BITS Pilani, Dubai Campus
Dubai International Academic City, Dubai

IV Year (CHEM/MECH/EEE/CS/EIE/ECE)
First Semester, 2011-2012

No of Questions
PART A: 4
PART B: 6
No of Pages: 4

Comprehensive Examination (CLOSED BOOK)

Course No: EA C482 — **Course Title: Fuzzy Logic and Applications**
Date: 9th Jan 2012 — **Weightage: 40%**
Duration: 3 Hours — **Max. Marks. 80**

(Answer PART –A and PART –B in separate answer books).
(Use Graph Sheet for PART-A Q3 and Q4(b). Assume suitable data if required)

ANSWER ALL QUESTIONS

PART – A

1. a) A four-person family wants to buy a house. An indication of how comfortable they want to be depends on the number of bedrooms in the house. But they also want a large house. Let U = {1,2,3,4,5,6,7,8,9,10} be the set of available houses described by their number of bedrooms. Then the fuzzy set C (for comfortable) may be described as C={0.2, 0.5, 0.8, 1, 0.7, 0.3, 0,0,0,0}. Let I be the fuzzy set Large defined as I=.{0,0,0.2,0.4,0.6,0.8,1,1,1,1}.Find

(i) C ∩ I **[1M]**

(ii) C ∪ I **[1M]**

(iii) Clearly comment on the interpretation of the results in (i) & (ii) **[3M]**

b) The membership function for "tallness" and "old-age" are given by the following expressions.

$$\mu_{tall}(x) = \begin{cases} 0 & if\ height(x) < 5\ \text{ft} \\ \frac{height(x) - 5\ \text{ft}}{2} & if\ 5\ \text{ft} \le height(x) \le 7\text{ft} \\ 1 & if\ height(x) > 7\ \text{ft} \end{cases}$$

$$\mu_{old}(x) = \begin{cases} 0 & if\ age(x) < 18 \\ \frac{age(x) - 18}{42} & if\ 18 \le age(x) \le 60 \\ 1 & if\ age(x) > 60 \end{cases}$$

Tabulate the membership degree for the following expressions

a = x is tall and x is old

b = x is tall or x is old

c = not (x is tall)

using the the values of (height, age) given below

i. (3'2", 65 years) ii. (5'5", 30 years) iii. (5'9", 27 years) iv. (5'10", 32 years) and v. (6'1", 31 years) **[5M]**

PTO

2. **a)** The speed of the motor in degrees per second and the voltage in volts are described using the following fuzzy sets.

$$S_2 = \left\{\frac{0.33}{0} + \frac{0.67}{1} + \frac{1}{2} + \frac{0.67}{3}\right\} \text{ (i.e. Speed about 2)}$$

$$V_o = \left\{\frac{1}{0} + \frac{0.75}{1} + \frac{0.50}{2} + \frac{0.25}{3} + \frac{0}{4} + \frac{0}{5}\right\} \text{ (i.e. Voltage about 0)}$$

i) Find the Cartesian Product relation R between S_2 and V_0. **[2M]**

Creating another fuzzy set on Universe V for "Voltage about 3" might give

$$V_3 = \left\{\frac{0}{0} + \frac{0.25}{1} + \frac{0.50}{2} + \frac{1}{3} + \frac{0.50}{4} + \frac{0}{5}\right\}$$

ii) Use max min composition to find R ∘ V_3 **[2M]**

iii) Use max product composition to find R ∘ V_3 **[2M]**

b) What are the advantages and disadvantages of Fuzzy Logic and Neural Network techniques (write only key points in your answer) **[8M]**

3. Two membership functions A and B are shown below (Figures 1 & 2). Find the defuzzified output for the logical union of the 2 membership functions.(**use graph sheet)**

i) Centroid Method (using integration) and

ii) Weighted Average Method **[5M+3M]**

A

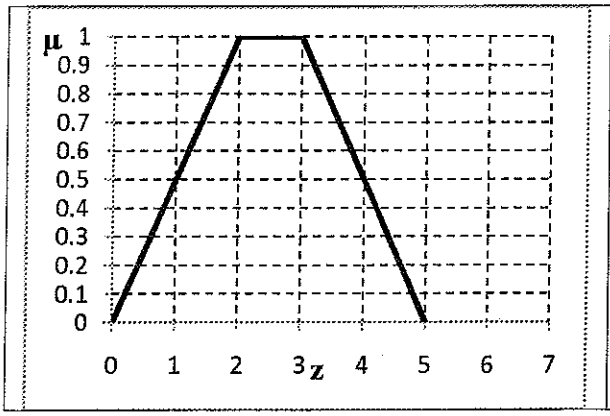

Figure 1

B

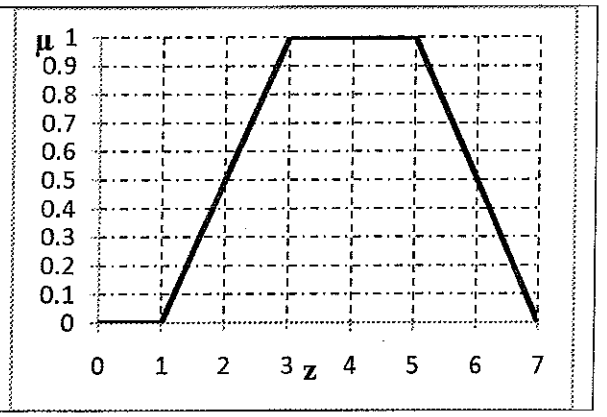

Figure 2

4. **a)** What are the advantages of using a fuzzy logic based anesthetic depth controller over conventional techniques? (write only key points in your answer). **[3M]**

b) A Mamdani type fuzzy logic based microwave oven has 2 input variable Quantity of Food (QF) and Type of Food (TF) and one output variable Cooking Time (CT). It selects appropriate Cooking Time based on Quantity of Food and Type of Food. The variable Quantity of Food (QF in grams) is partitioned into 3 fuzzy sets as Small, Medium and Large having triangular membership function:

$\mu_{Small} = (QF; 0, 25, 100)$, $\mu_{Medium} = (QF; 25, 175, 350)$, $\mu_{Large} = (QF; 250, 400, 500)$

The variable Type of Food (TF no units) is partitioned into 3 fuzzy sets as Soft, Medium and Hard have triangular membership function:

$\mu_{Soft} = (TF; 0, 25, 55)$, $\mu_{Medium} = (TF; 25, 50, 75)$, $\mu_{Hard} = (QF; 60, 110, 125)$

The output Cooking Time (in mins) is characterized by 3 fuzzy sets as Low, Medium and High having triangular membership functions as described below.

$\mu_{Low} = (CT; 0, 5, 15)$, $\mu_{Medium} = (CT; 10, 15, 20)$, $\mu_{High} = (CT; 15, 25, 30)$

The fuzzy rule base is as follows.
R1: IF QF is Small AND TF is Soft THEN CT is Low
R2: IF QF is Small AND TF is Medium THEN CT is Medium
R3: IF QF is Small AND TF is Hard THEN CT is Medium
R4: IF QF is Medium AND TF is Soft THEN CT is Medium
R5: IF QF is Medium AND TF is Medium THEN CT is Medium
R6: IF QF is Medium AND TF is Hard THEN CT is High
R4: IF QF is Large AND TF is Soft THEN CT is Medium
R7: IF QF is Large AND TF is Medium THEN CT is High
R9: IF QF is Large AND TF is Hard THEN CT is High

Given that the input variable have values QF = 55g & TF = 65, draw the aggregated fuzzy output CT recommended by the rules **(use graph paper)**.
(Note: No deffuzification is required) **[5M]**

PART – B

1. Why neural networks are preferred for modeling over conventional identification technique? Explain the steps involved in modeling of neural networks. **[4M]**

2. **(a)** Develop a Perceptron network to implement the following OR function shown in Table 1.

Table 1: Truth Table for OR function

Inputs		Target
X_1	X_2	
1	1	1
-1	1	1
1	-1	1
-1	-1	-1

Assume $\alpha = 1$ and test the response of the net. Also draw a decision boundary for the above OR function. **[3M]**.

(b) Develop a perceptron network for the above truth table without bias up to 2 epochs and test the response of the net. Comment on your results. **[3M]**

(c) List any two applications of perceptron neural network **[2M]**

P T O

3. What are the difficulties encountered while training a back propagation neural network? When is the training of a network stopped? **[4M]**

4. For the given kohonen self organizing map with weights as shown in Figure 3

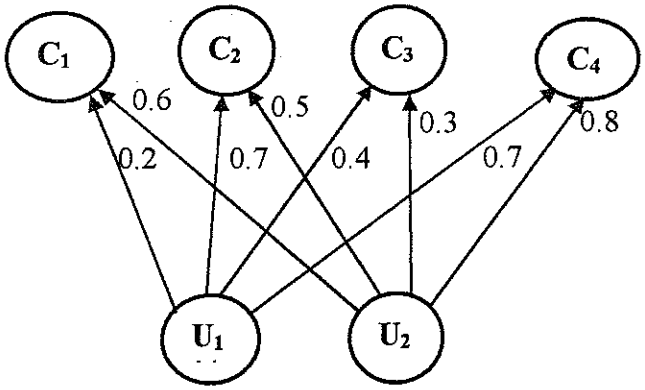

Figure 3

(i) Use the square of the Euclidean distance, find the cluster unit that is closer to the input vector.(0.4 0.4)

(ii) Using a learning rate $\alpha = 0.3$, find the new weights for the winning cluster unit.

(iii) If units before and after the winning cluster unit are also allowed to learn the input pattern, find their new weights. **[5M]**

5. Consider network architecture of back propagation as 3-2-1. For the inputs $x_1 = 0.9$, $x_2 = 0.9$ and $x_3 = 0.9$, the desired output is 0.75. Assume all the bias weights connected to the hidden units and output unit as 0.2. The weight matrix from input to hidden layer and hidden to output layer are

$$\begin{bmatrix} \mathbf{0.1} & \mathbf{0.3} \\ \mathbf{0.3} & \mathbf{0.1} \\ \mathbf{0.1} & \mathbf{0.5} \end{bmatrix} \text{ and } \begin{bmatrix} \mathbf{-0.3} \\ \mathbf{0.5} \end{bmatrix} \text{ respectively}$$

Use activation function as binary sigmoidal with learning rate of $\alpha = 1$ and steepness parameter $\sigma = 1$. Draw the labeled network for the details given above and find the new weights for 1 epoch. Limit your calculations up to four decimal places. **[15M]**

6. Consider a Bidirectional Associative Memory network (with bipolar input vectors) to map two letters (given by 5 x 3 patterns) to the following bipolar target codes as shown in following Figures 4 and 5

*	*	*
*		
*	*	*
*		
*	*	*

Figure 4

	*	*
*		
*		
*		
	*	*

Figure 5

(a) Letter E → target code (-1, 1)

(b) Letter C → target code (1, 1)

a) Find the total weight matrix with input patterns E and C. **[2M]**

b) Obtain the response of the net with E and C as the inputs **[2M]**

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BITS Pilani, Dubai Campus
Dubai International Academic City, Dubai

IV Year (CHEM/MECH/EEE/CS/EIE/ECE)
First Semester, 2011-2012

Test 2 (Open Book)

Course No: EA C482 | **Course Title: Fuzzy Logic and Applications**
Date: 11th Dec 2011 | **Weightage: 20%**
Duration: 50 minutes | **Max. Marks. 40**

(This question paper has 2 pages and 2 questions. Use Graph Sheet for Q1)

1. A Mamdani type fuzzy logic controller (FLC) is used for controlling a plant, as shown in Figure 1. The inputs to the FLC are **Error (E)** and **Change in Error (CE)**, and the output is **Change in Controller Output (CU)**. All the three variables are partitioned into three fuzzy sets Negative (N), Zero (Z) and Positive (P), with membership functions as described below.

A. For input variable **Error (E)**,

1) Negative (N): Membership degree varies linearly from 1 to 0 as the value of Error (E) changes from -1 to 0.

2) Zero (Z): Membership degree varies linearly from 0 to 1, and 1 to 0 as the value of Error (E) changes from -1 to 0 and 0 to 1, respectively.

3) Positive (P): Membership degree varies linearly from 0 to 1, as the value of Error (E) changes from 0 to 1.

B. For input variable **Change in Error (CE)**.

1) Negative (N): Membership degree varies linearly from 1 to 0 as the value of Change in Error (CE) changes from -0.5 to 0.

2) Zero (Z): Membership degree varies linearly from 0 to 1, and 1 to 0 as the value of Change in Error (E) changes from -0.5 to 0 and 0 to 0.5, respectively.

3) Positive (P): Membership degree varies linearly from 0 to 1, as the value of Change in Error (E) changes from 0 to 0.5.

C. For output variable **Change in Controller Output (CU)**,

1) Negative (N): Membership degree varies linearly from 1 to 0 as the value of CU changes from -5 to 0.

2) Zero (Z): Membership degree varies linearly from 0 to 1, and 1 to 0 as the value of CU changes from -5 to 0 and 0 to 5, respectively.

3) Positive (P): Membership degree varies linearly from 0 to 1, as the value of CU changes from 0 to 5.

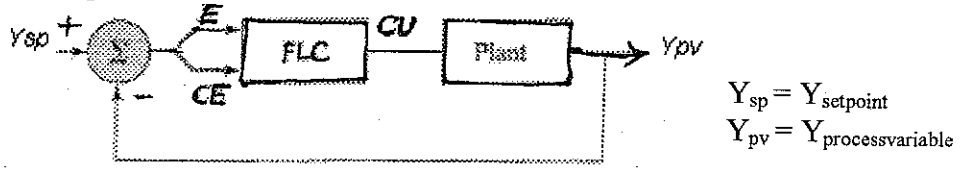

Figure 1: Schematic of an FLC

P.T.O

The fuzzy rule base is as follows

CE \ E	N	Z	P
P	Z	P	P
Z	N	Z	P
N	N	N	Z

a) Draw the membership functions for the Error, Change in Error and Change in Controller Output.

b) Obtain the induced decision table for Error = 0.5, Change in Error = 0.25 and find the defuzzified output, using centroid method (integration) **[20M]**

2. Figure 2 shows a backpropagation neural network presented with the input pattern ($x_1 = 0$, $x_2 = 1$) and target output is 1. Find the new weights using backpropagation neural network learning algorithm. Use a learning rate of $\alpha = 0.25$, steepness parameter $\sigma = 1$. Use binary sigmoidal activation function. Limit your calculation upto four decimal places. **[20M]**

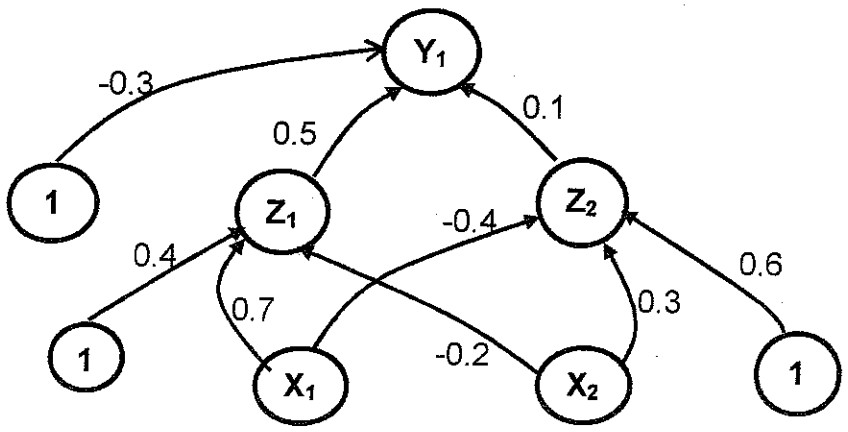

Figure 2

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BITS Pilani, Dubai Campus
Dubai International Academic City, Dubai

IV Year (CHEM/EEE/MECH/CS/EIE/ECE)
First Semester, 2011-2012

Test 1 (Closed Book)

Course No: EA C482 | **Course Title: Fuzzy Logic and Applications**
Date: 16th Oct 2011 | **Weightage: 25%**
Duration: 50 minutes | **Max. Marks. 50**

(This question paper has 2 pages and 4 questions. Answer all questions)
(Use graph sheet for Question 2(b))

1. Consider two Universe of Discourses X, Y where X = { 2,3,4,5,6,7,8,9} and Y = {1, 2, 3, 4, 5, 6}. Medium and Small are fuzzy subsets of X and Y, characterized by the following membership functions.

$$\mu_{Meduim} = \left\{\frac{0.1}{2} + \frac{0.3}{3} + \frac{0.7}{4} + \frac{1}{5} + \frac{1}{6} + \frac{0.7}{7} + \frac{0.5}{8} + \frac{0.2}{9}\right\}$$

$$\mu_{Small} = \left\{\frac{1}{1} + \frac{1}{2} + \frac{0.9}{3} + \frac{0.6}{4} + \frac{0.3}{5} + \frac{0.1}{6}\right\}$$

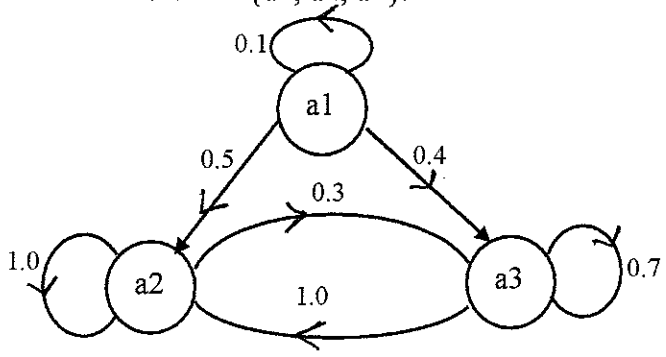
i. Find the Cartesian product R = Medium X Small. **(4M)**

ii. When another fuzzy set Large (subset of X) is introduced,

$$\mu_{Large} = \left\{\frac{0}{2} + \frac{0}{3} + \frac{0}{4} + \frac{0.1}{5} + \frac{0.3}{6} + \frac{0.6}{7} + \frac{0.9}{8} + \frac{1}{9}\right\}$$

Find the S = Large ∘ R using the max-min & max-product composition. **(8M)**

2. a) For the network shown in the following Figure, write the expression for fuzzy relation R on A x A where A = {a1, a2, a3}. **(4M)**



b) Let U = { 0,1,2,3,….,100} represent the age of human beings. Sketch the trapezoidal membership functions for the following concepts.

i. Young = (x; 0, 0, 25, 40)
ii. Old = (x; 50,60,100,100)
iii. Also sketch the membership function for concept "Middle Aged" which is defined to be neither young nor old. **(8M)**

P.T.O

3. **a)** What is the motivation for using fuzzy logic in control engineering? (write only the key points in your answer) (4M)

b) Consider the problem of controlling the *Heater Power* of a boiler based on *Pressure* and *Temperature* within the boiler. The *Temperature* and *Pressure* has two linguistic values ***Low*** and ***high***. *Heater Power* has three linguistic value**s** ***Low***, ***Medium*** and ***High.*** Obtain fuzzy rule based system for the above problem such that it will be logically correct. **(4M)**

c) Write the expressions for multiple conjunctive antecedents and multiple disjunctive antecedents. **(4M)**

4. a) Given four jobs (Jobs 1, 2, 3, and 4), the salary amount is represented by a fuzzy set $Salary = \{(1, 0.875), (2, 0.7), (3, 0.5), (4, 0.2)\}$

The constraints "Job Interest" (how interesting job is) , and "Drive" (closeness to home) which are fuzzy subsets of Jobs, are defined by

$Job\ Interest = \{(1, 0.4), (2, 0.6), (3, 0.8), (4, 0.6)\}$,

$Drive = \{(1, 0.1), (2, 0.9), (3, 0.7), (4, 1)\}$

i. Choose the job that will give us the highest salary, given the constraints that the job should be interesting and close to our home.

ii. Clearly comment on your results. **(5M)**

b) For purposes of road navigation, the curvature of the turning is being modeled. The universe of discourse is the type of curvature U = {0,1,2,…,9}, The fuzzy sets "somewhat straight" and "Curved" are defined by the following membership functions.

$$\text{"Somewhat straight"} = \left\{\frac{1}{0} + \frac{0.9}{1} + \frac{0.8}{2} + \frac{0.7}{3} + \frac{0.6}{4} + \frac{0.5}{5} + \frac{0.4}{6} + \frac{0.3}{7} + \frac{0.2}{8} + \frac{0.1}{9}\right\}$$

$$\text{"Curved"} = \left\{\frac{0}{0} + \frac{0.1}{1} + \frac{0.2}{2} + \frac{0.3}{3} + \frac{0.4}{4} + \frac{0.5}{5} + \frac{0.6}{6} + \frac{0.7}{7} + \frac{0.8}{8} + \frac{0.9}{9}\right\}$$

Find the membership functions for the following phrases.

i) Fairly curved (=[curved]$^{2/3}$),

ii) very very somewhat straight.

iii) Not fairly curved and very very somewhat straight. **(5M)**

c) The hotness of ambient temperature with a membership function is given by

$$\mu_{hot}(x) = \begin{cases} 0 \text{ if } (x \le 20^{\circ}C) \\ \dfrac{x-20}{80} \text{ if } (20^{\circ}\text{ C} \le x \le 100^{\circ}\text{ C}) \\ 1 \text{ if } (x \ge 100^{\circ}C) \end{cases}$$

Show the above membership function for hotness as well as coldness. Tabulate the membership grades of hotness and coldness for 20°C to 100°C, at intervals of 10°C. The membership grade of coldness is taken as complement of the membership grade of hotness. **(4M)**

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BITS PILANI, DUBAI CAMPUS
FIRST SEMESTER 2011 – 2012
FOURTH YEAR (CHEM/EEE/MECH/CS/ECE/EIE)
QUIZ 2 (CLOSED BOOK)

A

Course Code: EA C482 | Date: 28.11.11
Course Title: Fuzzy Logic and Applications | Max Marks: 14
Duration: 20 minutes | Weightage: 7%

Name: . . . . . **ID No:** . . . . . **Sec / Prog:** . . .

Instructions: Write your answers in the blank space provided after each question. You may use the reverse side if necessary.

1. Draw the structure of Artificial Neural Network Model **[1M]**

2. A single neuron has inputs $x_1 = 0.15$, $x_2 = 0.23$, $x_3 = 0.38$ and $x_4 = 0.48$. The corresponding weight values are 0.1, 0.2, 0.3 and 0.4. Calculate the output of the neuron for each of the following activation functions.
   a) Binary sigmoid activation function. (steepness parameter = 0.5)
   b) Bipolar sigmoid activation function (steepness parameter = 1.0)
   Assume the bias = 0 **[2M]**

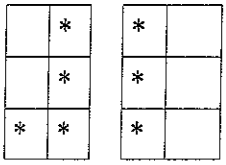
3. What is the need for selecting appropriate number of hidden layers in a Backpropagation Neural Network? (write only key points) **[2M]**

4. Given a set of 50 data points where i=1, 2... 50, how many data points will be selected for training and testing data sets. Clearly mention the data points. **[2M]**

5. Define Memorization and Generalization in Neural Networks. **[2M]**

6. Define weights in Neural Networks. **[2M]**

7. A BAM network (with bipolar input vectors and bipolar target codes) is used to recognize two characters 'J' and 'I' represented using a 3x2 grid. Find the total weight matrix stored in the network for the above input patterns. **[2M]**



(a) Character J → target code (-1, 1)

(b) Character I → target code (1, 1)

8. Write the expression for identity and binary step activation functions used in neural network. **[1M]**

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BITS PILANI, DUBAI CAMPUS
FIRST SEMESTER 2011 – 2012
FOURTH YEAR (CHEM/EEE/MECH/CS/EIE/ECE)
QUIZ 1

No of questions = 10
No of Pages = 2
Version B

Course Code: EA C482
Course Title: Fuzzy Logic and Applications
Duration: 20 minutes

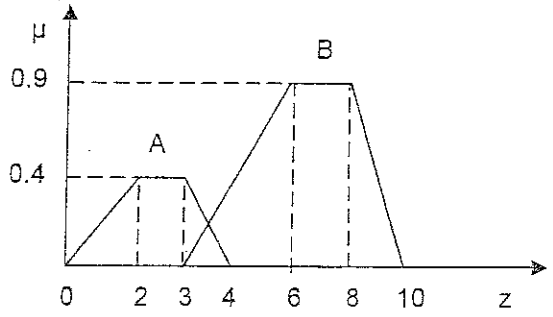
Date: 31.10.11
Max Marks: 16
Weightage: 8%

Name: ..... **ID No:** ..... **Sec / Prog:** .....

Instructions: Write your answers in the blank space provided after each question. You may use the reverse side if necessary.

1. Give the format of the rule base for PI like FLC and PD like FLC **[2M]**

2. Find the crisp output for the following membership function, using "Weighted average" method. **[3M]**



3. The membership grade of fuzzy relation R "y is much greater than x" is defined as:

$$\mu_R(x,y) = \begin{cases} \dfrac{y-x}{x+y+2} & if\,(y>x) \\ 0 & if\,(y \le x) \end{cases}$$

If x={1,2,3}, and y={1,2,3}, express the fuzzy relation R as matrix **[2M]**

4. Which of the following is not true regarding the principles of fuzzy logic? [1M]
   a. Boolean logic is a subset of fuzzy logic.
   b. Japan is currently the most active users of fuzzy logic
   c. Fuzzy logic follows the principle of Aristotle and Buddha
   d. Fuzzy logic is a concept of `certain degree'

Ans : ☐

5. Distinguish between discrete fuzzy set and continuous fuzzy set,by membership diagram (assume any 5 arbitary values for Universe of discourse) [1M]

6. Considering a graphical representation of the 'tallness' of people using its appropriate member function, which of the following combinations are true? [1M]
   i. TALL is usually the fuzzy subset.
   ii. HEIGHT is usually the fuzzy set.
   iii. PEOPLE is usually the universe of discourse.
   a. i & ii only
   b. i, iii only
   c. ii & iii
   d. i, ii & iii

   Ans : [ ]

7. What is the advantage of using sugeno type of fuzzy logic controller? (write only the key points) [2M]

8. Given fuzzy set Cold = $\left\{\frac{0.1}{1}+\frac{0.6}{2}+\frac{1}{3}+\frac{0.7}{4}+\frac{0.2}{5}\right\}$ on Universe of Discourse U ={1,2,3,4,5}, find the fuzzy set for "Minus Cold" [1M]

9. Define Core of a fuzzy Set A [1M]

10. Given 2 fuzzy sets A=$\left\{\frac{0}{a}+\frac{1}{b}+\frac{0.5}{c}+\frac{0.9}{d}\right\}$ and B=$\left\{\frac{0.2}{a}+\frac{0.3}{b}+\frac{0.05}{c}+\frac{0.09}{d}\right\}$ on the Universe of Discourse U = {a,b,c,d}, find i) A - B and ii) 0.5 B [2M]