# Question Paper

Exam Date & Time: 30-Nov-2022 (09:00 AM - 12:00 PM)

## MANIPAL ACADEMY OF HIGHER EDUCATION

**FUZZY LOGIC SYSTEMS [BME 4065]**

**Marks: 50** **Duration: 180 mins.**

**A**

**Answer all the questions.**

Instructions to Candidates: Answer ALL questions Missing data may be suitably assumed

1) (3)

Consider a discrete fuzzy set $A$ in the universe of discourse $X = \{1,2,3,4,5,6,7,8,9,10\}$ defined as:

A)

$$A = \{(1,0.1), (2, 0.2), (3, 0.4), (4, 0.8), (5, 0.2), (6, 0.8), (7, 0.2), (8,0.1)\}$$

Determine the height and normalize the fuzzy set A.

B) (3)

Consider a discrete fuzzy set $A$ in the universe of discourse $X = \{1,2,3,4,5,6,7,8,9,10\}$ defined as:

$$A = \{(1,0.1), (2, 0.2), (3, 0.4), (4, 0.8), (5, 0.2), (6, 0.8), (7, 0.2), (8,0.1)\}$$

Determine the bandwidth of the fuzzy set A.

C) Consider a Fuzzy set $A$ in $X = \{1, 2, 3, 4\}$, as: (4)

$$A = 0.7/1 + 0.3/2 + 0.2/3 + 0.6/4$$

Examine the law of contradiction for given fuzzy set.

2) Consider the Fuzzy sets $A, B$ in $X = \{1, 2, 3, 4\}$, defined as: (5)

A)

$$A = 0.5/1 + 1.0/2 + 0.3/3$$

$$B = 0.4/1 + 0.4/2 + 1.0/3$$

Determine the distance $d(A, B)$ between given fuzzy sets.

B) Consider the fuzzy sets $A$ and $B$ in $X = \{1,2,3,4\}$. Determine the intersection of the fuzzy sets $A, B$ using the Bounded Product T-norm operator. (3)

$$A = 0.7/1 + 0.5/2 + 0.1/3 + 0.6/4$$

$$B = 0.8/2 + 0.3/3$$

C) Consider a fuzzy set $A$ in $X = \{1,2,3,4\}$, Evaluate the Sugeno's class of complements for $\lambda = 0$. (2)

$$A = 0.7/1 + 0.5/2 + 0.1/3 + 0.6/4$$.

3) Consider the crisp sets $A$ and $B$ in $X$ and $Y$. If $x_A \in X$ and $x_B \in Y$ represents the elements of crisp set $A$ and $B$ (3)

A) respectively then inspect the crisp relation set such that the first element $x_A$ is greater than second element $x_B$ of a cartesian product and show that is the subset of cartesian product of $A \times B$.

$$A = \{0, 1, 2 3\}$$

$$B = \{1 3\}$$

$B = \{1,3\}$.

B) Consider the fuzzy sets $A$ and $B$ in $X = \{0,1,2\}$ and $Y = \{1,2\}$ respectively and are defined below. Determine the fuzzy relations as: (4)

$R_1$ : the first element is less than or equal to second element of a cartesian product

$R_2$ : the second element is less than or equal to first element of a cartesian product

Inspect the containment of $R_1$ in $R_2$.

$A = 0.2/0 + 0.5/1 + 1.0/2$

$B = 0.3/1 + 0.9/2$.

C) Consider a fuzzy set $A$ in the universe of discourse $X = [-10,10]$ defined as: (3)

$$A(x) = \sum_{x \in X} \mu_A(x)/x, \quad \mu_A(x) = \pi(x; [-2, -1, 2, 4])$$

Determine the fuzzy set $B$ in the universe of discourse $Y = [-10,10]$ using the Extension Principle if the mapping function defined as:

$$y = f(x) = \begin{cases} x & for\ x \leq 0 \\ x - 2 & for\ x > 0 \end{cases}.$$

4) Consider three fuzzy sets $A, B$ and $C$ in $X = \{0,1,2\}, Y = \{1,2\}$ and $Z = \{0,1,2\}$ respectively and are defined below. Determine the fuzzy relations as: (3)

A)

$R_1$ : the cartesian product of $A\ and\ B$

$R_2$ : the cartesian product of $B\ and\ C$

Compose the fuzzy relation using the max-min composition.

$A = 0.2/0 + 0.5/1 + 1.0/2$

$B = 0.3/1 + 0.9/2$

$C = 0.2/1 + 0.7/2$.

B) Consider a linguistic value characterized by a fuzzy set $A$ in the universe of discourse $X = \{1,2,3,4,5\}$ defined as: (3)

$A = 0.1/2 + 0.7/3 + 0.8/4 + 1.0/5$

Determine the contrast intensification of the linguistic value $A$.

C) Consider the term set of linguistic values '***malignant'*** and ***'benign'*** characterized by fuzzy sets for a linguistic variable '***acceleration of cell growth (acg)***' in the universe of discourse $X = \{0,1,2,3,4,5,6,7,8,9,10\}$ as: (4)

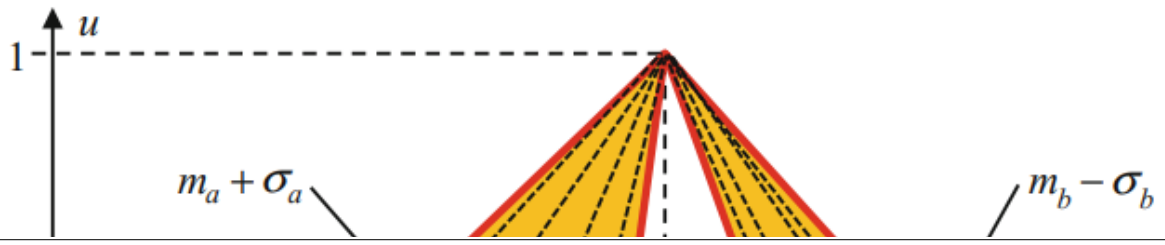
$malignant = 0.2/4 + 0.5/5 + 0.8/6 + 1.0/7 + 0.9/8 + 0.4/9 + 0.1/10$

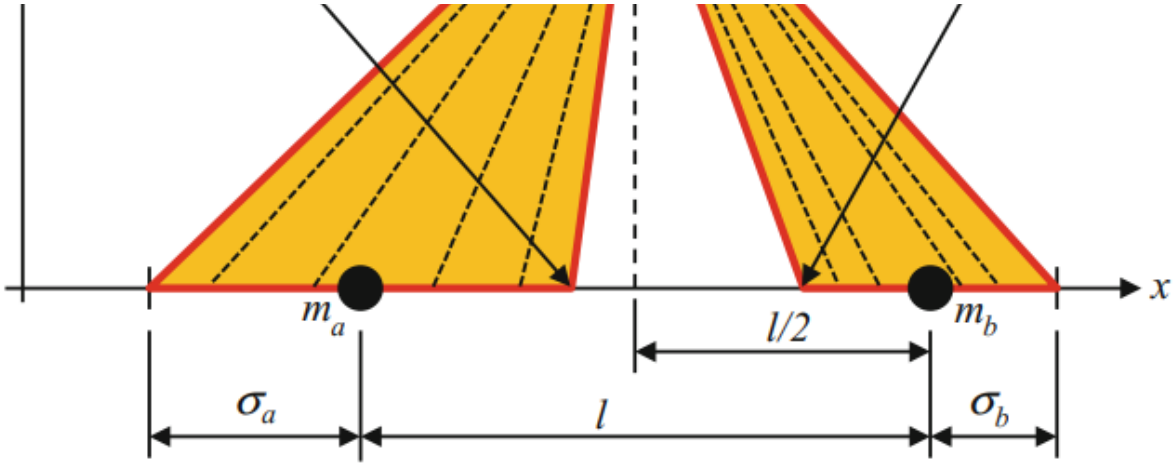
$benign = 0.1/1 + 0.4/2 + 0.9/3 + 1.0/4 + 0.8/5 + 0.5/6 + 0.2/7$

Examine the composite linguistic term ***'Not very malignant but not very benign'***.

5) Determine the FOU for a triangular MF as shown in the figure below, but for when $m_a + \sigma_a < m_b - \sigma_b$. (4)

A)






B) Identify any two FOUs that have lower and upper trapezoidal MFs. (3)

C) Consider two Type-2 Fuzzy sets $\tilde{A}(x)$ and $\tilde{B}(x)$ for a particular element $x$ for which $U \in [0,1]$. The secondary MFs of these two sets are $\mu_{\tilde{A}(x)}(u) = 0.4/0 + 0.8/0.1$ and $\mu_{\tilde{B}(x)}(u) = 0.2/0.4 + 0.9/0.8$. Determine $\tilde{A}(x) \cup \tilde{B}(x)$ using minimum t-norm. (3)

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