Subject (course) name: **Fuzzy Modelling**		
Programme: **Computer Science** Specialty:		Subject code: **17**
		Title graduate: **Engineer**
Type of course: **obligatory**	Course level: **First-cycle studies**	Year: **II** Semester: **V** Semester: **autumn**
Form of classes: **Lectures, Classes, Labs, Seminar, Project**	Number of hours per week: **2L, 0, 2Lab, 0, 0**	Credit points: **4 ECTS**

GUIDE TO SUBJECT

SUBJECT OBJECTIVES

C1. General knowledge of the theory of fuzzy sets, types of fuzzy models and the basic principles of their design.

C2. General methodology of the implementation of the basic operations on fuzzy sets using selected software.

C3. Practical skills in the implementation and testing of fuzzy models.

SUBJECT REQUIREMENTS

1. General knowledge of mathematics in the field of differential calculus, integral calculus and set theory.
2. General knowledge of physics in the field of statics and dynamics.
3. General knowledge of electrical engineering in the field of circuit theory.
4. Computer skills and the use of literature sources and Internet resources.
5. General ability to prepare reports on the performed exercises.
6. General ability to work independently and in groups.

LEARNING OUTCOMES

EK 1 – Student is able to characterize the basic concepts of fuzzy logic, the types and parameters of fuzzy sets, types of membership functions, parametric and non-parametric operators.

EK 2 – Student is able to describe the basic types and structures of fuzzy models and principles for their design.

EK 3 – Student is able to write scripts for the calculation and graphical presentation of membership functions and selected operators.

EK 4 – Student is able to apply the selected software to the implementation of fuzzy models.

EK 5 – Student is able to interpret the results of computer simulations designed fuzzy models.

SUBJECT CONTENT

Form of classes - lectures

Topic	Hours
W1 – Basic concepts of the theory of fuzzy sets	**2**
W2 – Membership functions of fuzzy sets	**2**
W3 – General recommendations for the selection of membership functions	**2**
W4 – Basic characteristic parameters of fuzzy sets	**2**
W5 – Arithmetic of fuzzy numbers	**2**
W6 – Non-parametric T-norm operators	**2**
W7 – Non-parametric S-norm operators	**2**
W8 – Structure of the fuzzy model	**2**
W9 – Forms of representation of the knowledge base	**2**
W10 – Fuzzification and defuzzification methods	**2**
W11 – Methods of creating the rule base	**2**
W12 – Realization of Mamdani fuzzy models	**2**
W13 – Realization of Sugeno fuzzy models	**2**
W14 – Multidimensional fuzzy modelling	**2**
Final test	**2**
Total	**30**

Form of classes – laboratory

Topic	Hours
Introduction to Matlab software and Fuzzy Logic Toolbox	**2**
L1 – Triangular and trapezoidal membership functions of fuzzy sets	**2**
L2 – Sigmoidal and Gaussian membership functions of fuzzy sets	**2**
L3 – Characteristic parameters of fuzzy sets	**2**
L4 – Product of fuzzy sets	**2**
L5 – Basic T-norm operators	**2**
L6 – Sum of fuzzy sets	**2**
Final test of the first series of laboratory exercises	**2**
L7 – Basic S-norm operators	**2**
L8 – Normalization of fuzzy model inputs	**2**
L9 – Defuzzification methods of fuzzy models	**2**
L10 – Mamdani fuzzy model	**2**
L11 – Sugeno fuzzy model	**2**
L12 – Tuning parameters of fuzzy models	**2**
Final test of the second series of laboratory exercises	**2**
Total	**30**

STUDY METHODS

1. Lectures using multimedia presentations
2. Discussion during the course and in addition during individual consultations
3. Laboratory - working with computers

EDUCATIONAL TOOLS

1. Audiovisual equipment, black(white)board, lectures in electronic version
2. Manuals to perform laboratory exercises
3. Computers in the laboratory with the Matlab/Simulink software

METHODS OF ASSESMENT (F – Forming, P – Summary)

F1. Assessment of self preparation for laboratory classes – oral answer
F2. Assessment of the correct and timely preparation of laboratory reports
P1. Lecture - written test of the theory and computational tasks, final exam
P2. Laboratory - assessment of the ability to correctly implementation of laboratory exercises
P3. Laboratory - assessment of the ability to solve complex tasks and drawing conclusions

STUDENT WORKLOAD

Form of activity		Averaged workload (hours)		
		[h]	∑ [h]	ECTS
Participation in class activities	lecture	30	60	3
	laboratory	30		
Preparation for laboratory classes (reading literature)		7	30	1
Familiarizing yourself with the specialized software		7		
Preparation of laboratory reports		8		
Preparation for the final test		8		
Total			**90**	**4**

A. BASIC READING

1. Jantzen J.: Foundations of Fuzzy Control. John Wiley and Sons, Chichester, United Kingdom, 2007.

2. Nguyen H. T., Walker E. A.: A First Course in Fuzzy Logic. Chapman and Hall/CRC; Third Edition, 2005.

3. Sivanandam S.N., Sumathi S., Deepa S. N.: Introduction to Fuzzy Logic using MATLAB. Berlin, Springer-Verlag 2006.

3. Chen G., Pham T. T.: Introduction to Fuzzy Sets, Fuzzy Logic, and Fuzzy Control Systems. CRC Press, First Edition, 2000.

B. FURTHER READING

1. Harris J.: An Introduction to Fuzzy Logic Applications. Springer, 2001.

2. Pedrycz W.: Fuzzy Control and Fuzzy Systems. John Wiley and Sons, New York, 1993.

3. Website: http://www.mathworks.com/

Learning objectives	In relation to the learning outcomes specified for the field of study	Subject objectives	Study methods	Methods of assessment
EK1	K_W12	C1	Lecture	P1
EK2	K_W12	C1	Lecture	P1
EK3	K_U12	C2, C3	Laboratory	F1, F2, P2, P3
EK4	K_U10	C2, C3	Laboratory	F1, F2, P2
EK5	K_U10	C3	Laboratory	F1, F2, P2, P3

II. EVALUATION

Grade	Outcome
EK1	**Student is able to characterize the basic concepts of fuzzy logic, the types and parameters of fuzzy sets, types of membership functions, parametric and non-parametric operators**
2 (F)	Student is not able to characterize the basic concepts of fuzzy logic, the types and parameters of fuzzy sets, types of membership function, parametric and non-parametric operators
3 (E)	Student is able to characterize the basic concepts of fuzzy logic
4 (C)	Student is able to characterize the basic concepts of fuzzy logic, the types and parameters of fuzzy sets
5 (A)	Student is able to characterize the basic concepts of fuzzy logic, the types and parameters of fuzzy sets, membership functions, parametric and non-parametric operators
EK2	**Student is able to describe the basic types and structures of fuzzy models and principles for their design**
2 (F)	Student is not able to describe the basic types and structures of fuzzy models and principles for their design
3 (E)	Student is able to describe the general structure of fuzzy model
4 (C)	Student is able to describe the general structure of fuzzy model, the basic types of fuzzy models, the action of the Mamdani fuzzy model
5 (A)	Student is able to describe the general structure of fuzzy model, the basic types of fuzzy models,

	the action of the Mamdani fuzzy model and the Sugeno fuzzy model, the design principles of fuzzy models
EK3	**Student is able to write scripts for the calculation and graphical presentation of membership functions and selected operators**
2 (F)	Student is not able to write scripts for the calculation and graphical presentation of membership function and selected operators
3 (E)	Student is able to write scripts for the calculation and graphical presentation of two membership functions and the minimum operator
4 (C)	Student is able to write scripts for the calculation and graphical presentation of four membership functions, the minimum operator, the maximum operator and two T-norm operators
5 (A)	Student is able to write scripts for the calculation and graphical presentation of four membership functions, the minimum operator, the maximum operator, four T-norm operators and four S-norm operators
EK4	**Student is able to apply the selected software to the implementation of fuzzy models**
2 (F)	Students is not able to apply the selected software to the implementation of fuzzy models
3 (E)	Student is able to apply the selected software to define the input membership functions
4 (C)	Student is able to apply the selected software to define the input membership functions, the output membership functions and the rule base
5 (A)	Student is able to apply the selected software to define the input membership functions, output membership functions, the rule base, the Mamdani fuzzy model and **the Sugeno fuzzy model**
EK5	**Student is able to interpret the results of computer simulations designed fuzzy models.**
2 (F)	The student is not able to interpret the results of computer simulations designed fuzzy models
3 (E)	Student is able to interpret the results of computer simulations of the Mamdani fuzzy model
4 (C)	Student is able interpret the results of computer simulations of Mamdani & Sugeno fuzzy models
5 (A)	Student is able interpret the results of computer simulations of Mamdani & Sugeno fuzzy models and determine the impact of the rule base

III. OTHER USEFUL INFORMATION

1. All information for students on the schedule are available on the notice board and on the website: https://we.pcz.pl/
2. Information on the consultation shall be provided to students during the first lecture and will be placed on the website https://we.pcz.pl/
3. Terms and conditions of credit courses will be provided to students during the first lecture