FUZZY LOGIC AND FUZZY SYSTEMS

COURSE SYLLABUS

Code and name of specialty	121 - Software Engineering 122 – Computer Science 126 – Information management systems and technologies	**Institute**	**Faculty of Computer Science and Software Engineering**
Program name	Software Engineering Computer Science and Intelligent Systems Information Systems Software	**Department**	Software Engineering and Management Information Technologies
Type of program	**Educational and Professional**	**Language of instruction**	Ukrainian, English

LECTURER

Name and surname, email

Scientific degree - Candidate of Technical Sciences

Academic title - Associate Professor

Position - Associate Professor of Software Engineering and Management Information Technologies

Number of publications - more than 50, including 2 textbooks with the stamp of the Ministry of Education and Science of Ukraine and NTU "KhPI", 1 article in the publication indexed in Scopus

https://scholar.google.com.ua/citations?user=YnZ2JQQAAAAJ&hl=uk

https://orcid.org/0000-0003-4454-2314

https://www.scopus.com/authid/detail.uri?authorId=57208908501&eid=2-s2.0-85066097891

Basic courses - decision making theory (bachelors), development and implementation of information systems (masters), information systems software (masters), models and methods of soft computing (masters), models and methods of decision support (masters)

GENERAL DESCRIPTION OF THE COURSE

Summary

Discipline "FUZZY LOGIC AND FUZZY SYSTEMS" is a discipline in the cycle of professional selective training in the specialties 121 "Software Engineering", 122 "Computer Science", 126 "Information management systems and technologies". The course is taught in the 5th semester in the amount of 120 hours (4 ECTS credits), in particular: lectures - 32 hours, laboratory - 16 hours, self-study - 72

	hours. The course provides two content modules and one final module test. The discipline ends with credit. The course is aimed at forming in students the basic concepts, terms, principles and approaches of fuzzy logic and fuzzy systems.
Course objectives	Training of specialists capable of setting and solving decision-making problems in conditions of uncertainty, formalizing them in the form of fuzzy systems using the apparatus of fuzzy logic in combination with the formation of a scientific worldview and providing a broad outlook in the fundamental field of decision support systems.
Types of classes and control	Lectures, laboratory classes, self-study. The course ends with a credit
Term	5

Student workload (credits) / Type of course	4 / Selective	**Lectures (hours)**	32	**Laboratory classes (hours)**	16	**Self-study (hours)**	72

Program competences	121 GC01 – Ability to abstract thinking, analysis and synthesis 121 GC02 – Ability to apply knowledge in practical situations 121 GC05 – Ability to learn and master modern knowledge 121 GC06 – Ability to search, process and analyze information from various sources 121 GC07 – Ability to work in a team 121 PC19 – Knowledge of information data models, the ability to create software for data storage, retrieval and processing 121 PC20 – Ability to apply fundamental and interdisciplinary knowledge to successfully solve software engineering problems 121 PC26 – Ability to algorithmic and logical thinking 122 GC1 – Ability to abstract thinking, analysis and synthesis 122 GC2 – Ability to apply knowledge in practical situations 122 GC3 – Knowledge and understanding of the subject area and understanding of professional activity 122 GC6 – Ability to learn and master modern knowledge 122 GC7 – Ability to search, process and analyze information from various sources 122 GC9 – Ability to work in team 122 PC2 – Ability to detect statistical patterns of non-deterministic phenomena, the use of computational intelligence methods, including statistical, neural network and fuzzy data processing, machine learning and genetic programming methods, etc 122 PC5 – Ability to provide a formalized description of operations research tasks in organizational, technical, and socio-economic systems for different purposes, to determine their optimal solutions, to build optimal management models taking into account changes in the economic situation, to optimize management processes in different systems and hierarchies 122 PC6 – Ability to think systematically, apply the systems analysis methodology to study complex problems of different nature, methods of formalization and solution of system problems with conflicting goals,

	uncertainties, and risks 126 GC 1. Ability to abstract thinking, analysis and synthesis 126 GC 2. Ability to apply knowledge in practical situations 126 GC 3. Ability to understand the subject area and professional activity 126 GC 5. Ability to learn and master modern knowledge 126 GC 6. Ability to search, process and summarize information from various sources 126 PC 1. Ability to analyze the object of design or operation and its subject area 126 PC 6. Ability to use modern information systems and technologies (production, decision support, data mining, etc.), cybersecurity techniques and techniques in the performance of functional tasks and responsibilities 126 PC 13. Ability to perform computational experiments, compare the results of experimental data and solutions

Learning outcomes	**Teaching and learning methods**	**Forms of assessment (continuous assessment CAS, final assessment FAS)**
121 PO01. Analyze, purposefully search for and select the necessary information and reference resources and knowledge to solve professional problems, taking into account modern advances in science and technology	The teaching process involves the use of such basic technologies as: lectures, laboratory classes, work in small groups, brainstorming, presentations that develop communication and leadership skills, independent work with literary sources, mixed forms of learning using distance platforms	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), rapid surveys (CAS), online tests (CAS), final / semester control in the form of semester credit, according to the schedule of the educational process (FAS)
121 PO05. Know and apply relevant mathematical concepts, methods of domain, system and object-oriented analysis and mathematical modelling for software development	The teaching process involves the use of such basic technologies as: lectures, laboratory classes, work in small groups, brainstorming, presentations that develop communication and leadership skills, independent work with literary sources, mixed forms of learning using distance platforms	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), rapid surveys (CAS), online tests (CAS), final / semester control in the form of semester credit, according to the schedule of the educational process (FAS)
121 PO07. Know and apply in practice the fundamental concepts, paradigms and basic principles of operation of language, tools and computing software engineering	The teaching process involves the use of such basic technologies as: lectures, laboratory classes, work in small groups, brainstorming, presentations that develop communication and leadership skills, independent work with	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), rapid surveys (CAS), online tests (CAS), final /

	literary sources, mixed forms of learning using distance platforms	semester control in the form of semester credit, according to the schedule of the educational process (FAS)
121 PO08. Be able to develop a human-machine interface	The teaching process involves the use of such basic technologies as: lectures, laboratory classes, work in small groups, brainstorming, presentations that develop communication and leadership skills, independent work with literary sources, mixed forms of learning using distance platforms	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), rapid surveys (CAS), online tests (CAS), final / semester control in the form of semester credit, according to the schedule of the educational process (FAS)
121 PO10. Conduct a pre-project survey of the subject area, systematic analysis of the design object	The teaching process involves the use of such basic technologies as: lectures, laboratory classes, work in small groups, brainstorming, presentations that develop communication and leadership skills, independent work with literary sources, mixed forms of learning using distance platforms	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), rapid surveys (CAS), online tests (CAS), final / semester control in the form of semester credit, according to the schedule of the educational process (FAS)
121 PO11. Choose source data for design, guided by formal methods of describing requirements and modelling	The teaching process involves the use of such basic technologies as: lectures, laboratory classes, work in small groups, brainstorming, presentations that develop communication and leadership skills, independent work with literary sources, mixed forms of learning using distance platforms	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), rapid surveys (CAS), online tests (CAS), final / semester control in the form of semester credit, according to the schedule of the educational process (FAS)
121 PO13. Know and apply methods of algorithm development, software design and data and knowledge structures	The teaching process involves the use of such basic technologies as: lectures, laboratory classes, work in small groups, brainstorming, presentations that develop communication and leadership skills, independent work with	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), rapid surveys (CAS), online tests (CAS), final /

	literary sources, mixed forms of learning using distance platforms	semester control in the form of semester credit, according to the schedule of the educational process (FAS)
122 PC1. Ability to mathematically formulate and study continuous and discrete mathematical models, justify the choice of methods and approaches for solving theoretical and applied problems in the field of computer science, analysis and interpretation	The teaching process involves the use of such basic technologies as: lectures, laboratory classes, work in small groups, brainstorming, presentations that develop communication and leadership skills, independent work with literary sources, mixed forms of learning using distance platforms	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), rapid surveys (CAS), online tests (CAS), final / semester control in the form of semester credit, according to the schedule of the educational process (FAS)
122 PC4. Ability to use modern methods of mathematical modelling of objects, processes, and phenomena, to develop models and algorithms for the numerical solution of mathematical modelling problems, to take into account the errors of approximate numerical solution of professional problems	The teaching process involves the use of such basic technologies as: lectures, laboratory classes, work in small groups, brainstorming, presentations that develop communication and leadership skills, independent work with literary sources, mixed forms of learning using distance platforms	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), rapid surveys (CAS), online tests (CAS), final / semester control in the form of semester credit, according to the schedule of the educational process (FAS)
122 PC5. Ability to provide a formalized description of operations research tasks in organizational, technical, and socio-economic systems for different purposes, to determine their optimal solutions, to build optimal management models taking into account changes in the economic situation, to optimize management processes in different systems and hierarchies	The teaching process involves the use of such basic technologies as: lectures, laboratory classes, work in small groups, brainstorming, presentations that develop communication and leadership skills, independent work with literary sources, mixed forms of learning using distance platforms	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), rapid surveys (CAS), online tests (CAS), final / semester control in the form of semester credit, according to the schedule of the educational process (FAS)
122 PC17. Ability to apply the theoretical and practical basics of modern management theory for complex organizational, technical and socio-economic systems to build intelligent management	The teaching process involves the use of such basic technologies as: lectures, laboratory classes, work in small groups, brainstorming, presentations that develop communication and leadership	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), rapid surveys (CAS),

systems, in the process of designing intelligent systems to use modern information processing technologies and methods of computational intelligence	skills, independent work with literary sources, mixed forms of learning using distance platforms	online tests (CAS), final / semester control in the form of semester credit, according to the schedule of the educational process (FAS)
122 PC19. Ability to comprehensively use for the creation of intelligent management systems methods of mathematical modelling and analysis of complex systems, methods of modelling and analysis of business processes, information technologies for the management of business systems	The teaching process involves the use of such basic technologies as: lectures, laboratory classes, work in small groups, brainstorming, presentations that develop communication and leadership skills, independent work with literary sources, mixed forms of learning using distance platforms	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), rapid surveys (CAS), online tests (CAS), final / semester control in the form of semester credit, according to the schedule of the educational process (FAS)
126 PLO 2. Apply knowledge of basic and natural sciences, systems analysis and modeling technologies, standard algorithms and discrete analysis in solving problems of design and use of information systems and technologies	The teaching process involves the use of such basic technologies as: lectures, laboratory classes, work in small groups, brainstorming, presentations that develop communication and leadership skills, independent work with literary sources, mixed forms of learning using distance platforms	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), rapid surveys (CAS), online tests (CAS), final / semester control in the form of semester credit, according to the schedule of the educational process (FAS)
126 PLO 3. To use basic knowledge of informatics and modern information systems and technologies, programming skills, technologies of safe work in computer networks, methods of creation of databases and Internet resources, technologies of development of algorithms and computer programs in high-level languages with application of project-oriented programming to solve problems of design and use of information systems and technologies	The teaching process involves the use of such basic technologies as: lectures, laboratory classes, work in small groups, brainstorming, presentations that develop communication and leadership skills, independent work with literary sources, mixed forms of learning using distance platforms	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), rapid surveys (CAS), online tests (CAS), final / semester control in the form of semester credit, according to the schedule of the educational process (FAS)
126 PLO 4. Conduct a systematic analysis of design objects and justify the choice of structure,	The teaching process involves the use of such basic technologies as: lectures, laboratory classes, work	Written individual assignments for laboratory work (CAS),

algorithms and methods of information transfer in information systems and technologies	in small groups, brainstorming, presentations that develop communication and leadership skills, independent work with literary sources, mixed forms of learning using distance platforms	assessment of knowledge in laboratory classes (CAS), rapid surveys (CAS), online tests (CAS), final / semester control in the form of semester credit, according to the schedule of the educational process (FAS)

ASSESSMENT AND GRADING

Ranges of points corresponding to grades

Total score (points) for all types of learning activities	**ECTS grading scale**	**The national grading scale**
90-100	A	excellent
82-89	B	good
74-81	C	
64-73	D	satisfactory
60-63	E	
35-59	FX	Unsatisfactory (with the exam retake option)
0-34	F	Unsatisfactory (with mandatory repetition of the course)

Allocation of grade points

100% final evaluation in the form of credit (40%) and current assessment (60%).

40% credit: semester credit, according to the schedule of the educational process

60% current assessment (writing modular tests - 20% of the semester grade, laboratory classes - 20% of the semester grade, self-study - 20% of the semester grade)

Course policy	The policy of the academic discipline is determined by the system of requirements for the study of the discipline, the inadmissibility of

	omissions, the implementation of the required minimum of educational work; incentives and penalties - accrual or deduction of points. Participation in laboratory classes requires prior preparation and advance processing of all necessary materials for productive discussions during the class. Written assignments must be submitted by the deadline. The policy of the discipline is based on the norms of the legislation of Ukraine on academic integrity, the Charter, the provisions of NTU "KhPI". For violation of academic integrity, students may be held subject to the following academic liability: • reduction of results of estimation of modular control works, credit; • re-assessment of modular tests, credit; • repeated assessment of laboratory work; • re-evaluation based on the results of self-study; • appointment of additional modular control individual tasks, modular control works, tests.

COURSE STRUCTURE AND CONTENT

Lecture 1	The task of decision making. Types of uncertainty in decision-making tasks. Approaches to the formalization of uncertainty in decision-making tasks	**Laboratory classes 1-2**	Research of methods of construction of membership functions		Review of literature sources on the conceptual foundations and applications of fuzzy logic
Lecture 2	Fundamentals of fuzzy logic. The main characteristics of fuzzy sets. The main types of membership functions. Logical-linguistic description of the problem				
Lecture 3	Methods of constructing membership functions				Review of literature sources on the analysis of methods for constructing membership functions
Lecture 4	Operations on fuzzy sets	**Laboratory classes 3-4**	Research of methods of performing arithmetic operations on	**Self-study**	Review of literature sources on the study of means of forming fuzzy sets and operations on them using tools, analysis
Lecture 5	Fuzzy relationship of preference and ways to				

	determine it. Basic characteristics, properties and operations on fuzzy relations		fuzzy numbers		of methods of performing arithmetic operations on fuzzy numbers
Lecture 6	Fuzzy quantities, numbers and intervals. Basic definitions and methods of performing operations on fuzzy numbers				
Lecture 7	Models and methods of decision making in conditions of uncertainty	**Laboratory classes 5-6**	Research of fuzzy inference algorithms		A review of the literature on the analysis of methods and algorithms to support decision-making in conditions of uncertainty
Lecture 8	Fuzzy inference. Fuzzy inference algorithms - Mamdani, Tsukamoto, Sugeno, Larsen, simplified fuzzy inference algorithm. Methods of clarity. Falling fuzzy conclusions				Review of literature sources on the analysis of applied problems of fuzzy inference
Lecture 9-11	Fuzzy systems	**Laboratory classes 7-8**	Modeling of fuzzy system by means of fuzzy logic tools		Review of literature sources on basic design functions hybrid systems, analysis of applied fuzzy and fuzzy hybrid systems
Lecture 12-14	Theoretical foundations of hybrid systems				
Lecture 15-16	Hybrid fuzzy systems, generalization of some software engineering problems. Ways to present uncertainty in databases, fuzzy databases, knowledge				

	extraction				

RECOMMENDED READING

Compulsory	1 Michael Voskoglou (2020). Fuzzy Sets, Fuzzy Logic and Their Applications, 366 p. 2 Chander Mohan (2019) An introduction to fuzzy set theory and fuzzy logic, 392 p. 3 Guanrong Chen (2019) Trung Tat Pham Introduction to Fuzzy Sets, Fuzzy Logic, and Fuzzy Control Systems, 328 p. 4 Jenny Carter, Francisco Chiclana, Arjab Singh Khuman, Tianhua Chen (2021). Fuzzy Logic: Recent Applications and Developments, 385 p.	**Recommended**	1 Lotfi A Zadeh, Rafik A Aliev (2018). Fuzzy Logic Theory and Applications: Part I and Part II, 610 p. 2 Hasan, M. K. (2019). Fuzzy Sets and Fuzzy Logic with Applications: Imprecision, Uncertainty and Vagueness, 328 p. 3 Andreas Meier, Edy Portmann, Kilian Stoffel, Luis Terán (2017). The Application of Fuzzy Logic for Managerial Decision Making Processes: Latest Research and Case Studies (Fuzzy Management Methods), 115 p.

ACADEMIC INTEGRITY

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": to show discipline, politeness, friendliness, honesty, responsibility. Conflict situations should be openly discussed in study groups with the teacher, and in case of conflict resolution to contact the head of the Department of Software Engineering and Management Information Technologies

The content of this syllabus is consistent with the course program.