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

Department of Automation of Electrical and Mechatronic Complexes

INTELLIGENT SYSTEMS AUTOMATIC CONTROL

Work program of the discipline (Syllabus)

Details of the discipline	
Level of higher education	***Second (Master'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	*Custom*
Form of study	*Full-time (daytime)*
Year of preparation, semester	*1st year, spring semester*
Scope of discipline	*5.0 credits / 150 hours*
Semester control / control measures	*Exam*
Timetable	*http://rozklad.kpi.ua/*
Language of instruction	*English*
Information about Course Leader / Instructors	Lecturer: *Ph.D., Associate Professor Kulakovskyi Leonid;* *e-mail*: l.kulakovskyi@kpi.ua*; (09:00 – 18:00)* Practical / Laboratory: *Ph.D., Associate Professor Kulakovskyi Leonid; e-mail:* : l.kulakovskyi@kpi.ua*; (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 most interesting and promising directions in the development of intelligent systems of automatic and program control of electrical complexes is the use of the mathematical apparatus of the theory of fuzzy logic to create special devices that allow quite accurate control of various technological processes. Modern automatic control systems for complex electrical complexes are becoming more and more intelligent. They contain a lot of different input information, the full representation of which is not accurate or complete. It is for the study of such systems that a special technology based on the use of the mathematical apparatus of the theory of fuzzy logic has become widely used.

The purpose of studying the discipline is to form the student's theoretical and practical skills in the study of intelligent automatic control systems based on the use of the theory of fuzzy logic with the help of applied software.

Professional Competencies (PC): (PC07) Ability to develop plans and projects to ensure the achievement of a specific goal, considering all aspects of the problem to be solved, including the production, operation, maintenance, and disposal of equipment of Electric Power, Electrotechnical and and electromechanical complexes and Program Learning Outcomes (PLO): (PLO14) Master new versions or new software designed for computer modeling of objects and processes in electric power, electrotechnical and electromechanical systems; (PLO17) To create intellectually adaptive systems for

automated control and control of the technical condition of electromechanical equipment based on the use of programmable logic controllers.

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 "Intelligent Automatic Control Systems" is taught on the basis of knowledge and skills gained by students during the study of credit modules of such disciplines as: "Theory of Automatic Control of Electrical Complexes and Mechatronic Systems", "Computer control of technological processes, experiments, equipment", "Modeling of electrical and mechatronic systems", etc.

The knowledge and skills acquired in the process of studying the credit module "Intelligent Automatic Control Systems" are necessary for every specialist of the electrical engineering profile, who solve engineering problems in the field of electrical engineering.

3. The content of the discipline

Chapter 1. Basic provisions of fuzzy set theory and fuzzy logic.

Topic 1.1. Membership functions, characteristics, and operations on fuzzy sets.

Topic 1.2. Fuzzy logic. Expression. Truth. Logical operations.

Chapter 2. Stages of creating fuzzy inference systems.

Topic 2.1. Formation of a base of vague rules. Fuzzification.

Topic 2.2. Logical processing of fuzzy data. Defuzzification.

Chapter 3. Algorithms for constructing fuzzy systems.

Topic 3.1. Mamdani and Sugeno algorithms.

Topic 3.2. Larsen's and Tsukamoto's algorithms.

Chapter 4. Construction of automated fuzzy-control systems.

Topic 4.1. Components of fuzzy control systems.

Topic 4.2. Determination of the structure and parameters of the fuzzy controller.

Chapter 5. Software and hardware for the implementation of fuzzy control systems.

Topic 5.1. Application packages.

Topic 5.2. Hardware implementation of microcontrollers.

4. Training Materials & Resources

Basic

1. Godfrey, H. Fuzzy Logic with MATLAB. CreateSpace Independent Publishing Platform, North Charleston, SC, United States, 2016, 328 p.

2. Chaira, Tamalika, and Ajoy Kumar Ray. Fuzzy image processing and applications with MATLAB. CRC Press, 2017, 222 p.

3. Mendel, Jerry M. Uncertain Rule-Based Fuzzy Systems: Introduction and New Directions, 2nd Edition. 2nd ed. 2017. Cham: Springer International Publishing, 2017. – 684 p.

4. Dernoncourt, Franck. Introduction to fuzzy logic. Massachusetts Institute of Technology 21, 2013, pp. 50-56.

Secondary

1. Ćajić, Elvir, Irma Ibrišimović, Alma Šehanović, Damir Bajrić, and Julija Šćekić. "Fuzzy Logic and Neural Networks for Disease Detection and Simulation in Matlab." In CS & IT Conference Proceedings, vol. 13, no. 23. CS & IT Conference Proceedings, 2023, pp. 17-23.

2. Zadeh L.A. Fuzzy sets. – Information and Control, vol. 8, 1965, pp. 338–353.

3. Mamdani E.H., Assilian S. An experiment in linguistic yn thesis with a fuzzy logic controller. – International Journal of Man-Machine Studies, vol. 7, no. 1, 1975, pp. 1 – 13.

4. Takagi T., Sugeno M. Fuzzy identification of systems and its applications to modeling and control. – IEEE Transactions on Computers, Man, and Cybernetics, vol. 15, no. 1, 1985, pp. 116 – 132.

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]-[4] 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 and practical 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. Directions of development of artificial intelligence technologies. **List of main issues:** Features of the creation of intelligent automatic control systems. Expert systems. Fuzzy logic. Artificial neural networks and genetic algorithms. Advantages and disadvantages of intelligent systems. Selection of methods according to the complexity of the object of control. **References:** [2, 3].
2	**Title of the lecture:** Fundamentals of fuzzy set theories and fuzzy logic. **List of main issues:** Historical aspects of the emergence of the concept of fuzzy sets and fuzzy logic. The life of Professor Lotfi A. Zadeh. Development of the theory and practical use of fuzzy logic. Examples of the use of fuzzy logic technologies in control systems of technological objects and household appliances. **References:** [1, 4].
3	**Title of the lecture topic:** Fuzzy sets. The concept of a linguistic variable **List of main issues:** Examples of the existence of fuzzy sets. Graphical representation of characteristic functions. **References:** [3, 7].
4	**Title of the lecture topic:** Membership functions of fuzzy sets. **List of main issues:** Definition of membership functions of fuzzy sets. Direct and indirect methods of construction. Basic geometric shapes of membership functions that are built into the Matlab system. Analytic expressions. Piecewise linear and smoothed graphs of membership functions. **References:** [2, 5].
5	**Title of the lecture topic:** Main **characteristics of fuzzy sets** **List of main issues:** Basic mathematical characteristics of fuzzy sets. Universum. Carrier. Height. Normal and subnormal are not fuzzy sets. Boundaries and transition points of fuzzy sets. Convex and unimodal fuzzy set. Graphical representation of the main characteristics. **References:** [1, 8].

6	**Title of the lecture topic:** Mathematical operations on fuzzy sets. **List of main questions**: Basic logical and algebraic operations on fuzzy sets: intersection, union, inclusion, difference, etc. Fundamental properties of fuzzy sets: commutativity, associativity, distributivity, idempotency, etc. **References:** [3, 4].
7	**Lecture topic title:** Fuzzy relationships, numbers, and intervals. **List of main issues**: The concept of fuzzy relation. tuples of elements. Fuzzy quantities: numbers and intervals. Fuzzy zero. Positive and negative fuzzy numbers. Basic algebraic operations on fuzzy numbers. Triangular and trapezoidal numbers and intervals. **References:** [5, 7].
8	**Title of the lecture topic:** Fundamentals of the theory of fuzzy logic. **List of main issues**: Basic concepts and definitions. FALSEHOOD and TRUTH. Vague statements. Fuzzy truth. Degrees of truth. Logical operations on fuzzy statements: negation, conjunction, disjunction, implication, equivalence. **References:** [1, 8].
9	**Title of the lecture topic:** The main stages of creating fuzzy inference systems. Drawing up a database of fuzzy rules. **List of main issues:** The concept of fuzzy inference. Stages and mathematical apparatus. Formation of a base of fuzzy rules. Compositional rule of fuzzy inference by Lotfi A. Zadeh. **References:** [1, 5].
10	**Title of the lecture topic:** The main stages of creating fuzzy inference systems. Fuzzification. Aggregation. Activation. Accumulation. **List of main issues:** The concept of fuzzification of fuzzy data. Logical processing of linguistic variables. Use of Boolean operators. Inference operators of fuzzy systems. Aggregation. Activation. Accumulation. **References:** [2, 3].
11	**Title of the lecture topic:** The main stages of creating fuzzy inference systems. Defuzzification. **List of main issues:** The concept of the fuzzification process of fuzzy data. Graphical display. Methods of median and center of maxima. Gravitational method. **References:** [4, 7].
12	**Title of the lecture topic:** Structures of the main algorithms for constructing fuzzy automatic control systems. Mamdani's algorithm **List of main issues:** The main stages of creating a fuzzy system using the Mamdani algorithm. Definitions. Mathematical reasoning. Basic dependencies and graphical structure of the algorithm. An example of using the Mamdani algorithm to find the control signal of the fuzzy controller of a closed automatic control system. **References:** [2, 6].
13	**Title of the lecture topic:** Structures of the main algorithms for constructing fuzzy automatic control systems. Sugeno, Larsen and Tsukamoto algorithms. **List of main issues:** The main stages of creating a fuzzy system using Sugeno, Larsen and Tsukamoto algorithms. Definitions. Mathematical reasoning. Basic dependencies and graphical structure of algorithms. **References:** [1, 5].
14	**Title of the lecture topic:** Methods of building automated fuzzy-control systems. **List of main issues:** Architecture of Systems of Classical Control Theory. Disadvantages of using traditional PID controllers. The main components of fuzzy control systems. General structure and examples of implementation of fuzzy control systems. **References:** [3, 4].

15	**Title of the lecture topic:** Creation of fuzzy controllers to control automated processes. Typical structure of a fuzzy control system. **List of main issues:** Schemes for constructing fuzzy-control systems with sequential and parallel arrangement of regulators. Analytical method for constructing fuzzy-controllers. Determination of the structure and parameters of a single-channel fuzzy controller when controlling a dynamic system **References:** [2, 8].
16	**Title of the lecture topic:** Software tools for the implementation of fuzzy systems. The Cubi Calc application package and the Matlab interactive modeling environment. **List of main issues:** Features of the Cubi Calc package. A specialized module of the Fuzzy Logic Toolbox of the Matlab environment, which is designed to simulate fuzzy systems. Features of the user interface. Package features and the main FIS editors of the system. Fuzzy System Editor. Affiliation function modules. Fuzzy rules database editor and fuzzy inference process visualizers. **References:** [3, 6].
17	**Title of the lecture topic:** Software tools for the implementation of fuzzy systems. A set of software and hardware fuzzyTECH. **List of main issues:** Features of the interface and functionality of the software. The main stages of fuzzy project development: description of a fuzzy system, off-line and on-line optimization, implementation of a microcontroller. **References:** [1, 5].
18	**Title of the lecture topic:** Fuzzy microcontrollers. Stages and standards of development. Hardware implementation. **List of main issues:** Integration of software and hardware for creating fuzzy microcontrollers. Structure of the IEC 1131-7 standard. FCL programming language. Application Compatibility and Consistency Levels.. Fuzzy microcontroller architecture. **References:** [2, 4].

Practical classes (computer workshop)

The main task of the cycle of practical classes in the form of a computer workshop 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.	**Title of the topic of practical classes and list of main questions (reference to literature)**
1	**Title of the lesson:** Introduction to the interface of the Fuzzy Logic Toolbox interactive graphics module of the Matlab environment. **List of main issues:** Creating, editing, and saving fuzzy inference systems using the graphical interface of the FIS system editor. **References:** [1, 3]
2	**Title of the lesson:** Introduction to the interface of the Fuzzy Logic Toolbox interactive graphics module of the Matlab environment. **List of main issues:** Using the Fuzzy Logic Designer,theMF Editor , and the Rule Editor. **References:** [2, 3]

3	**Title of the lesson:** Interactive in the visualization of the process of fuzzy logical inference. **List of main issues:** Use of the Rule Viewer process in the visualizer and in the visualizationof the Surface Viewer. **References:** [3, 4]
4	**Title of the lesson:** Implementation of a single-channel fuzzy control system such as Mamdani. **List of main issues:** Formation of a base of fuzzy rules. Fuzzification. Logical processing of fuzzy data. Defuzzification by the method of "center of gravity of fuzzy sets". Display and visualization of the input-output surface. **References:** [2, 6]
5	**Title of the lesson:** Implementation of a single-channel fuzzy-control system such as Sugeno. **List of main issues:** Formation of a base of fuzzy rules. Fuzzification. Logical processing of fuzzy data. Defuzzification by the "weighted average" method. Display and visualization of the input-output surface. **References:** [1, 8]
6	**Title of the lesson:** Integration of the fuzzy system into the Simulink app. **List of main issues:** Export the created fuzzy system to the Workspace workspace, or upload it to a file. Using the Simulink library browser. The main blocks of fuzzy systems. The function block of the fuzzy Logic Controller. Ensuring synchronous operation of the unit and the created fuzzysystem. **References:** [3, 7]
7	**Title of the lesson:** Working with the Fuzzy Logic Toolbox in command-line mode. **List of main issues:** Plotting membership functions. Performing the defuzzification process. Displaying the structure of a fuzzy model in the form of system commands. Displaying the structure of a fuzzy model in the form of a flowchart. **References:** [3, 5]
8	**Title of the lesson:** Working with the Fuzzy Logic Toolbox in command-line mode. **List of main issues:** Display graphs of membership functions. Displays the graph of the input-output surface. Converting a system like Mamdani to a system like Sugeno. Replacing the form of membership functions with equivalent ones. Performing basic fuzzy arithmetic operations. **References:** [1, 4]
9	**Title of the lesson:** The use of special Simulinkblocks for building fuzzy systems in the Matlab environment. **List of main issues:** Fuzzy-controller unit (Fuzzy Logic Controller). Blocks of membership functions (Membership Function). Triangular membership function (Triangular MF). Trapezoidal membership function (Trapezoidal MF). Z-shaped membership function (Z-Shaped MF). S-shaped membership function (S-Shaped MF). **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;
execution of CW – 10 hours;
preparation for the exam – 30 hours.

As an individual semester task, according to the curriculum, students perform contol work (CW)

Tasks for control work

Task 1. Analytical study of a single-channel fuzzy-control system

Order of the task:

1. Perform the fuzzification process.
2. Perform the process of defuzzification of the fuzzy-control system by the method of "heights" of fuzzy sets and make a block diagram of the algorithm for the functioning of the mathematical model.
3. Perform the process of defuzzification of the fuzzy-control system by the method of "boundaries and heights" of fuzzy sets and make a block diagram of the algorithm for the functioning of the mathematical model.
4. Perform the process of defuzzification of the fuzzy-control system by the method of "center of gravity" of fuzzy sets and make a block diagram of the algorithm for the functioning of the mathematical model.

Task 2. Interactive Exploration of a Single-Channel Fuzzy Control System

Order of the task:

1. Build graphs of specified membership functions using special command-line operators of the Matlab system.
2. Calculate the coordinates of the centers of gravity of the figures under the graphs of membership functions.
3. Synthesize a single-channel fuzzy inference system like Mamdani using the Fuzzy Logic Toolbox.
4. Display the structure of the created fuzzy-control system of the Mamdani type in the command window of the Matlab system.
5. Synthesize a single-channel fuzzy inference system like Sugeno using the Fuzzy Logic Toolbox.
6. Display the structure of the created fuzzy-control system of the Sugeno type in the command window of the Matlab system.
7. Integrate the created fuzzy control systems into the Simulink app.
8. Replace piecewise-linear membership functions and synthesize an equivalent fuzzy control system.

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 "Intelligent Automatic Control 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 the implementation of computer practicum and calculation and graphic 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 "Intelligent Automatic Control 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 "Intelligent Automatic Control 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:

– two answers in 9 practical classes (based on the fact that at each practical lesson on average 5 students are evaluated (with a group of 20 people – $9 \times 5 / 20 \approx 2$ reps.);
– two tests (one modular test is divided into two tests lasting one academic hour each);
– performance of calculation work;

2. Criteria for awarding points:

2.1. Work in practical classes:

The weight score is 5. The maximum number of points in all practical classes is equal to:

5 points × 2 rep. = 10 points.

Criteria for evaluating the response in practical classes	**Points**
Complete Comprehensive Answer	5
Correct answer with some flaws	3
Incomplete answer with significant flaws	2
A rather weak or incorrect answer	0

2.2. Modular control

The weight score is 5. The maximum number of points for 2 one-hour modular tests (MCR) is: 5 points × 2 MCR = 10 points.

Criteria for assessing the implementation of the ICR	**Points**
Complete answer (at least 90% of the required information)	5
a sufficiently complete answer (at least 75% of the required information), or a complete answer with minor inaccuracies	3
incomplete answer (at least 60% of the required information) and minor errors	2
Unsatisfactory response (does not meet the requirements for "satisfactory")	0

2.3. Calculation work

The weight score is 20. The maximum number of points for all criteria for the implementation and protection of the CW is 20 points

Criteria for assessing the implementation and protection of CW	**Points**
All requirements for the work have been fulfilled	24… 30
Almost all the requirements for the work have been met, or there are minor errors	15… 23
There are shortcomings in meeting the requirements for work and certain mistakes	7… 14
The work does not meet the established requirements	0… 6

For participation in the 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.

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

Semester control: Exam.

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

Starting scale size: RC = 10 + 10 + 30 = 50 points.

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

The maximum sum of the weight points of all control measures during the semester is

RS = 10 + 10 + 30 + 50 = 100 points.

Conditions for admission to the exam: completion of all tasks of the computer workshop and WGR, as well as a preliminary rating on the credit module must be $rC \geq 25$ points (at least 50% of RC).

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

The sum of starting points and points for the examination work is transferred to the exam 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 main directions of development of artificial intelligence and the use of modern intelligent technologies.
2. To present the main historical stages in the development of the theory of fuzzy logic.
3. Formulate concepts and give examples of fuzzy sets.
4. To reveal the main methods for determining the membership functions of fuzzy sets and to display several examples graphically with analytical dependence.
5. Define the main characteristics of fuzzy sets.
6. Explain basic logical operations on fuzzy sets.
7. Explain basic algebraic operations on fuzzy sets.
8. To reveal the essence of fuzzy relations, numbers and intervals, as well as to describe the basic mathematical operations on them.
9. To reveal the basic concepts of fuzzy logic: fuzzy statements and fuzzy truths.
10. Explain basic logical operations on vague statements.
11. To reveal the main stages of creating fuzzy inference systems.
12. Explain the essence of the process of forming a base of fuzzy rules.
13. Explain the essence of the fuzzification process.
14. Describe the essence of the process of logical processing of fuzzy data.
15. Describe the essence of the defuzzification process. The median method and the center of maxima method.
16. Describe the essence of the defuzzification process. Gravitational method.
17. To reveal the stages and structure of the algorithm for constructing fuzzy systems of the Mamdani type.
18. Give an example of the application of the Mamdani algorithm. Formation of a base of vague rules. Fuzzification. Aggregation.
19. Give an example of the application of the Mamdanii algorithm. Activation. Accumulation. Defuzzification.
20. To reveal the stages and structure of the algorithm for constructing fuzzy systems of the Sugeno type.
21. To reveal the stages and structure of the algorithm for constructing fuzzy systems of the Larsen type.
22. To reveal the stages and structure of the algorithm for constructing fuzzy systems of the Tsukamoto type.
23. To reveal the methodology of building automated fuzzy-control systems. Architecture of Systems of Classical Control Theory.
24. To reveal the methodology of building automated fuzzy-control systems. The main components of fuzzy control systems.
25. To describe the method of synthesis of fuzzy-regulators. Analytical method
26. Determine the structure and parameters of the fuzzy controller in the dynamic object control system.
27. Provide the main software tools for implementing fuzzy systems. Cubi Calk Package. Matlab interactive environment. Complex of fuzzyTECH products.

28. To reveal the main stages of the fuzzyTECH fuzzyTECH fuzzy system project.

29. To reveal the conditions and possibilities of creating fuzzy microcontrollers. Basic elements of a programming language.

30. To reveal the conditions and possibilities of creating fuzzy microcontrollers. Hardware implementation.

Work program of the discipline (syllabus):

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

Approved by the Department of Automation of Electrical and Mechatronic Complexes. Protocol

No. 21 of 25.06.24

Agreed: Methodological Commission of the IEE (No. 18 of 24.06.24)