Syllabus template

Semester: 8	
Programme: Mathematics	
Course: Fuzzy set and its applications	
Paper Code:C4MT230831T	**Credits: 6**
Hours/week: 4	
Category: Core/MDC/SEC/VAC: Core (Elective)	
Theory / Practical / composite: Theory	
No of Modules: Nil	

Course Overview: Fuzzy set and its application

This course introduces the fundamental concepts of fuzzy set theory for handling uncertainty and imprecise information. It covers fuzzy sets and their operations, α-cuts, fuzzy numbers and their arithmetic, fuzzy relations and fuzzy graphs. The course also develops fuzzy logic and approximate reasoning through linguistic variables, fuzzy inference, implication rules, and fuzzy rule-based models such as Mamdani, TSK, and Tsukamoto. Finally, it introduces applications of fuzzy theory in pattern recognition, fuzzy clustering, and decision making. Overall, the course emphasizes both the mathematical foundations and practical applications of fuzzy set theory.

Course Outcome: On successful completion of the course a student will be able to do the following:

1. **Explain** the fundamental concepts of fuzzy sets, including membership functions, fuzzy set operations, t-norms, t-conorms, fuzzy negations, α-cuts, support, height, kernel, normality, and convexity.
2. **Analyze** fuzzy numbers, including triangular, trapezoidal, and generalized fuzzy numbers, and perform arithmetic operations on fuzzy numbers using appropriate methods.
3. **Examine** crisp and fuzzy relations, binary fuzzy relations, fuzzy equivalence relations, composition of fuzzy relations, and fuzzy graphs to model relationships involving imprecise information.
4. **Apply** the principles of fuzzy logic and approximate reasoning, including linguistic variables, fuzzy propositions, fuzzy inference, implication rules, and fuzzy rule-based models such as Mamdani, TSK, and Tsukamoto models.
5. **Utilize** fuzzy set theory and fuzzy logic in practical applications such as artificial intelligence, pattern recognition, fuzzy clustering, and decision making, particularly for problems involving uncertainty and imprecision.

Prerequisites: Basic knowledge of set theory, matrices and functions.

SYLLABUS

UNIT/Module	CONTENT	NO OF CLASSES	CO Mapping	COGNITIVE LEVEL

I.	Fuzzy Set Theory: Crisp sets, Basic concept of Fuzzy sets, Operations on fuzzy sets e.g. union, intersection, complement, t-norms, t-conorms, fuzzy negations. α - cut, support, height and kernel of a fuzzy set, normal fuzzy sets, convex fuzzy sets, Scalar cardinality of a fuzzy set, Representations of fuzzy sets, Extension principle for fuzzy sets and related results.	**14**	**CO1**	**K1, K2**
II.	Fuzzy Number and Fuzzy Relations: Fuzzy numbers (triangular and trapezoidal fuzzy numbers), Generalized fuzzy numbers, arithmetic operations on fuzzy numbers, Crisp and fuzzy relations, Binary fuzzy relations, Fuzzy equivalence relations, Composition of fuzzy relations, Fuzzy graph.	**12**	**CO2 CO3**	**K1, K2, K3**
III.	Fuzzy logic and Approximate Reasoning: Classical logic, multivalued logic, fuzzy propositions, fuzzy quantifiers, linguistic variables, linguistic hedges, Fuzzy inference, Fuzzy mapping rules and fuzzy implication rules, Fuzzy rule-based models for function approximation, Types of fuzzy rule-based models (Mamdani, TSK and Tsukamoto models), Fuzzy implications and approximate reasoning.	**16**	**CO3 CO4**	**K2, K3, K4**
IV.	Application: Pattern recognition, Fuzzy Clustering and Introduction to Decision Making.	**10**	**CO5**	**K4, K5**

Text Books

1. Fuzzy sets and systems: theory and applications, D. Dubois, H. Prade, Academic Press, Inc. 1997.
2. Fuzzy Set Theory and Its Applications, Zimmermann, H.J, Springer Science and Business Media, Dordrecht, 2001.
3. Fuzzy sets and fuzzy logic, theory and applications, G.J. Klir, B. Yuan, Prentice Hall of India, 2006.

Suggested readings
1. A. Kaufmann, (2005), "Introduction to Fuzzy Theory", Academic press, New York. 2. T. M. Ross (2006), "Fuzzy Engineering Application", Wiley Western Company 3. Fuzzy Implications, M. Baczynski, B. Jayaram, Springer-Verlag Berlin Heidelberg, 2008.
Web Resources and eLearning Sources
1. https://onlinecourses.nptel.ac.in/noc25_ee40/preview?utm_source=chatgpt.com 2. https://www.udemy.com/course/fuzzy-logic-course/?srsltid=AfmBOoo-wPj7s7f_xE_6c7xPHUV4cqHXIym8nliOX-YtLd7WVipc0lyV&utm_source=chatgpt.com&couponCode=MT260902G1B 3. http://www.pzs.dstu.dp.ua/logic/bibl/yuan.pdf 4. https://pzs.dstu.dp.ua/logic/bibl/engineering.pdf
Evaluation: Theory CIA: **20+5+5=30** Semester Exam: **70**
Paper Structure for Theory Semester Exam Module: 7 questions each of **10** marks out of a set of **13** questions.

Course outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive levels
CO1	**Explain** the fundamental concepts of fuzzy sets, including membership functions, fuzzy set operations, t-norms, t-conorms, fuzzy negations, α-cuts, support, height, kernel, normality, and convexity.	**K1, K2**
CO2	**Analyze** fuzzy numbers, including triangular, trapezoidal, and generalized fuzzy numbers, and perform arithmetic operations on fuzzy numbers using appropriate methods.	**K1, K2, K3**
CO3	**Examine** crisp and fuzzy relations, binary fuzzy relations, fuzzy equivalence relations, composition of fuzzy relations, and fuzzy graphs to model relationships involving imprecise information.	**K2, K3, K4**
CO4	**Apply** the principles of fuzzy logic and approximate reasoning, including linguistic variables, fuzzy propositions, fuzzy inference, implication rules, and fuzzy rule-based models such as Mamdani, TSK, and Tsukamoto models	**K2, K3, K4**
CO5	**Utilize** fuzzy set theory and fuzzy logic in practical applications such as artificial intelligence, pattern recognition, fuzzy clustering, and decision making,	**K4, K5**

	particularly for problems involving uncertainty and imprecision.	