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

Department of Automation of Electrical and Mechatronic Complexes

SIMULATION OF ELECTRICAL AND MECHATRONIC SYSTEMS

Work program of the discipline (Syllabus)

Details of the discipline	
Level of higher education	***First (bachelor's)***
Field of knowledge	*14 Electrical Engineering*
Speciality	*141 Electric Power Engineering, Electrical Engineering and Electromechanics*
Educational program	*Engineering of Intelligent Electrical and Mechatronic Complexes*
Discipline status	*Regulatory*
Form of study	*Full-time (full-time)/part-time/remote/*
Year of preparation, semester	*4th year, autumn semester*
Scope of discipline	*5.0 credits / 150 hours*
Semester control / control measures	*Exam*
Timetable	*http://roz.kpi.ua/*
Language of instruction	*Ukrainian*
Information about Course Leader / Instructors	Lecturer: *Ph.D., Associate Professor Danilin Oleksandr Valeriyovych; e-mail: avdan@ukr.net; mеn. +38-067-907-91-19 (09:00 – 18:00)* Practical / Laboratory: *Ph.D., Associate Professor Danilin Oleksandr Valeriyovych; e-mail: avdan@ukr.net; mеn. +38-067-907-91-19 (10:00 – 18:00)*
Course Placement	Available on the Sikorsky platform. The access code is provided by the teacher in the first lesson.

The program of the discipline

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

One of the important problems of engineering is the development of research methods for modern electrical systems and, on their basis, the creation of automated complexes and their control systems. When solving these problems, great importance is paid to *modeling*. In general, the modeling process can be represented as the study of some physical processes in the form of interrelated stages, each of which performs certain actions aimed at building and further use of information and logical models of systems. A characteristic feature of this process is its cyclic or interactive nature, which reflects modern requirements for the analysis and synthesis of complex automatic control systems.

The purpose of studying the discipline is to form the student's theoretical and practical knowledge of building models of electromechanical systems of varying complexity and creating effective control algorithms for their study in practice.

Program learning outcomes: (K11) ability to solve practical problems using computer-aided design and calculation (CAD) systems; (K19) Awareness of the need to improve the efficiency of electric power, electrical and electromechanical equipment; (K22) Ability to provide simulation of electrotechnical and electromechanical objects and technological processes of production using standard packages and means of automation of engineering calculations, to conduct experiments according to specified methods with processing and analysis of results; (K25) Ability to apply the methods of the theory of automatic control, system analysis and numerical methods for the development of mathematical

models of electrical and mechatronic complexes, analysis of the quality of their functioning using the latest computer technologies; (PR06) Apply application software, microcontrollers and microprocessor technology to solve practical problems in professional activities; (PR08) select and apply suitable methods for the analysis and synthesis of electromechanical and electropower systems with specified indicators; (PR17) Solve complex specialized problems in the design and maintenance of electromechanical systems, electrical equipment of power plants, substations, systems and networks; (PRN22) To create universal and most effective algorithms for modeling the processes of electrical and mechatronic systems and to conduct their research on modern equipment with modern software.

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

The academic discipline "Modeling of Electrical Systems" is taught on the basis of knowledge and skills gained by students during the study of credit modules of such disciplines as: "Physics", "Higher Mathematics", "Theoretical Foundations of Electrical Engineering", "Theory of Automatic Control of Electrical Complexes and Mechatronic Systems", "Computer Engineering and Programming", etc.

The knowledge and skills acquired in the process of studying the credit module "Modeling of Electrical Systems" are necessary for every specialist of the electrical profile who solve engineering problems in the field of electrical engineering and in the study of the following disciplines: "Electric Drive", "Automated Electric Drive of Machines and Installations", "Modeling of Electrical and Mechatronic Systems", etc.

3. The content of the discipline

Chapter 1. Analytical Implementation of Elements of Electrical Systems
- Topic 1.1. DC Op-Amps
- Topic 1.2. Automatic Adjustment Algorithms

Chapter 2. Mapping Systems in a Continuous State Space
- Topic 2.1. Vector-Matrix Model of a Continuous System
- Topic 2.2. Direct decomposition method

Chapter 3. Methods for constructing block diagrams in the state space
- Topic 3.1. Direct, sequential programming
- Topic 3.2. Parallel, combined programming

Chapter 4. General Methods for Modeling Dynamical Systems
- Topic 4.1. Numerical-Analytical Method of Modeling
- Topic 4.2. Discrete Z-Transform Methods

4. Training Materials & Resources

Basic

5. Modeling of electromechanical processes and systems. Helps. / O.V. Danilin, V.M. Chermalikh, P.V. Rosen. – K.: NTUU "KPI", 2007. – 52 p.

6. Shchokin V.P. Modeling of electromechanical systems: textbook / V.P. Shchokin [and others]. - Kyiv: Kondor, 2018. - 203 p.

7. Using the MATLAB–Simulink Package to Model Dynamical Systems and Devices: Method. Instructions for the performance of laboratory, calculation and graphic work, course and diploma design for students. Special. 7.092203 – "Electromechanical Automation Systems and Electric Drive" and 7.092204 – "Electromechanical Equipment of Energy-Intensive Industries" / Compilers: O.V. Chermalikh, O.V. Danilin, V.V. Kuznetsov. Kyiv: Polytechnic Publishing House, 2004. – 72 p.

Secondary

8. Lozynskyi A.O., Moroz V.I., Paranchuk Y.S. Solving electromechanics problems in the environments of MathCAD and MATLAB packages: Textbook. – Lviv: Lviv Polytechnic State University Press, 2000. – 166 p.

9. Kozbur I.R. Modeling of control systems in the MATLAB SIMULINK package, methodical instructions for laboratory work on the course "Computer methods of research of automatic control systems", for 4th year students of the specialty 6.050201 "System Engineering" / incl. : I.R. Kozbur, G.V. Kozbur, R.I. Mykhailyshyn. Ternopil: TNTU, 2019. - 23 p. http://elartu.tntu.edu.ua/handle/lib/28056

10. Modeling of electrical and mechatronic systems. Educational edition [Electronic resource] : tutorial for bachelor's degree programs for an educational program "Engineering of Intelligent Electrotechnical and Mechatronic Complexes" / O. V. Danilin, A. V. Bosak, V. O. Bronytskyi, L. V. Toropova ; Igor Sikorsky Kiev Polytechnic Institute. – Electronic text data (1 file: 1,27 MB). – Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2021. – 55 p. https://ela.kpi.ua/handle/123456789/47291

11. Gogoliuk, P. F. Teoriya avtomatnoho upravlinnia [Theory of automatic control]. Helps. / P.F. Gogolyuk, T.M. Grechin; Ministry of Education and Science, Youth and Sports of Ukraine, Nats. Lviv Polytechnic University. - Lviv: Lviv Polytechnic Publishing House, 2012. - 279 p.

References, the bibliography of which is given with a link, can be found on the Internet. Literature, the bibliography of which does not contain references, can be found in the library of Igor Sikorsky Kyiv Polytechnic Institute. Igor Sikorsky.

Separate sections of basic literature [1]-[3] are required reading. Sections of basic literature that are mandatory reading, as well as the connection of these resources with specific topics of the discipline, are given below, in the methodology of mastering the discipline. All other literary sources are optional, it is recommended to read them

Educational content

5. Methods of mastering the discipline (educational component)

The general methodical approach to teaching the discipline is defined as communicative-cognitive and professionally oriented, according to which the student – the subject of learning – is at the center of the educational process. The methodology of teaching the discipline combines visual teaching methods with explanation. Teaching is carried out in the form of lectures, practical and laboratory classes in the form of a computer workshop.

Lectures

Salary No.	Title of the topic of the lecture and a list of the main issues (links to literature)
1	**Title of the lecture topic:** Introduction to the discipline **List of main issues:** Basic concepts of modeling (physical and mathematical modeling, object-oriented principle, system, process, parameters, properties, state, characteristics, etc.). **References:** [2, 4]
2	**Lecture topic:** Simulation, object-oriented modeling **List of main issues:** Methods of constructing a simulation model. Block diagram of a generalized electromechanical system. The main blocks and modules of the system. Vector-matrix model of ETS. Deterministic and non-deterministic models. Mathematical model of the "black box" **References:** [1, 7]
3	**Title of the lecture topic:** Implementation of elements of electrical systems. **List of main issues:** The principle of superposition. Formation of models according to the rules of combined regulation. Image of the resistances of the main elements. Series and parallel connection of links. Simulation of a summing device. Transmission function of an op-amp. **References:** [1, 3].
4	**Title of the lecture topic:** Automatic adjustment algorithms. Proportional regulation. **List of main issues:** Proportional regulation. Basic mathematical dependencies and transfer functions of the corresponding links. **References:** [2, 7].
5	**Title of the lecture topic:** Automatic adjustment algorithms. Proportional-integral regulation. **List of main issues:** Proportional-integral regulation. Basic mathematical dependencies and transfer functions of the corresponding links. **References:** [2, 7].

6	**Title of the lecture topic:** Automatic adjustment algorithms. Differential adjustment **List of main issues:** Differential regulation. Basic mathematical dependencies and transfer functions of the corresponding links. **References:** [2, 7].
7	**Lecture topic:** PID Controller in Automatic Control Systems **List of main issues:** Transfer functions and schematic diagrams of different types of PID controller. **References:** [3, 4]
8	**Title of the lecture topic:** Implementation of nonlinear elements. **List of main issues:** Analytical description and construction of block diagrams of algorithms of elements of the "relay" type Using the MATLAB environment for interactive modeling of nonlinear elements **References:** [2, 6].
9	**Title of the lecture topic:** Implementation of nonlinear elements and differentiation operations. **List of main issues:** Analytical description and construction of block diagrams of the algorithms of an element with a "Hysteresis loop". Using the MATLAB environment for interactive modeling of nonlinear elements. Implementation of the differentiation operation. **References:** [1, 3].
10	**Title of the lecture topic:** Method of direct decomposition. **List of main issues:** The main mathematical dependencies of the method of direct decomposition in two ways, the compilation of appropriate structural diagrams and a diagram of the state of a linear system. **References:** [3, 6].
11	**Title of the lecture topic:** Construction of structural diagrams in the state space **List of main issues:** State space method, state variables. Direct and sequential programming. Obtaining analytical expressions and creating appropriate algorithms for mathematical models **References:** [2, 5].
12	**Title of the lecture topic:** Construction of structural diagrams in the state space **List of main questions:** State space method, state variables. Parallel and mixed (combined) programming. Obtaining analytical expressions and creating appropriate algorithms for mathematical models **References:** [3, 4].
13	**Title of the lecture topic:** Numerical-Analytical Method of Computer Modeling **List of main issues:** Dependence of the quality of the process on the choice of the sampling period (integration step). Obtaining mathematical dependencies for systems with an infinite chain of integrators. **References:** [1, 6].
14	**Title of the lecture topic:** Numerical-Analytical Method of Computer Modeling **List of main issues: Construction of a** block diagram and an algorithm for computer modeling of a nonlinear system by the numerical-analytical method **References:** [1, 6].
15	**Title of the lecture topic:** Z-transformation method. **List of main issues:** Discrete Laplace transform. Basic mathematical dependencies. **References:** [3, 7].
16	**Title of the lecture topic:** Z-transformation method. **List of main issues:** Discrete integration operators. Transition from a continuous system to a discrete one. **References:** [3, 7].

17	**Title of the lecture topic:** Mathematical modeling using the numerical-analytical method **List of main issues:** Construction of a structural diagram and an algorithm for computer modeling of a nonlinear system using the numerical-analytical method **References:** [2, 4].
18	**Title of the lecture topic:** Mathematical modeling using *the* Z-transform method **List of main issues:** Construction of a block diagram and an algorithm for computer modeling of a linear system using a *Z-transform* **References:** [2, 4].

Practical classes (computer workshop)

The main task of the cycle of practical classes is to consolidate the theoretical provisions of the discipline and acquire the ability to apply them in practice by performing certain appropriately formulated tasks with the help of special computer programs.

Salary No.	Name of the topic of practical classes (computer practicum) and a list of the main questions (references to literature)
1	**Title of the lecture topic:** Method of direct decomposition. First method **List of main issues:** The main mathematical dependencies of the method of direct decomposition in two ways, the compilation of appropriate structural diagrams and a diagram of the state of a linear system. **References:** [3, 6].
2	**Title of the lecture topic:** Method of direct decomposition. Second way **List of main issues:** Basic mathematical dependencies of the method of direct decomposition in two ways, compilation of appropriate block diagrams and diagrams of the state of a nonlinear system. **References:** [3, 6].
3	**Title of the lesson:** Numerical-analytical method of modeling systems. **List of main issues:** Construction of structural diagrams of the algorithm for the functioning of electrical systems **References:** [2, 5].
4	**Title of the lesson:** Numerical-analytical method of modeling systems. **List of main issues:** Synthesis of SIMULINK-models of electrical systems in the MATLAB environment and obtaining graphical results of computer modeling **References:** [1, 7].
5	**Title of the topic of the lesson:** Discrete *Z-transform methods.* **List of main issues:** Construction of structural diagrams of the algorithm for the functioning of electrical systems **References:** [2, 4].
6	**Title of the topic of the lesson:** Discrete *Z-transform methods.* **List of main issues:** Synthesis of SIMULINK-models of electrical systems in the MATLAB environment and obtaining graphical results of computer modeling **References:** [1, 3].
7	**Title of the topic of the lesson:** State Space Method. Construction of block diagrams. Direct Programming **List of main issues:** Basic principles of building block diagrams in the state space. Direct decomposition method. Drawing up block diagrams by direct programming. **References:** [2, 3]

8	**Title of the topic of the lesson:** State Space Method. Construction of block diagrams. Sequential programming **List of main issues:** Basic principles of constructing block diagrams in the state space. Direct decomposition method. Drawing up block diagrams by sequential programming. **References:** [2, 3]
9	**Name of the topic of the lesson:** State Space Method. Construction of block diagrams. Parallel Programming **List of main issues:** Basic principles of building block diagrams in the state space. Direct decomposition method. Drawing up block diagrams by parallel programming. **References:** [2, 4]

Laboratory classes

The main task of the cycle of laboratory classes is to conduct simulation experiments on a computer in order to form skills and abilities of practical confirmation of certain theoretical provisions, mastering the methodology of experimental research and processing of the data obtained.

Salary No.	**Lab Topic Title and a list of the main questions (references to literature)**
1	**Title of the lesson:** Methods of modeling linear and nonlinear electrical systems. **List of main issues:** Drawing up a block diagram of the algorithm for computer modeling of an electrical system. Numerical-Analytical Method of Systems Modeling. Z-transformation method. **References:** [1, 7].
2	**Title of the lesson:** Investigation of a linear dynamical system of the second order under non-zero initial conditions by the numerical-analytical method by direct programming **List of main issues: Construction of a** structural diagram of the algorithm for studying a linear dynamical system of the second order by the numerical-analytical method **References:** [1, 5]
3	**Title of the lesson:** Investigation of a linear dynamical system of the second order under non-zero initial conditions by the numerical-analytical method by direct programming **List of main issues:** Synthesis of SIMULINK-models of a second-order linear dynamical system in the MATLAB environment and obtaining graphical results of computer modeling by numerical-analytical method **References:** [2, 3]
4	**Title of the lesson:** Investigation of a second-order linear dynamical system under non-zero initial conditions by *the* Z-transform method by direct programming **List of main issues:** Construction of a block diagram of the algorithm for studying a linear dynamical system of the second order by the Z-transform method **References:** [4, 5]
5	**Title of the lesson:** Investigation of a second-order linear dynamical system under non-zero initial conditions by *the* Z-transform method by direct programming **List of main issues:** Synthesis of SIMULINK models of a second-order linear dynamical system in the MATLAB environment and obtaining graphical results of computer modeling by *the* Z-transform method **References:** [1, 3]

6	**Title of the lesson:** Investigation of a nonlinear dynamical system without taking into account the initial conditions by the numerical-analytical method by sequential programming **List of main issues:** Construction of a structural diagram of the algorithm for studying a nonlinear dynamical system without taking into account the initial conditions by the numerical-analytical method **References:** [2, 5]
7	**Title of the lesson:** Investigation of a nonlinear dynamical system without taking into account the initial conditions by the numerical-analytical method by sequential programming **List of main issues:** Synthesis of SIMULINK models of a nonlinear dynamical system without taking into account the initial conditions in the MATLAB environment and obtaining graphical results of computer modeling by numerical-analytical method **References:** [2, 4]
8	**Title of the lesson:** Investigation of a nonlinear dynamical system without taking into account the initial conditions *by the* Z-transform method by sequential programming **List of main issues:** Construction of a block diagram of an algorithm for studying a nonlinear dynamical system without taking into account the initial conditions by *the* Z-transform method **References:** [1, 2]
9	**Title of the lesson:** Investigation of a nonlinear dynamical system without taking into account the initial conditions *by the* Z-transform method by sequential programming **List of main issues:** Synthesis of SIMULINK models of a nonlinear dynamical system without taking into account the initial conditions in the MATLAB environment and obtaining graphical results of computer modeling by the Z-transform *method* **References:** [1, 4]

6. Independent work of a student/graduate student

Independent work of the student according to the curriculum provides 96 hours:
preparation for classroom classes – 46 hours;
preparation for the modular test – 10 hours;
performance of RR – 10 hours;
preparation for the exam – 30 hours.

As an individual semester task, according to the curriculum, students perform calculation work (RR)

Tasks of calculation work

Task 1

Investigation of Mathematical Models of a Second-Order Linear Dynamical System under Non-Zero Initial Conditions by Direct Programming

Order of the task:

1. To make a generalized block diagram of a second-order linear dynamical system and to determine the general transfer function
2. To compose a differential equation of a linear dynamical system in operator form, taking into account the initial conditions, and to represent it as a generalized block diagram in a continuous space of states
3. To represent the transfer functions in an integral form and to make a detailed block diagram of a linear dynamical system of the second order in a continuous space of states
4. Replace a continuous mathematical model with a discrete one using the specified approximation of integrators and build a block diagram of the algorithm for studying a linear dynamical system of the second order by the numerical-analytical method

5. To synthesize Simulink models of a linear dynamical system of the second order in the Matlab environment and to obtain graphical results of computer modeling by the numerical-analytical method

6. Replace a continuous mathematical model with a discrete one using the given *Z-transform* method and make a block diagram of a second-order linear dynamical system in the discrete state space

7. To Build a Block Diagram of the Algorithm for Studying a Mathematical Model of a Linear Dynamical System of the Second Order by the Z-Transform Method

8. Synthesize Simulink models of a second-order linear dynamical system in the Matlab environment and obtain graphical results of computer modeling using the *Z-transform* method

Task 2

Investigation of Mathematical Models of a Nonlinear Dynamical System Without Taking into Account the Initial Conditions by Sequential Programming

Order of the task:

1. To determine the transfer functions of linear links of a nonlinear dynamical system and to make a generalized block diagram in a continuous state space

2. To represent transfer functions in integral form and to make a detailed block diagram of a nonlinear dynamical system in a continuous state space

3. Replace a continuous mathematical model with a discrete one using a given approximation of integrators and build a block diagram of the algorithm for studying a nonlinear dynamical system by the numerical-analytical method

4. Synthesize Simulink models of a nonlinear dynamical system in the Matlab environment and obtain graphical results of computer modeling by numerical-analytical method

5. Replace a continuous mathematical model with a discrete one using the given *Z-transform method and make a block diagram of a nonlinear dynamical system in a discrete state space*

6. To build a block diagram of the algorithm for studying a mathematical model of a nonlinear dynamical system by *the* Z-transform method

7. To synthesize Simulink models of a nonlinear dynamical system in the Matlab environment and to obtain graphical results of computer modeling using *the Z-transform* method

Policy & Control

7. Academic discipline policy (educational component)

At the time of each lesson, both lecture and practical, the student must have the Zoom application installed on the device from which he works (in the case of distance learning), as well as open the course "Modeling of Electrical Systems" on the Sikorsky platform (the access code to the course is provided at the first lesson according to the schedule). syllabus; lecture material; tasks for a computer workshop; options for modular tests; methodical recommendations for performance of computer practicum and calculation work; the list of theoretical questions and practical tasks for the exam is posted on the Sikorsky platform and in the KPI Electronic Campus system.

During the course "Modeling of Electrical Systems", students are required 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 "Igor Sikorsky Kyiv Polytechnic Institute".

The deadlines for each task are specified in the course "Modeling of Electrical Systems" on the Sikorsky platform.

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

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

1. The student's rating in the credit module is calculated from 100 points, of which 50 points are the starting scale. The starting rating (during the semester) consists of the points that the student receives for:

– performing 2 tasks of the computer workshop at 9 practical classes;

– performing 4 tasks in 9 laboratory classes;
– two tests (one modular test is divided into two tests lasting one academic hour each);
– execution of 2 tasks of calculation work;

2. Criteria for awarding points:

2.1. Practical classes (computer workshop):

The weight score is 3. Maximum number of points: 3 × points 2 points. = 6 points.

Criteria for evaluating the performance of the tasks of the computer workshop	**Points**
Complete Comprehensive Answer	3
Correct answer with some flaws	2
Incomplete answer with significant flaws	1
A rather weak or incorrect answer	0

2.2. Laboratory classes

The weight score is 3. Maximum number of points: 3 × points 4 points. = 12 points.

Criteria for evaluating the performance of laboratory tasks	**Points**
Complete exhaustive fulfillment (at least 90%)	3
Full performance with some flaws (at least 75%)	2
Incomplete implementation with significant deficiencies (at least 60%)	1
Rather weak or incorrect performance (less than 60%)	0

2.3. Modular control

The weight score is 3. Maximum number of points: 3 points × 2 work. = 6 points.

Criteria for assessing the implementation of the ICR	**Points**
Complete answer (at least 90% of the required information)	3
a sufficiently complete answer (at least 75% of the required information), or a complete answer with minor inaccuracies	2
incomplete answer (at least 60% of the required information) and minor errors	1
Unsatisfactory response (does not meet the requirements for "satisfactory")	0

2.4. Calculation work

The weight score is 13. Maximum number of points: 13 points × 2 work. = 26 points.

Criteria for assessing the implementation and protection of RR	**Points**
All requirements for the work have been fulfilled	10… 13
Almost all the requirements for the work have been met, or there are minor errors	5… 9
There are shortcomings in meeting the requirements for work and certain mistakes	1… 4
The work does not meet the established requirements	0

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

3. Calendar control.

Calendar control is carried out twice a semester as a monitoring of the current state of implementation 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 relevant calendar control.

4. Semester control.

Semester control: Exam.

Conditions for admission to semester control: fulfillment of all tasks of computer practicum and laboratory work, as well as the performance of modular tests and calculation work. In addition, the preliminary rating score for the credit module must be *an rC* ≥ 25 points (at least 50% of *RC).*

Rating scale size: R = RC + RE = 50 + 50 = 100 points.

Starting scale size: RC = 6 + 12 + 6 + 26 = 50 points.

Exam scale: RE = 50 points (50% of R).

5. The task of the examination work is done in writing and consists of one theoretical question and one practical task. The list of questions is given in this syllabus. The theoretical question is worth 20 points, and the problem is worth 30 points.

Theoretical Question Evaluation System	**Points**
"excellent", full answer (at least 90% of the required information)	16… 20
"good", a sufficiently complete answer (at least 75% of the required information or minor inaccuracies)	10… 15
"satisfactory", incomplete answer (at least 60% of the required information and some errors)	6… 9
"unsatisfactory", unsatisfactory answer	0… 5

Assessment system for practical questions (tasks)	**Points**
"excellent", complete error-free solution of the problem	25… 30
"good", complete solution of the problem with minor inaccuracies	18… 24
"satisfactory", the task was completed with certain shortcomings	9… 17
"unsatisfactory", the task was not completed	0… 8

For part-time study.

Current control: MCR (conducted directly at the lecture in the presence of the teacher, 6 points); computer workshops (6 points), laboratory work (12 points), calculation work (26 points). The structure of the MCR, the requirements for them and the evaluation criteria are similar to those for full-time education and are given above.

6. The sum of starting points and points for the examination work is transferred to the final grade according to the table:

Rating points	University Scale Score
95… 100	Perfectly
85… 94	very good
75… 84	well
65… 74	Satisfactory
60… 64	enough
Less than 60	Disappointing
Failure to comply with the conditions of admission to the exam	Not allowed

9. Additional information on the discipline (educational component)

The list of questions that are submitted for semester control is given in the appendix to the syllabus. A higher education applicant has the opportunity to take an online course(s) on one or more topics provided for by the curriculum of the discipline. The applicant can choose an online course independently or on the recommendation of a teacher, on the Coursera or Udemy platform. 1 hour of the course is estimated at 0.83 points. The maximum number of hours that can be counted based on the results of non-formal education is 12 hours, respectively, the maximum number of points for such results is 10 points.

EXAM QUESTIONS FOR THE COURSE:

1. To reveal the basic concepts of modeling (physical and mathematical modeling, object-oriented principle, system, process, parameters, properties, state, characteristics).
2. To reveal the basic concepts of modeling (deterministic and non-deterministic models, simulation modeling, mathematical model of the "black box") and to reflect the general structure of the electrical system.
3. Display the main elements of DC op-amps, schematic diagram, transfer function, and realize the combiner.
4. To present the main characteristics of automatic control algorithms and to display the schematic diagrams and transfer functions of proportional, integral and proportional-integral regulation.
5. To present the main characteristics of automatic control algorithms and to display the schematic diagrams and transfer functions of differential regulation.
6. To present the main characteristics of automatic control algorithms and to display schematic diagrams and transfer functions of proportional-integral-differential regulation.
7. To present the method of mapping systems in a continuous state space and to present a vector-matrix model of a continuous linear system.
8. To reflect the main mathematical dependencies of the method of direct decomposition in the first way, to draw up the appropriate structural diagrams and a diagram of the state of the linear system.
9. To display the main mathematical dependencies of the method of direct decomposition in the second way, to make appropriate structural diagrams and a diagram of the state of a linear system.
10. Formulate the main provisions of the principle of superposition, make structural diagrams and transfer functions of a linear system.
11. To state the main provisions and build a block diagram of a nonlinear system by direct programming.
12. To state the main provisions and build a block diagram of a nonlinear system by sequential programming.

13. To state the main provisions and build a block diagram of a nonlinear system by parallel programming.

14. To compare the general methods of modeling systems and to make a block diagram of the algorithm for studying a second-order nonlinear system by the numerical-analytical method.

15. Compare general methods of modeling systems and outline the main mathematical dependencies and stages of *the Z-transform method.*

16. To make a block diagram of the algorithm for studying a second-order nonlinear system by *the* Z-transform method.

Work program of the discipline (syllabus):

Compiled by: Associate Professor of the AEMC Department, Ph.D.,
Associate **Professor Danilin Oleksandr Valeriiovych**

Approved by: AEMC Department (Minutes No. 17 dated 31.05.2023)

Approved by: Methodological Commission of the IEE (Minutes No. 9 dated 22.06.2023).)