UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER I
SESSION 2020/2021

COURSE NAME	:	FUZZY SYSTEM DEVELOPMENT
COURSE CODE	:	BIT 33703
PROGRAMME CODE	:	3 BIT
EXAMINATION DATE	:	JANUARY / FEBRUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER ALL QUESTIONS

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

Q1 In a survey, students are compared based on their score marks and activity participation. A universe of discourse of score marks is:

$X = \{0, 20, 40, 60, 80, 100\}$.

The standard discrete form of fuzzy set for marks $\tilde{S}_1$ and activity participation $\tilde{S}_2$ are as follows:

$$\tilde{S}_1 = \left\{\frac{0}{0} + \frac{0.5}{20} + \frac{0.65}{40} + \frac{0.85}{60} + \frac{1.0}{80} + \frac{1.0}{100}\right\}$$

$$\tilde{S}_2 = \left\{\frac{0}{0} + \frac{0.45}{20} + \frac{0.6}{40} + \frac{0.8}{60} + \frac{0.95}{80} + \frac{1.0}{100}\right\}$$

Find the following membership functions using standard fuzzy operations.

(a) $\mu_{\tilde{S}_1} \cup \mu_{\tilde{S}_2}(x)$

(3 marks)

(b) $\mu_{\tilde{S}_1} \cap \mu_{\tilde{S}_2}(x)$

(3 marks)

(c) $\mu_{\tilde{S}_1 \cup \tilde{S}_1}(x)$

(3 marks)

(d) $\mu_{\tilde{S}_1 \cap \tilde{S}_1}(x)$

(3 marks)

Q2 Suppose a fuzzy subset F is defined as

$$\mu_F = \begin{cases} 0 & for \quad 0 < y < 30 \\ (y - 30) / 30 & for \quad 30 \le y \le 60 \\ (90 - y) / 30 & for \quad 60 \le y \le 90 \\ 0 & for \quad 90 \le y \le 120 \end{cases}$$

(a) Based on the above definition, calculate the value of μ_F when the values of y are 45, 80 and 110.

(6 marks)

(b) Draw the graph to represent the above function.

(4 marks)

Q3 TechnyCorp is manufacturing a new washing machine and has created the Fuzzy Associative Matrix as illustrated in **Table 1** to relate `quantity` and `softness` to `cycle_time`. The following trapezoidal/triangular normalized membership functions have been estimated:

Table 1: Fuzzy Associative Matrix

Quantity / Softness	Small	Medium	Large
Soft	Delicate	Normal	Normal
Normal soft	Light	Normal	Normal
Normal hard	Normal	Normal	Strong
Hard	Strong	Strong	Strong

30 60 90

Table 2: `cycle_time`

Cycle time	Membership function
Delicate	$delicate(x) = \begin{cases} 1, & \text{if } 0 < x \leq 20 \\ (45 - x) & \\ \overline{(45 - 20)}, & \text{if } 20 \leq x \leq 45 \\ 0, & \text{if } x \geq 45 \end{cases}$
Light	$light(x) = \begin{cases} 0, & \text{if } x < 15 \\ \dfrac{(x - 15)}{(45 - 15)}, & \text{if } 15 \leq x \leq 45 \\ \dfrac{(75 - x)}{(75 - 45)}, & \text{if } 45 \leq x \leq 75 \\ 0, & \text{if } x > 75 \end{cases}$
Normal	$normal(x) = \begin{cases} 0, & \text{if } x < 25 \\ \dfrac{(x - 25)}{(55 - 25)}, & \text{if } 25 \leq x \leq 55 \\ \dfrac{(85 - x)}{(85 - 55)}, & \text{if } 85 \leq x \leq 85 \\ 0, & \text{if } x > 85 \end{cases}$
Strong	$strong(x) = \begin{cases} 0, & \text{if } x < 55 \\ \dfrac{(x - 55)}{(80 - 55)}, & \text{if } 55 \leq x \leq 80 \\ 1, & \text{if } x > 80 \end{cases}$

Answer the following questions:

(a) Design a fuzzy system which accommodates the given situation.

(4 marks)

(b) Construct the rule base statements for the given situation.

(10 marks)

(c) Draw the membership function graph for fuzzy variable `quantity`, based on the following fuzzy function:

$$small(x) = \begin{cases} 1, & \text{if } 0 < x \leq 2.5 \\ \dfrac{(4.5 - x)}{(4.5 - 2.5)} & \text{if } 2.5 \leq x \leq 4.5 \\ 0, & \text{if } x > 4.5 \end{cases}$$

$$medium(x) = \begin{cases} 0, & \text{if } x < 3 \\ \dfrac{(x - 3)}{(5 - 3)}, & \text{if } 3 \leq x \leq 5 \\ \dfrac{(7 - x)}{(7 - 5)}, & \text{if } 5 \leq x \leq 7 \\ 0, & \text{if } x > 7 \end{cases}$$

$$large(x) = \begin{cases} 0, & \text{if } x < 5.5 \\ \dfrac{(x - 5.5)}{(7.5 - 5.5)}, & \text{if } 5.5 \leq x \leq 7.5 \\ 1, & \text{if } x > 7 \end{cases}$$

(8 marks)

(d) Draw the membership function graph for fuzzy variable `softness`, based on the following fuzzy function.

$$soft(x) = \begin{cases} 1, & \text{if } 0 < x \leq 0.2 \\ \dfrac{(0.45 - x)}{(0.45 - 0.2)} & \text{if } 0.2 \leq x \leq 0.45 \\ 0, & \text{if } x \geq 0.45 \end{cases}$$

$$normal\_soft(x) = \begin{cases} 0, & \text{if } x < 0.15 \\ \dfrac{(x - 0.15)}{(0.45 - 0.15)}, & \text{if } 0.15 \leq x \leq 0.45 \\ \dfrac{(0.75 - x)}{(0.75 - 0.45)}, & \text{if } 0.45 \leq x \leq 0.75 \\ 0, & \text{if } x > 0.75 \end{cases}$$

$$normal\_hard(x) = \begin{cases} 0, & \text{if } x < 0.25 \\ \dfrac{(x - 0.25)}{(0.55 - 0.25)}, & \text{if } 0.25 \leq x \leq 0.55 \\ \dfrac{(0.85 - x)}{(0.85 - 0.55)}, & \text{if } 0.55 \leq x \leq 0.85 \\ 0, & \text{if } x > 0.85 \end{cases}$$

$$hard(x) = \begin{cases} 0, & \text{if } x < 0.55 \\ \dfrac{(x - 0.55)}{(0.8 - 0.55)}, & \text{if } 0.55 \leq x \leq 0.8 \\ 1, & \text{if } x > 0.8 \end{cases}$$

(8 marks)

(e) If the `quantity = 0.37` and the `softness = 0.6`, calculate `cycle time` using the max-min technique and centroid defuzzification (Estimate your own centroid location).

(10 marks)

TERBUKA

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