

BITS Pilani, Dubai Campus
Dubai International Academic City, Dubai

III YEAR(CS)/IV Year (ALL)
 First Semester 2013-2014

No of Questions:10 No of Pages: 4

Comprehensive Examination (CLOSED BOOK)

Course No: BITS F343/EA C482 Course Title: Fuzzy Logic and Applications
 Date: 07th Jan 2014 Weightage: 40%
 Duration: 3 Hours Max. Marks. 80

Note: Answer all questions. Use Graph Sheet for Q3.
Assume suitable data if required

- 1) a) Define the power of a Fuzzy set A. [2M]
 b) Two fuzzy sets A and B are given as follows :

$$A = \left\{ \frac{0.2}{a} + \frac{0.3}{b} + \frac{0.5}{c} + \frac{0.9}{d} + \frac{0.4}{e} \right\}, B = \left\{ \frac{0.1}{1} + \frac{1.0}{2} + \frac{0.6}{3} + \frac{0.4}{4} + \frac{0.6}{5} \right\}$$

- i) Find the Cartesian product relation R between A and B. [2M]

Another fuzzy set representing masonry strength of the clay bricks is given by

$$C = \left\{ \frac{1.0}{a} + \frac{0.3}{b} + \frac{0.2}{c} + \frac{0.8}{d} + \frac{0.9}{e} \right\}$$

- ii) Use max min composition to find $D = C \circ R$ [3M]

- iii) Use max product composition to find $D = C \circ R$ [3M]

2. Two membership functions (A and B) are shown below (Fig.1&Fig.2). Find the defuzzified output for two membership functions using

- i) Weighted Average Method ii) Centre of Sums Method [5M]

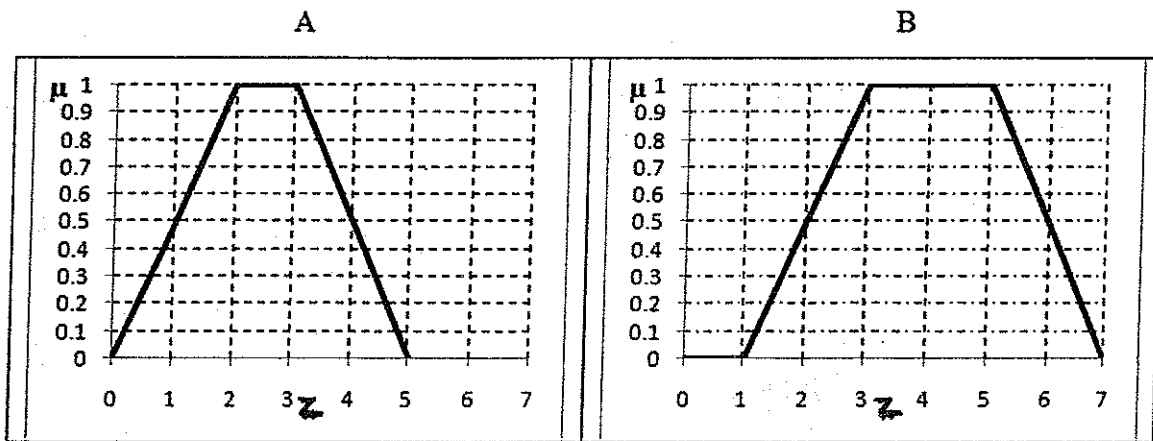


Fig.1

Fig.2

(Note: graph sheet is not required)

3) In finding the Nuselt number Nu (a dimensionless number for determining heat transfer) for an hexagonal cylinder in cross flow, the input variables are Re(Reynolds number) and Pr(Prandtl number). Both Re and Pr are considered to be fuzzy due to uncertainty in the variables. Calculation of Nu is very involved and incorporation of a rule-base can be used to bypass these calculations and the following rules are used to govern this process.

- (i) IF Re is high AND Pr is low THEN Nu is low
- (ii) IF Re is low AND Pr is low THEN Nu is low
- (iii) IF Re is high AND Pr is high THEN Nu is medium
- (iv) IF Re is low AND Pr is high THEN Nu is medium

The input fuzzy variables are described by the following membership functions as shown in Fig.3 and Fig.4

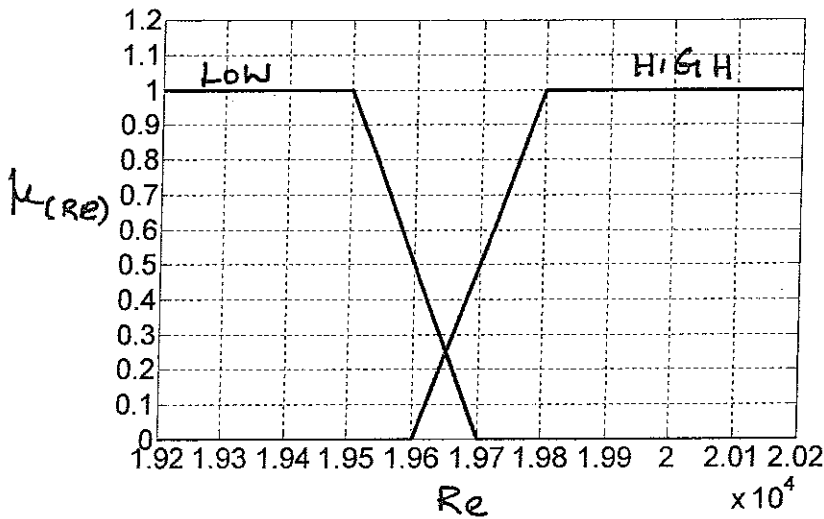


Fig.3

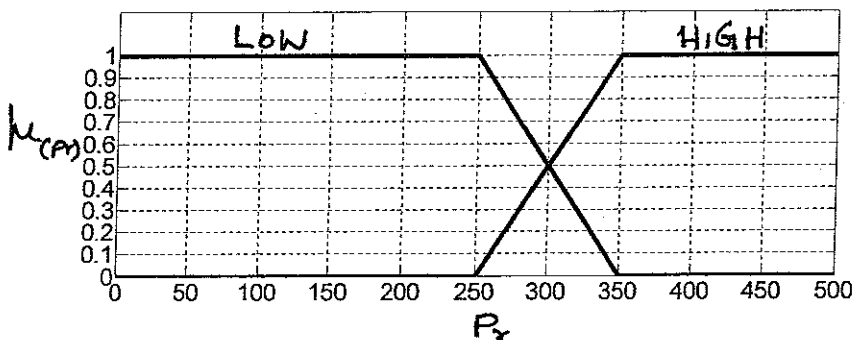


Fig.4

The output variable Nu is described by triangular membership functions as given by $\mu_{low} = (Nu; 375 \ 475 \ 575)$ and $\mu_{medium} = (Nu; 525 \ 625 \ 725)$ (use graph paper for the range as 350 to 750 in steps of 25). For this problem, conduct a mamdani graphical inference and obtain the induced decision table for the following input values of $Re = 19.60 \times 10^3$ and $Pr = 300$. Also find the defuzzified value of Nu using Centroid (integration method) [10M]

- 4 a) A Kohonen self organizing map is shown in Fig.5 along with the weights.
- Using the square of the Euclidean distance, find the cluster unit C_j that is closest to the input vector $(0.3, 0.4)$.
 - Using a learning rate of 0.3, find the new weights for unit C_j .
 - Find new weights for C_{j+1} , if they are allowed to learn.

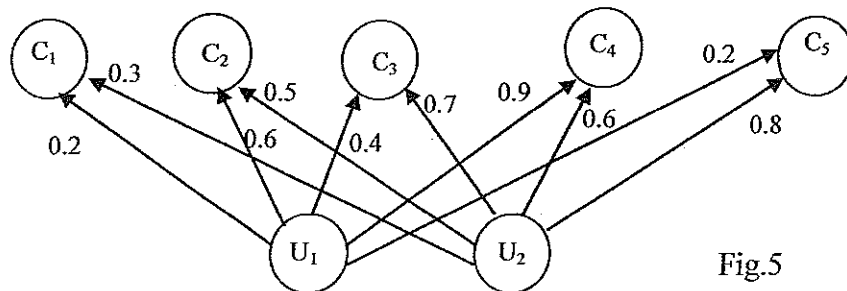


Fig.5

[7M]

- b) Explain activation functions of binary step function, binary sigmoid and bipolar sigmoid as per the following formats:

- Name of the activation function
- Graphical representation and
- Mathematical Equations

[3M]

5. Develop a Perceptron network to implement the OR function with inputs (X_1 & X_2), bias (X_0) and Target (t) as shown below:

X_0	X_1	X_2	t
1	1	1	1
1	-1	1	1
1	1	-1	1
1	-1	-1	-1

Consider 2 epochs and test the response of the net. Assume $\alpha = 1$ and threshold function as 0. Also draw a decision boundary for the above OR function. Assume initial bias and weights as 0. [5M]

6. Consider network architecture of back propagation as 3-2-1. All Bias weights connected to hidden and output nodes are 0.2. For inputs $X_1 = 0.9$, $X_2 = 0.9$ and $X_3 = 0.9$, the desired output is 0.75. The weight matrix from input to hidden layer and hidden to output layer are

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

Use Activation function as binary sigmoidal with learning rate of $\alpha = 1$ and steepness parameter as 1. Draw the labeled network for the specifications given above and do the calculations up to feed forward stage and back propagation of error. [12M]

7. (a) What is the reason that logic function has rapidly become one of the most successful technologies for developing sophisticated control systems? Write only key points in your answer. [4M]

(b) Compare fuzzy systems and neural networks with respect to the following aspects:

(i) Knowledge representation (ii) Linguistic interface and (iii) Robustness

Write only key points in your answer.

[6M]

8. A Bidirectional Associative Memory network (with bipolar input vectors and bipolar target codes) is used to recognize two letters A and C represented using a 5x3 grid as shown in Fig.(a) and Fig.(b).

Fig.(a)

	*	
*		*
*	*	*
*		*
*		*

Fig.(b)

	*	*
*		
*		
*		
	*	*

(a) Letter A → target code (-1, 1)

(b) Letter C → target code (1, 1)

a) Find the total weight matrix with inputs A and C [4M]

b) Obtain the response of the net with A and C as the input. [6M]

9. For the Fuzzy set representation of

$$\text{Low Temperature} = \left\{ \frac{1}{131} + \frac{0.8}{132} + \frac{0.6}{133} + \frac{0.4}{134} + \frac{0.2}{135} + \frac{0}{136} \right\} \text{ and}$$

$$\text{High Pressure} = \left\{ \frac{0}{400} + \frac{0.2}{600} + \frac{0.4}{700} + \frac{0.6}{800} + \frac{0.8}{900} + \frac{1}{1000} \right\}$$

Find i) **Not very** low Temperature and **very** Low Temperature

ii) **Intensely** High Pressure.

iii) **Slightly** High Pressure [4M]

10. Consider a class with 13 students of different CGPA (given by notation m) in the range from 5 to 6.2. Intuition is used to fuzzily this scalar quantity into the fuzzy or linguistic variables as **LOW (L)**, **MEDIUM (M)**, **HIGH (H)** for CGPA. The membership function associated with each scalar quantity as defined by intuition is

$$\mu_L = \begin{cases} 1 & \text{if } m \leq 5.2 \\ \frac{5.4 - m}{0.2} & \text{if } 5.2 < m < 5.4 \\ 0 & \text{if } m \geq 5.4 \end{cases} \quad \mu_H = \begin{cases} 0 & \text{if } m \leq 5.6 \\ \frac{m - 5.6}{0.2} & \text{if } 5.6 < m < 5.8 \\ 1 & \text{if } m \geq 5.8 \end{cases}$$

$$\mu_M = \begin{cases} 0 & \text{if } m \leq 5.3 \text{ or } m \geq 5.7 \\ \frac{m - 5.3}{0.2} & \text{if } 5.3 < m < 5.5 \\ \frac{5.7 - m}{0.2} & \text{if } 5.5 \leq m \leq 5.7 \end{cases}$$

Tabulate the values of membership grades for LOW, MEDIUM, HIGH & Sketch the membership function (continuous) for LOW, MEDIUM, HIGH

Take ranges of CGPA from 5 to 6.2 in steps of 0.1. [4M]

BITS Pilani, Dubai Campus
III Year CS/IV YEAR (CHEM/MECH/EEE/CS/EIE/ECE)
First Semester, 2013-2014
Test 2 (Open Book)

Course No: EA C482 /BITS F343
 Date: 8th Dec 2013
 Weightage: 20%

Course Title: Fuzzy Logic and Applications
 Max. Marks. 40
 Duration: 50 minutes

ANSWER ALL QUESTIONS

(This question paper has 2 pages and 3 questions. Use Graph Sheet for Q1)

1. A Mamdani type fuzzy logic based controller has two input variables 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 as follows:

- 1) Small (S): Membership degree varies linearly from 0 to 1 as the value of Quantity of food(QF) changes from 0 to 25 and membership grade decreases from 1 to 0 as the value of QF changes from 25 to 100.
- 2) Medium(M): Membership degree varies linearly from 0 to 1 as the value of Quantity of food(QF) changes from 25 to 175 and membership grade decreases from 1 to 0 as the value of QF changes from 175 to 350.
- 3) Large(L): Membership degree varies linearly from 0 to 1 as the value of Quantity of food(QF) changes from 250 to 400 and membership grade decreases from 1 to 0 as the value of QF changes from 400 to 500.

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

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

The output **Cooking time** (in mins) is characterized by 3 fuzzy sets as Low, Medium and High having triangular membership function as described below:

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

The fuzzy rules are 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
- R7 : IF QF is Large AND TF is Soft THEN CT is Medium
- R8 : 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

[6M]

[1M]

- (i) Obtain the induced decision table for QF =50g & TF =70 . [4M]
- (ii) Draw the aggregated fuzzy output recommended by the rules which are fired. [5M]
- (iii) Find the defuzzified output value of the Cooking Time. Use Centroid method for defuzzification (Use Graph Paper). [4M] [20M]

2. Consider network architecture of backpropagation as **2-2-1**(number of nodes in the input layer is 2, number of nodes in the hidden layer is 2 and the number of node in the output layer is 1), bias weights connected to hidden node 1 as **1** and hidden node 2 as **-0.1** and bias weight connected to output node as **-0.6**. For inputs of $x_1 = 1$, $x_2 = 0$, the desired target is **one**. The weight matrix from input to hidden layer and hidden to output layer are

$$\begin{bmatrix} -1.0 & 4.5 \\ 7.2 & 9.8 \end{bmatrix} \text{ and } \begin{bmatrix} -3.5 \\ 5.2 \end{bmatrix} \text{ respectively.}$$

Use appropriate activation function for the inputs given above with a learning rate of $\alpha = 0.75$ and steepness parameter (σ) as **0.5**. Also draw the labeled network for the specifications given above and find the new weights. Limit your calculations to four decimal places.

[16M]

3. What type of neural network can be used for pattern classification? Draw the decision boundaries for the following patterns shown in Table 1. Comment on your results.

[4M]

Table 1

XOR		
x_1	x_2	out
0	0	0
0	1	1
1	0	1
1	1	0



BITS Pilani, Dubai Campus
Dubai International Academic City, Dubai
IV Year (CHEM/EEE/MECH/CS/EIE/ECE) / III YEAR
First Semester, 2013-2014
Test 1 (Closed Book)

Course No: EA C482/BITS F343
Date: 10.10.2013
Duration: 50 minutes

Course Title: Fuzzy Logic and Applications
Weightage: 25%
Max. Marks. 50

This question paper has 2 pages and 5 questions. Answer all the questions. Graph sheet is attached along with question paper. Use graph sheet for Qn 3(b)

1. (a) Given four jobs(jobs 1,2,3 &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 Job 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 the highest salary, given the constraints that the job should be interesting and close to your home. [6M]
(ii) Clearly comment on your results.

- (b) A process control system involves monitoring of two linguistic parameters low and high temperatures from 134°F to 138 °F . The parameters are characterized by linguistic terms as follows:

$$\text{Low Temperature} = \left\{ \frac{0}{134} + \frac{0.4}{135} + \frac{0.6}{136} + \frac{0.8}{137} + \frac{1.0}{138} \right\}$$

$$\text{High Temperature} = \left\{ \frac{0}{134} + \frac{0.2}{135} + \frac{0.6}{136} + \frac{0.8}{137} + \frac{1.0}{138} \right\}$$

- (i) Obtain the fuzzy sets for the following linguistic term:
Intensification of High Temperature
(ii) Verify the following statement:
Concentration of union of Low Temperature & High Temperature is equal to the union of the concentration of Low temperature & concentration of High temperature.
Limit your calculations to two decimal places. [4M+4M]

- 2 (a) Write an expressions for multiple conjunctive antecedents and Multiple disjunctive antecedents. [2M]
- (b) Differentiate between PI like FLC (Proportional Integral type fuzzy logic controller) and PD like FLC (Proportional Derivative type FLC). Write only key points in your answer. [3M]
- (c) Explain the procedure (in terms of flow chart) for tuning of FLC [5M]

3 (a) An air conditioner involves the delivery of air which can be warmed or cooled and have its humidity raised or lowered. An air conditioner is an apparatus for controlling especially lowering the temperature and humidity of an enclosed space. An air-conditioner typically has a fan which blows/cool/circulating fresh air and has a cooler and the cooler is under thermostatic control. Generally the amount of air being compressed is proportional to the ambient temperature. Consider an air conditioner which has five control switches: **COLD, COOL, PLEASANT, WARM and HOT**. The corresponding speeds of the motor controlling the fan on the air-conditioner has the graduations: **MINIMUM, SLOW, MEDIUM, FAST and BLAST**. How will you express fuzzy rules for the above problem. Also Form five fuzzy rules with above linguistic variables for air conditioner problem so that it is logically correct. [5M]

(b) Let $U = \{0,1,2,3,\dots,100\}$ represent the age of human beings. Sketch the membership functions for young = $(0,0,25,40)$; old = $(50,65,100,100)$. Also sketch the membership function of concept "Middle-aged" defined to be neither young nor old. (use graph sheet) [5M]

4. Consider the following fuzzy mapping rule from X to Y where $X = \{2,3,4,5,6,7,8,9\}$ and $Y = \{1, 2, 3, 4, 5, 6\}$. IF x is Medium THEN y is Small, where Medium and Small are fuzzy subsets of X and Y, characterized by the following membership functions:

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

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

(i) Find the Cartesian product $R = \text{Medium} \times \text{Small}$.

When another fuzzy set Large is given by

$$\mu_{Large} = \left\{ \frac{0}{2} + \frac{0}{3} + \frac{0}{4} + \frac{0.1}{5} + \frac{0.3}{6} + \frac{0.6}{7} + \frac{0.9}{8} + \frac{1.0}{9} \right\}$$

(ii) Find $S = \text{Large} \circ R$ using the max-min composition. [4M+4M]

5. Find the crisp output for the following membership functions (Fig. 1) using centre of sums method and weighted average method. [8M]

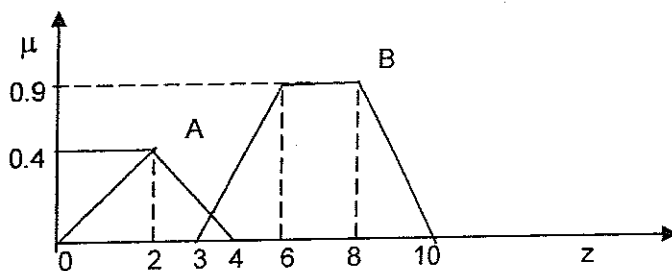


Fig. 1

BITS PILANI, DUBAI CAMPUS
FIRST SEMESTER 2013 – 2014
THIRD YEAR/FOURTH YEAR (CHEM/EEE/MECH/CS/EIE/ECE)
QUIZ 2 (CLOSED BOOK)

A

Course Code: EA C482/BITS F343
Course Title: Fuzzy Logic and Applications
Duration: 20 minutes

Date: 14.11.2013
Max Marks: 14
Weightage: 7%

Name: ID No: Sec / Prog:

Instructions: This question paper has 10 questions and 4 pages. Answer all questions

1. What is the significance of using momentum factor in a back propagation neural network? [1M]
2. How will you select the number of nodes in a hidden layer? Clearly explain with graphical representation. Write only key points in your answer. [2M]
3. Define Generalization in a neural network. [1M]

4. A 4-input neuron has inputs $x_1 = 0.15$, $x_2 = 0.23$, $x_3 = 0.38$ & $x_4 = 0.48$. 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 function:
Bipolar sigmoid activation function. (steepness parameter = 0.85)
Assume the bias = 0. [Note: Calculation steps are required] **[2M]**

5. Given a set of 200 data points where $i=1, 2, \dots, 200$, how many data points will be selected for training and testing data sets. Clearly mention the data points. **[1M]**

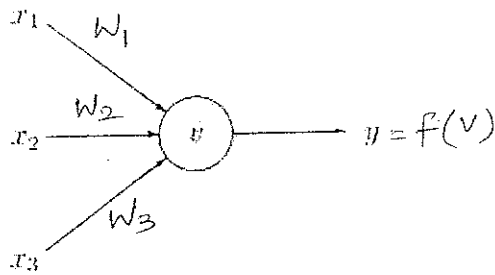
6. Suppose that a credit card company decided to deploy a new system for assessing credit worthiness of its customers. The new system is using a feed-forward neural network with a supervised learning algorithm. Suggest in a form of essay what should the bank have before the system can be used? Discuss in brief problems associated with this requirement. Write only key points in your answer **[2M]**

7. A 4 input neuron has weights 1, 2, 3 and 4. The transfer function is linear with the constant of proportionality being equal to 2. The inputs are 4, 8, 5 and 6 respectively. Assume that the bias is 0. Find the output.
[Note: Calculation steps are required in the final answer] [1M]

8. What are the different types of modeling in a neural network? [1M]

9. A strategy built on observation. Think of a little mouse running through a maze. If it turns left, it gets a piece of cheese; if it turns right, it receives a little shock. Presumably, the mouse will learn over time to turn left. Its neural network makes a decision with an outcome (turn left or right) and observes its environment (yum or ouch). If the observation is negative, the network can adjust its weights in order to make a different decision the next time. What type of learning is considered in the above example? [1M]

10. Below is a single neuron with three inputs



Suppose that the weights corresponding to the three inputs have the following values: $w_1=1, w_2=-2$ and $w_3 =1$. Calculate what will be the output value of the unit for each of the following input patterns. Assume activation function of binary step-function and threshold as 0 in your calculation.

[2M]

Pattern	P_1	P_2
x_1	1	0
x_2	0	1
x_3	0	1

(Note: Calculation steps are required)

4. Suppose that a credit card company decided to deploy a new system for assessing credit worthiness of its customers. The new system is using a feed-forward neural network with a supervised learning algorithm. Suggest in a form of essay what should the bank have before the system can be used? Discuss in brief problems associated with this requirement. Write only key points in your answer [2M]

5. What are the different types of modeling in a neural network? [1M]

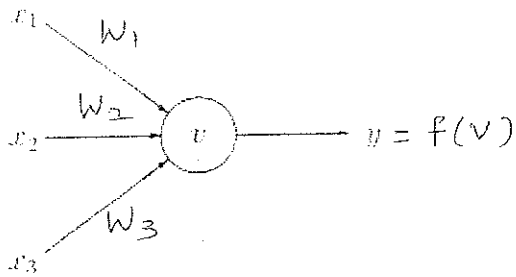
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7. A 4-input neuron has inputs $x_1 = 0.15$, $x_2 = 0.23$, $x_3 = 0.38$ & $x_4 = 0.48$. The corresponding weight values are 0.1, 0.2, 0.3 and 0.4. Calculate the output of the neuron for each of the following activation function:
Binary sigmoid activation function. (steepness parameter = 0.85)
Assume the bias = 0. [Note: Calculation steps are required] [2M]

8. Define memorization in a neural network. [1M]

9. What is the significance of using learning rate in a back propagation neural network? [1M]

10. Below is a single neuron with three inputs



Suppose that the weights corresponding to the three inputs have the following weight values: $w_1=2$, $w_2=-4$ and $w_3=1$. Calculate what will be the output value of the unit for each of the following input patterns. Assume activation function of binary step-function and threshold as 0 in your calculation.

[2M]

Pattern	P_1	P_2
x_1	1	0
x_2	0	1
x_3	0	1

(Note: Calculation steps are required)

BITS, PILANI – DUBAI
FIRST SEMESTER 2013 – 2014
FOURTH YEAR /THIRD YEAR
QUIZ 1 (CLOSED BOOK)

A

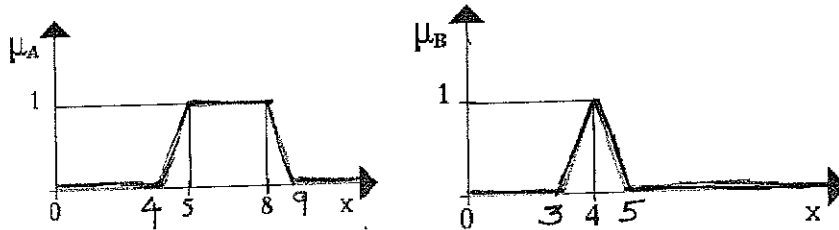
Course Code: EA C482/ BITS F343
 Course Title: Fuzzy Logic and Applications
 Duration: 20 minutes

Date:26.09.2013
 Max Marks: 16
 Weightage: 8%

Name: ID No: Sec/Prog:

Instructions: Write your answers in the blank space provided after each question. This question paper has 10 questions. Answer all questions

1. Given these fuzzy graphs for membership functions A and B.



Sketch the graphical representation of fuzzy set operation A OR B [1M]

2. The question of whether a glass of water is half-full or half empty is an age-old philosophical issue. Sketch the membership functions for the fuzzy set "full" and "empty", using percent volume as the element of information. Assume the maximum volume of water in the glass is V_0 . Write the equations for the fuzzy set "Full" and "Empty". [2M]

3. Is the core of a fuzzy set a crisp set? Justify. Write only key points in your answer. [1M]

4. Distinguish between discrete fuzzy set and continuous fuzzy set by membership diagram. Assume any 5 arbitrary values for universe of discourse. [2M]

5. Two fuzzy sets A, B are defined by the membership functions given below:

$$\mu_A(x) = x^2/(x^2+1), \mu_B(x) = 2^{-x}$$

Where $X = \{0,1,2,3\}$. Determine $(A \cap B)'$.

[2M]

6. Write a simple program using MATLAB to generate triangular membership function. [1M]

7. Define convex fuzzy set. Also draw a schematic of convex fuzzy set. [2M]

8. Can a fuzzy membership be true and false at the same time? Justify your answer. Write only key points in your answer. [2M]

9. Draw the membership function of the following with necessary expression: [2M]
(i) ~~Triangular~~ Sigmoidal

10. 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 "PLUS COLD". [1M]

BITS, PILANI – DUBAI
FIRST SEMESTER 2013 – 2014
FOURTH YEAR /THIRD YEAR
QUIZ 1 (CLOSED BOOK)

B

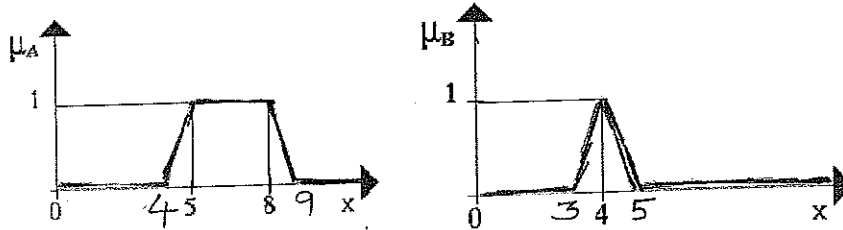
Course Code: EA C482/ BITS F343
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Sketch the graphical representation of fuzzy set operation A AND B [1M]

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3. Distinguish between discrete fuzzy set and continuous fuzzy set by membership diagram. Assume any 5 arbitrary values for universe of discourse. [4M]

4. Define convex fuzzy set. Also draw a schematic of convex fuzzy set. [2M]

5. Two fuzzy sets A, B are defined by the membership functions given below:
$$\mu_A(x) = x^2/(x^2+1), \mu_B(x) = 2^{-x}$$
Where $X = \{0,1,2,3\}$. Determine $(A \cup B)'$ [2M]

6. Can a fuzzy membership be true and false at the same time? Justify your answer. Write only key points in your answer. [2M]

7. Write a simple program using MATLAB to generate sigmoidal membership function [1M]

8. Draw the membership function of the following with necessary expression:
(i) Trapezoidal [2M]

9. Given fuzzy set $COLD = \{ 0.1/1 + 0.6/2 + 1/3 + 0.7/4 + 0.2/5 \}$ on universe of discourse $U = \{1, 2, 3, 4, 5\}$, find the fuzzy set for "MINUS COLD" [1M]

10. Is the core of a fuzzy set a crisp set? Justify your answer. Also write only key points in your answer. [1M]