on the method of combining neurons, networks can be unidirectional or recurrent (with feedback). In an artificial neural network (ANN), neurons are combined into layers in which parallel signal processing takes place.* *A typical form of supervised learning of the network is presented, when for each set of data that are fed into the training process at the input of the network, the corresponding output set is known. As a rule, at the beginning of training, the weighting coefficients are set equal to random small values, so that when the network is presented with a training sample for the first time, it is quite unlikely that the network will make a correct conclusion. The difference between what the network will produce and what should actually be obtained for a given training set is an error that can be used to adjust the weights. An example of an error correction rule is given - the delta rule, also called the Widrow-Hoff rule.* ***Didactic tools:*** *multimedia presentation, posters and drawings that explain individual points of the lecture .*

	Recommended Books: *[7] c.38-69;* **IWS*:*** *Information from the Internet by topic, a summary of the lecture with an analysis of the tasks and problems* *Lecture 17*. Application of intelligent systems for energy-saving operation of electromechanical systems on the example of adaptation of the multiplier drive to technological conditions. *The application of models in the form of multidimensional functions of many variables for electromechanical systems with the possibility of using a homogeneous two-layer neural network with sigmoidal transfer functions is substantiated.* *An example of control of a mechatronic system with a multiplier using a homogeneous two-layer neural network with input parameters is given: volume modulus of elasticity of the liquid, areas of the face of the multiplier and the piston of the hydraulic cylinder, as well as the stroke of the multiplier rod and the reading of the pressure sensor.* ***Didactic tools:*** *multimedia presentation, posters and drawings that explain individual points of the lecture .* ***Reommended Books:*** *[6] c.88-99; [7] c.95-108.* **IWS*:*** *Information from the Internet by topic, a summary of the lecture with an analysis of the tasks and problems* *Lecture 18*. Overview information for the course.

Practical training

The main tasks of the cycle of practical classes consist in consolidating the knowledge obtained in lectures,familiarization with individual sections.The main tasks of the cycle of practical classes are devoted to the formation of modeling competencies using the Mathcad system, as well as the AutoLISP programming language in the AutoCAD system.

№ T/I	Name of the subject of the lesson and list of main questions
1	Topic 1.1. ***Engineering support for the design of energy-saving intelligent machines and equipment of electromechanical systems.*** *Practical lesson 1.* Analysis of the kinematic system of the manipulator using an example working equipment of a hydraulic excavator *The graphic model of the kinematic system of the working equipment of the excavator is considered.* *Each student is given the input data for calculating the design parameters of the kinematic system of the working equipment of the hydraulic excavator.* *Task: - to determine the rational parameters of the kinematic system of the excavator according to the variant and the extreme characteristic that forms the maximum working zone.* *The result of the practical lesson: issuing the necessary information to the student for independent work on performing calculations and for drawing up a report in the given form.* ***Didactic tools:*** *1) a sample of execution and design in the form of a report of one of the options for practical work, methodological instructions that allow you to form input data for execution and explain the progress of practical work.* *2) a computer training program implemented on a computer to analyze and control the correctness of calculations performed by students.* ***Reommended Books:*** *[3] c.4-25; [4] c. 32-48.* **IWS*:*** *Completing tasks according to options on this topic.* *Practical lesson 2*. Determination of stability parameters of the manipulator *The stability of the manipulator when it is installed on a horizontal platform and a platform at a given angle is investigated, taking into account the angular speed of the platform rotation.* *Task: to determine the stability margin of the manipulator according to the option.* *The result of the practical session: determination of the parameters of stable functioning of the manipulator.* ***Didactic tools:***

1) a sample of execution and design in the form of a report of one of the options for practical work, methodical instructions;
2) a computer training program implemented on a computer (MathCAD) to analyze and control the correctness of calculations performed by students.
Reommended Books: *[4] c.22-53.*
IWS*:* *Completing tasks according to options on this topic.*

Topic 1.2. ***Energy-saving machines and intelligent equipment of electromechanical systems in the fuel and energy complex***

Practical lesson 3. Calculation of reactions in the hinges of the working equipment of the manipulator

The practical implementation of the superelement method for determining the reactions in the joints of the working equipment of a mining machine is considered using the example of the working equipment of a hydraulic excavator. Each student is given the parameters of the hydraulic drive and the characteristics of the operating modes of the load on the executive body. Task: - to determine the reactions in the joints and hydraulic cylinders of the working equipment for one of the most characteristic positions.

The result of the practical lesson: the publication of the necessary information to the student for independent work on the calculation of the reactions in the hinges of the work equipment and the preparation of the report in the given form.

Didactic tools:

1) a sample of execution and design in the form of a report of one of the options for practical work, methodical instructions, practical work materials that allow you to form input data for execution and explain the course of practical work.

2) a computer program (MathCAD) that demonstrates the implementation of the analytical method of superelements for determining reactions in the joints of working equipment.
Reommended Books: *[1] c. 4-7; [4] c. 76-112.*
IWS*:* *Completing tasks according to options on this topic.*

Practical lesson 4. Calculation of values and construction of charts of external loads on the manipulator

The option of grapho-analytical determination and construction of longitudinal and transverse forces, bending and torques for one extreme position of the working equipment of a hydraulic excavator based on a previous practical session using the same kinematic scheme of the excavator is considered.

According to the previous version, each student calculates and builds diagrams of external loads on the working body (arrow, handle). Task: - epurs should be built for the extreme, most dangerous, from the point of view of load, position of the working body. An algorithm for calculating the cross-section of the manipulator element with the property of intelligent adaptation to the external load is being developed.

The result of the practical lesson: the publication of the necessary information to the student for independent work on the calculation and construction of charts of external loads of work equipment and the preparation of a report in the given form.

Didactic tools:

1) a sample of execution and design in the form of a report of one of the options for practical work, methodological instructions, materials of previous practical work that allow you to form input data for execution and explain the progress of practical work.

2) a computer program (MathCAD) that demonstrates the implementation of the analytical method of constructing charts in graphic mode on a computer.
Reommended Books: *[1] c. 5-11; [4] c. 123-138.*
IWS*:* *Completing tasks according to options on this topic.*

Topic 2.1 ***Elements of the theory of intelligent electromechanical systems based on neural networks.***

Practical lesson 5. Adaptive hydropulse system of the walker manipulator.

The design and calculation scheme of a mechatronic system based on a neural network is considered. An analysis of the relationship between neural networks, genetic algorithms and fuzzy systems is carried out. Each student is given a version of the derivative function to study the properties in Mathcad and determine the rationality of the application.
Reommended Books: *[7] c. 45-55;*

	IWS: *Completing tasks according to options on this topic.* Practical lesson 6. Study of the impact of pneumatic accumulator parameters on the process of adaptation of a hydropulse system (GIS) with mechatronic control. *The adaptive design of the pneumatic accumulator with mechatronic control of the adaptation of the hydraulic system to the conditions of the working environment is being studied. According to the results of the study, the characteristics of the adaptation system are built and a variant of the structural element of the adaptation module is programmed in the AutoLISP language in the Autocad system.* ***Reommended Books:*** *[7] c. 55-72;* **IWS:** *Completing tasks according to options on this topic.*

Laboratory classes are not included in the curriculum

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 modular control work and assessment.

Control works

The purpose of conducting a modular control work is to identify the degree of assimilation of knowledge by students in the discipline, obtained during lectures and practical classes.

Pre-test consultations

The purpose of consultations is maximum adaptation of students to the requirements of the assessment.

At the consultations, issues from the lecture course and the practical course, the information from which is taken for credit, are considered.

Policy and control

7. Policy of academic discipline (educational component)

During the course, students are obliged to adhere to the general moral principles and rules of ethical behavior specified in the Code of Honor of the National Technical University of Ukraine "Ihor Sikorskyi Kyiv Polytechnic Institute".

Violation of the Code of Academic Integrity of the National Technical University of Ukraine "Ihor Sikorsky Kyiv Polytechnic Institute" is a serious violation, even if it is unintentional. The code is available at the link: https://kpi.ua/code.3.

In particular, adherence to the Code of Academic Integrity means that all work on exams and tests must be done individually. During independent work, students can consult with teachers and other students, but must solve tasks independently, guided by their own knowledge, skills and abilities. References to all resources and sources (for example, in reports, independent papers or presentations) should be clearly identified and properly formatted. In the case of joint work with other students on individual tasks, you should indicate the degree of their participation in the work.

Academic Integrity: The policy and principles of academic integrity are defined in section 3 of the Code. Norms of ethical behavior: Norms of ethical behavior of students and employees are defined in section 2.

Requirements for a student of the discipline:

- attending lectures and practical classes is a mandatory component of studying the material, the teacher records attendance at classes;
- the teacher uses the ZOOM, Google classroom systems to teach the material of the current lecture, additional resources, practical classes, etc.;
- at the lecture, the teacher uses his own presentation material; who, after the lecture, teaches in Google classroom on the relevant discipline, where there is a flow of students;
- during lectures, it is forbidden to distract the teacher from presenting the material to students, all questions, clarifications, etc. students ask at the end of the lecture in the time allotted for this;
- MKR is completed in a practical session and sent to Google classroom or the teacher's e-mail;
- in accordance with the "Code of Honor" of the ICR, students perform Tests and Reports independently;

• incentive points are awarded for: active participation in lectures; preparation of reviews of scientific papers; presentations on one of the topics, creation of educational and methodical materials;

• penalty points are issued for: untimely compilation of MCR, rewriting of MCR.

At the time of each lesson, both lecture and practical, the student must have a Google classroom course on the "Sikorsky" platform open on the device from which he works (the access code to the course is provided at the first lesson according to the schedule). Syllabus; lecture material; tasks for each practical session; variants of modular control work; methodical recommendations for practical work; options for credit test work are placed in Google classroom or on the "Sikorsky" platform and in the "KPI Electronic Campus" system.

All students, without exception, are obliged to comply with the requirements of the Regulations on the Academic Plagiarism Prevention System at the National Technical University of Ukraine "Ihor Sikorskyi Kyiv Polytechnic Institute".

Students who have scored the number of points during the semester (R ≥ 60 points) can get a grade without a credit test. In case of a desire to increase the grade, the student completes a credit test, based on the results of which a grade is assigned.

Students who received a rating in the discipline Rc< 60 during the semester are required to write a final test paper.

Students who scored a rating of Rs< 60 in the discipline during the semester are required to write a final test.

For participation in the All-Ukrainian Olympiad (competition of scientific works), a student is awarded 5 (I round) or 10 (II round) points. For writing an article and its publication, the student is awarded 10 points (a publication included in Scopus or WebofScience) or 6 points (a specialized publication of Ukraine). 3 points for publication of report abstracts at a scientific conference. The total amount of incentive points cannot exceed 10 points.

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

The student's credit module rating consists of the points he receives for:

1) performance of 1 modular control work;
2) execution and defense of 6 practical tasks;
3) the answer to the test.

The system of rating points and evaluation criteria:

	timely delivery	1 transfer (within two weeks from the initial control)	2 transfers (without compliance with deadlines)
1. Performance of modular control work:			
- completely correctly performed work	12	9	8
- the work is done with minor errors	8	7	5
- work is not included	0	0	0
2. Performance of practical tasks:			
- the task is defended with an excellent command of the material	8	4,5	4
- the task is completed with a satisfactory mastery of the material	5	3,5	3
- task not completed	0	0	0

Calculation of the rating scale (RS).
RC(max)= 12+6*8=60 points
RC(min)= 8+6*5=38 points

According to the results of the educational work for the first 7 weeks, the maximum amount of points scored is 16 points (2 points). At the first certification (8th week), the student receives "credit" if his current rating is **at least 0.5*16 = 8 points**.

According to the results of 13 weeks of training, the maximum amount of points scored should be 50 points (5 pr., 1 MKR). At the second certification (14th week), the student receives "credited" if his current rating is **at least 0.5*50 = 25 points.**

During the test, students perform a written test. Each task contains two theoretical questions and one practical one. Each theoretical question is valued at 15 points, practical - 10 points**.**

The evaluation system of theoretical questions:

-"excellent", complete answer (at least 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 - 11 points;

- "satisfactory", incomplete answer (at least 60% of the required information) and minor errors - 9 points;

- "unsatisfactory", an unsatisfactory answer (does not meet the requirements for "satisfactory") - 0 points.

Evaluation system of the practical question:

- "excellent", complete answer (at least 90% of the required information) - 10 points;

- "good", a sufficiently complete answer (at least 75% of the required information), or a complete answer with minor inaccuracies - 7.5 points;

- "satisfactory", incomplete answer (at least 60% of the required information) and minor errors - 6 points;

- "unsatisfactory", an unsatisfactory answer (does not meet the requirements for "satisfactory") - 0 points.

Scale of rating points and criteria for evaluation of credits (RE):

	points
- completely correct answer	40...38
- answer with minor errors	37...30
- answer with errors	29...20
- the answer is not counted	19-0

The rating scale for the discipline is R=RC+RE=60+40=100 points

Transfer of rating points to grades on the university scale

Rating points, RD	*Evaluation according to the university scale*
$95 \le RD \le 100$	Perfectly
$85 \le RD \le 94$	Very good
$75 \le RD \le 84$	Fine
$65 \le RD \le 74$	Satisfactorily
$60 \le RD \le 64$	Enough
$RD < 60$	Unsatisfactorily
Non-fulfillment of admission conditions to the semester control	Not allowed

A necessary condition for admission to the kindergarten is full completion of the curriculum, as well as a preliminary rating of at least 38 points and at least one positive certification.

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

9. Additional information on the discipline (educational component)

Control questions

from the discipline "Energy-saving intelligent machines and equipment of electromechanical and mechatronic systems"

1. Define the concepts of energy saving and recovery.
2. To substantiate the concept of "energy-saving intelligent machines".
3. Structural analysis of kinematics.
4. Explain the essence of Malyshev's formula.
5. Elements of structural synthesis.
6. Give dependencies that allow determination of stability parameters of the basic machine with a manipulator.
7. Give known ways of increasing the stability of mining machines.
8. What is the method of superelements for determining the reactions in the hinges of the working equipment of the manipulator**.**

9. Give the method of constructing charts of longitudinal, transverse forces and bending moments for structural elements of the manipulator.

10. Determination of the stress-strain state in the design elements of the manipulators. Theories of strength.

11. Основні поняття та визначення мехатроніки.

13. Analysis of the structure and functions of the manipulator hydraulic drive as a mechatronics module. Open diagram of the hydraulic drive.

14. Shield tunnel complexes. General concepts.

15. Calculation of the parameters of the rock cutting process by the rotary shield executive body.

16. Give oil and gas well operation schemes.

17. Technological complexes were developed at NTUU "KPI named after Igor Sikorsky".

18. Intellectual wells.

19. Adaptive hydropulse systems controlled by programmable logic controllers.

20. Give a typical diagram of the functioning of an intelligent system.

21. Fuzzy knowledge, a linguistic variable.

22. Explain the essence of the connectionist approach to the formation of intellectual systems.

23. The structure of an artificial neural network as a mechanism of intelligent control.

24. Types of neural networks and their functions.

25. Unidirectional multilayer networks of the sigmoidal type. Neural network training.

26. The structure of an adaptive mechatronic system based on the example of an adaptive pneumoaccumulator of an impact device.

Distance Learning:

Distance learning in this academic discipline is allowed on the basis of general decisions of the university due to force majeure circumstances.

Inclusive education:

This discipline can be taught to most students with special educational needs, except for students with severe visual impairments that do not allow them to complete tasks using personal computers, laptops and/or other technical aids.

Learning a foreign language:

Given the specifics of the academic discipline, some concepts and educational material can be studied in English (in fragments).

Taking into account the student-centered approach, at the request of students, it is allowed to study individual topics with the help of appropriate English-language electronic resources.

Extracurricular activities:

Consultations (individual and group) on this academic discipline and independent work of students can be carried out with prior consent in the scientific laboratory, in the scientific and technical library of the university and/or at home, respectively. The educational material provided for assimilation by the student in the process of independent work is submitted to the final control together with the educational material that was studied during classroom training sessions.

At the beginning of the semester, the teacher informs students/students about the possibility of taking appropriate free (or paid) courses at their discretion on the subject of the academic discipline. After the student receives an official certificate of completion of the relevant courses, the teacher has the right to enroll the relevant part of the course (or the course as a whole). The applicant can choose an online course independently or on the recommendation of the teacher. 1 hour of the course is valued at 1 point. The maximum number of hours that can be credited for the results of non-formal education is 12 hours, accordingly the maximum number of points for such results is 12 points.

Working program of the academic discipline (syllabus):

Folded assistant professor, d. t. s., prof. Slidenko Viktor Mikhailovich

Approved by the department AEMC (protocol № 17 dated 31.05.2023)

Approved by the Institute's Methodical Commission IEE (protocol №9 dated 22.06.2023)