UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	FUZZY SYSTEM DEVELOPMENT
COURSE CODE	:	BIT 33703
PROGRAMME CODE	:	3 BIT
EXAMINATION DATE	:	JUNE / JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS.

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) Give the significance of having fuzzy set theory in addition to the probability theory.

(2.5 marks)

(b) Give **TWO (2)** limitation of classical probability theory in providing a comprehensive methodology for dealing with uncertainty and imprecision.

(5 marks)

(c) Differentiate between randomness and fuzziness.

(5 marks)

Q2 (a) Compute the support and 0.5-cut for the fuzzy set shown in **Figure Q2**. The discretized form of the fuzzy set `A1="possmall"` can be written as follows:

$$A_1 = \begin{Bmatrix} (0,0),(\pi/16,0.25),(\pi/8,0.5),(3\pi/16,0.75),(\pi/4,1.0), \\ (5\pi/16,0.75),(3\pi/8,0.5),(7\pi/16,0.25),(\pi/2,0) \end{Bmatrix}$$

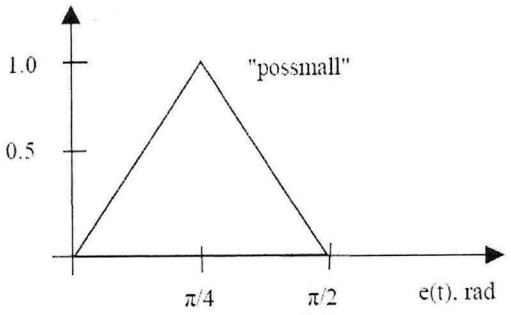

Figure Q2

(4 marks)

(b) 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.

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

(2 marks)

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

(2 marks)

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

(2 marks)

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

(2 marks)

Q3 Consider a Takagi - Sugeno type fuzzy system with two inputs and one output. The rules are given as follows:

Rule 1: if X_1 is small and X_2 is low then $y = 0.5X_1 + 0.5X_2$
Rule 2: if X_1 is small and X_2 is high then $y = X_1 + 0.5X_2$
Rule 3: if X_1 is big and X_2 is low then $y = X_1 + X_2$
Rule 4: if X_1 is big and X_2 is high then $y = 2X_1 + X_2$

The weight of i^{th} rule is $w_i(x_1, x_2) = \mu_{X_1}(x_1) * \mu_{X_2}(x_2)$.
The fuzzy membership functions of the input variables are illustrated in **Figure Q3**.

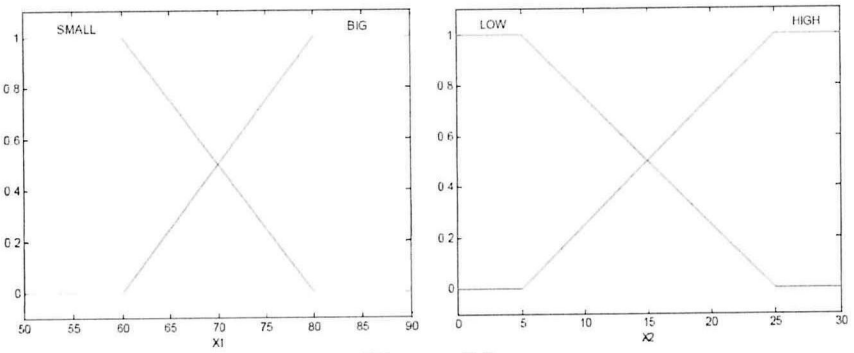

Figure Q3

(a) Use the weighted average method to compute the output of the controller for $X_1 = 65$ and $X_2 = 20$.

(6 marks)

(b) State the rationale why the weighted average method is applicable to compute the solution in **Q4 (a).**

(2 marks)

Q4 Techny Corp is planning a new product and has created the Fuzzy Associative Matrix as illustrated in **Table 1** to relate `demand` and `manufactured cost` to `price`. The following trapezoidal/triangular normalized membership functions have been estimated.

```
Demand (in millions of units annually)
      Small        {100, 1      300, 0}
      Large        {150, 0      350, 1}
Manufactured Cost (in yen per unit)
      Cheap        {10, 1       20, 0}
      Expensive    {12, 0       24, 1}
Price (in cost per unit)
      Low          {20, 1       35, 0}
      Medium       {25, 0       35, 1}
      High         {35, 0       50, 1}
```

Table 1: Fuzzy Associative Matrix

Price		
	Manufactured Cost	
Demand	Cheap	Expensive
Small	Low	Medium
Large	Medium	High

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. (4 marks)

(c) Draw the membership functions graphs for all the fuzzy input(s) and output. (12 marks)

(d) If the `Demand Forecast = 250` and the `Manufactured Cost Forecast = 15`, decide upon Price using the max-min technique and centroid defuzzification (Estimate your own centroid location). (10 marks)

Q5 Assume that there are two input and one output fuzzy variables for a fuzzy mechanical pencil system. Each fuzzy input and output variables comprise of three fuzzy labels.

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

$$short(x) = \begin{cases} 1, & \text{if } 0 < x < 1 \\ \dfrac{(3-x)}{2} & \text{if } 1 < x < 3 \\ 0, & \text{if } x > 3 \end{cases}$$

$$medium(x) = \begin{cases} 0, & \text{if } x < 1 \\ \dfrac{(x-1)}{2}, & \text{if } 1 \le x \le 3 \\ 1, & \text{if } 3 < x < 5 \\ \dfrac{(7-x)}{2}, & \text{if } 5 \le x \le 7 \\ 0, & \text{if } x > 7 \end{cases}$$

$$long(x) = \begin{cases} 0, & \text{if } x < 5 \\ \dfrac{(x-7)}{2}, & \text{if } 5 \le x \le 7 \\ 1, & \text{if } x > 7 \end{cases}$$

(7 marks)

(b) Find the membership values for all fuzzy labels for `length` is 2cm.

(3 marks)

(c) Draw a membership function graph for fuzzy variable `head_size`, based on the following fuzzy function.

$$small(x) = \begin{cases} 1, & \text{if } 0 < x < 0.3 \\ \dfrac{(0.5 - x)}{2} & \text{if } 0.3 < x < 0.5 \\ 0, & \text{if } x > 0.5 \end{cases}$$

$$medium(x) = \begin{cases} 0, & \text{if } x < 0.3 \\ \dfrac{(x - 0.3)}{0.2}, & \text{if } 0.3 \le x \le 0.5 \\ 1, & \text{if } 0.5 < x < 0.7 \\ \dfrac{(0.9 - x)}{0.2}, & \text{if } 0.7 \le x \le 0.9 \\ 0, & \text{if } x > 0.9 \end{cases}$$

$$big(x) = \begin{cases} 0, & \text{if } x < 0.7 \\ \dfrac{(x - 0.9)}{0.2}, & \text{if } 0.7 \le x \le 0.9 \\ 1, & \text{if } x > 0.9 \end{cases}$$

(7 marks)

(d) Find the membership values for all fuzzy labels for `head_size` 0.4mm.

(3 marks)

(e) Construct a Fuzzy Associative Matrix based on answer in Q5(b) and Q5(c) by applying MIN operator.

(7.5 marks)

(f) Find Centre of Area (COA) for `length` 2cm and `head_size` 0.4mm. The `Out_Length_Lead` of pencil represents the output for fuzzy intelligent mechanical pencil system as shown in **Figure Q5(f)**.

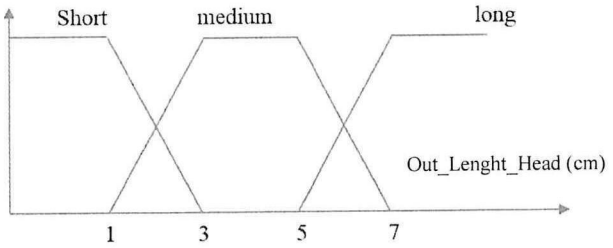

Figure Q5(f)

(10 marks)

- END OF QUESTIONS -