BITS Pilani, Dubai Campus
Dubai International Academic City, Dubai

IV Year (CHEM/MECH/EEE/CS/EIE/ECE/BIO-TECH)

Second Semester, 2011-2012

No of Questions
PART A: 4
PART B: 6

Comprehensive Examination

Course No: EA C482
Date: 03.06.2012
Duration: 3 Hours

Course Title: Fuzzy Logic and Applications
Weightage: 40%
Max. Marks. 80

Note: This question Paper has 4 pages and 10 questions. Answer all questions.
Answer PART –A and PART –B in separate answer books.
Assume suitable data if required. Use Graph Sheet for Question (3).

PART-A

1. Three variables of interest in power transistors are the amount of current that can be switched, the voltage and the cost. The following membership functions for power transistors were developed from a hypothetical components catalog:

Average current (in amps) = I = $\{\frac{0.4}{0.8} + \frac{0.7}{0.9} + \frac{1}{1} + \frac{0.8}{1.1} + \frac{0.6}{1.2}\}$

Average voltage (in volts) = V = $\{\frac{0.2}{30} + \frac{0.6}{45} + \frac{1}{60} + \frac{0.9}{75} + \frac{0.7}{90}\}$

A fuzzy set for the cost C, in dollars, of a transistor is defined as:

C = $\{\frac{0.4}{0.5} + \frac{1}{0.6} + \frac{0.8}{0.7}\}$

1A) Find the fuzzy Cartesian product P= V×I
1B) Using a fuzzy Cartesian product, find T= I×C.
1C) Using max–min composition, find E= P∘T.
1D) Using max–product composition, find E= P∘T. **[2+2+3+3M]**

2. The fuzzy sets A, B, and C are all defined on the universe X = [0, 1, 2, 3, 4, 5] with the following membership functions:

$$\mu_A(x) = \frac{1}{1+5(x-5)^2}$$
$$\mu_B(x) = 2^{-x}$$
$$\mu_C(x) = \frac{2x}{x+5}$$

2A) Write the fuzzy sets A, B and C in Zadeh's standard notation (with the membership values rounded to two decimal places).
2B) Sketch the membership functions. (graph sheet not required)
2C) Verify whether the following statement is true. Justify your answer. Concentration of the union of A and B is the same as the union of the concentration of A and concentration of B **[3+2+5M]**

P.T.O

3. Two membership functions A and B are shown below in Figure1 and figure 2 respectively.

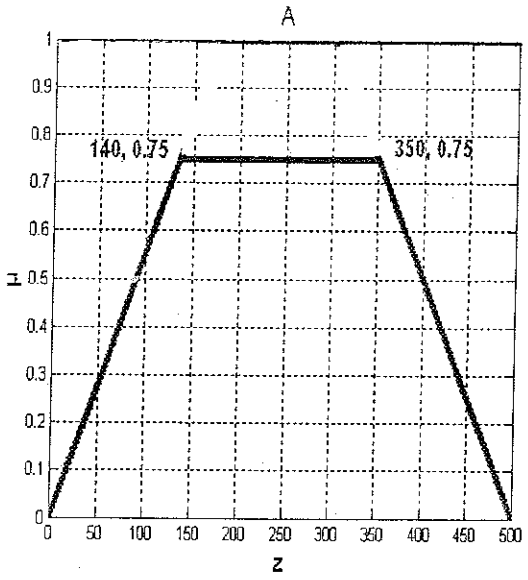

Figure 1

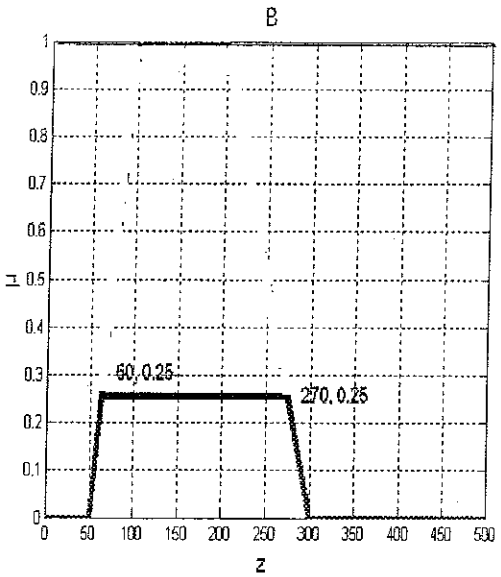

Figure 2

Find the defuzzified output for the logical union of these two membership functions by

3A) Centroid method (using Integration) and

3B) Weighted Average Method

(Use graph paper) **[8M+2M]**

4. A manufacturing company is planning to purchase a lathe and is assessing the proposals from four lathe manufacturers. The company has developed a reciprocal relation for the four manufacturers based on the speed of delivery of the lathes and the cost. The relation is

$$R = \begin{bmatrix} 0 & 0.1 & 0.7 & 0.2 \\ 0.9 & 0 & 0.6 & 1 \\ 0.3 & 0.4 & 0 & 0.5 \\ 0.8 & 0 & 0.5 & 0 \end{bmatrix}$$

Calculate the following:

4A) average fuzziness in R

4B) average certainty in R

4C) the distance to Type I and Type II consensus

4D) Illustrate question 4C graphically. **[3M+3M+3M+1M]**

(graph sheet not required)

PART – B

1. Explain activation functions of identity and bipolar sigmoid as per the following formats
   (i) Name of the activation function
   (ii) Graphical representation and
   (iii) Mathematical Equation **[2M]**

2. Develop a Perceptron network to implement the following AND function with binary inputs and bipolar target without bias for 2 epochs as shown in Table 1

Table 1

Inputs		Target
X_1	X_2	
1	1	1
1	0	-1
0	1	-1
0	0	-1

Assume α = 1 and threshold function as 0 and test the response of the net. Also Comment on your results. **[5M]**

3. 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. **[3M]**

4. Consider network architecture of back propagation as 3-3-1. For inputs x_1=**0.6**, x_2=**0.8** and x_3 =**0**, the desired output is **0.9**.Assume bias weights connected to hidden nodes 1,2 and 3 as 0,0 and -1. Consider bias weight connected to output node as -1. The weight matrix from input to hidden layer and hidden to output layer are

$$\begin{bmatrix} 2 & 1 & 0 \\ 1 & 2 & 2 \\ 0 & 3 & 1 \end{bmatrix} \text{ and } \begin{bmatrix} -1 \\ 1 \\ 2 \end{bmatrix} \text{ respectively.}$$

Use activation function as binary sigmoid with learning rate of α=**0.3** and steepness parameter as 1. Draw the labeled network for the specifications given above and find the new weights for one epoch. Limit your calculations up to four decimal places. **[17M]**

P.T.O

5. For the kohonen self organizing map with weights shown in Figure 3

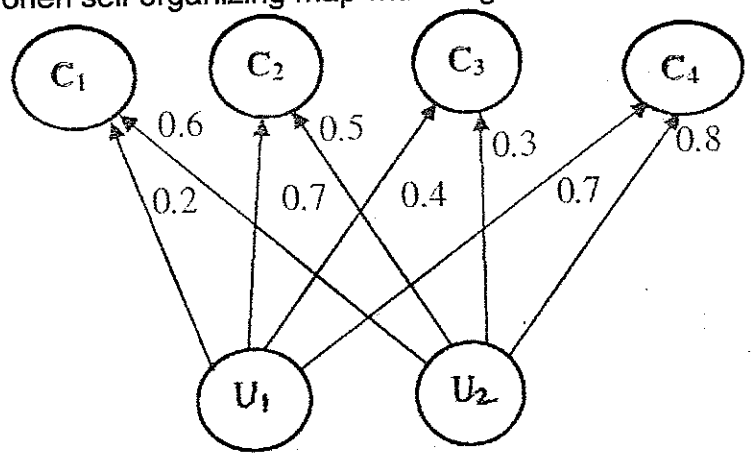

Figure 3

(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 learning rate of 0.1,Find the new weights for the winning cluster unit.
(iii) If units before and after winning cluster unit are also allowed to learn the input pattern, find their new weights. **[5M]**

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

(a) (b)

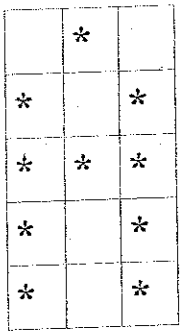

Figure 4

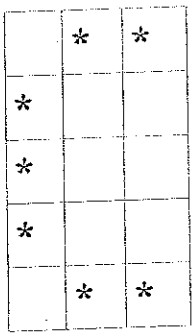

Figure 5

(a) Letter A → target code (-1, 1)

(b) Letter C → target code (1, 1)

a) Find the total weight matrix with input pattern A and C. **[2M]**
b) Obtain the response of the net with A and C as the input **[6M]**

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BITS Pilani, Dubai Campus
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IV Year (CHEM/MECH/EEE/CS/EIE/ECE/BIO-TECH)
Second Semester, 2011-2012

Test 2 (Open Book)

Course No: EA C482 **Course Title: Fuzzy Logic and Applications**
Date: 18th Apr 2012

Weightage: 20%
Duration: 50 minutes **Max. Marks. 40**

(This question paper has 2 pages and 2 questions. Use Graph Sheet for Q2)

1. Consider network architecture of backpropagation as 2-2-1. For the inputs (X_1 =1, X_2 = 0) ,the desired target pattern is 1. The weight matrix from input to hidden layer is given by $\begin{bmatrix} -1.0 & 4.5 \\ 7.2 & 9.8 \end{bmatrix}$. The weight matrix from hidden layer to output layer is $\begin{bmatrix} -3.5 \\ 5.2 \end{bmatrix}$. Assume all the bias weights connected to hidden units as 0.5.Consider the bias weight connected to output unit as -0.6. Use activation function of binary sigmoidal with learning rate of α = 0.25 and steepness parameter as 1. Draw the labeled network for the details given above and find the new weights for one epoch. Limit your calculations up to four decimal places. [20 M]

2. In finding the Nusselt number *Nu* (a dimensionless number for determining heat transfer) for a 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 the incorporation of a rule-base can be used to bypass these calculations and the following rules are used to govern this process:
IF *Re* is high and *Pr* is low THEN *Nu* is low
IF *Re* is low and *Pr* is low THEN *Nu* is low
IF *Re* is high and *Pr* is high THEN *Nu* is medium
IF *Re* is low and *Pr* is high THEN *Nu* is medium

P.T.O

The input fuzzy variables are described by the following membership functions, as shown in Fig. 1 and Fig.2.

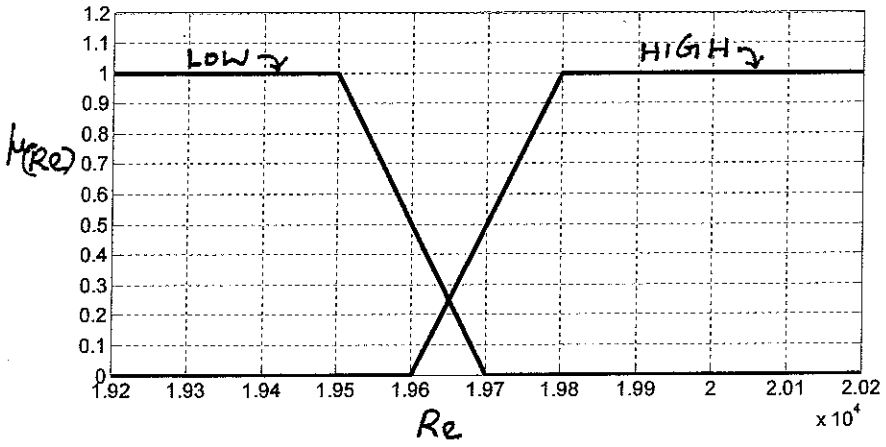

Fig.1

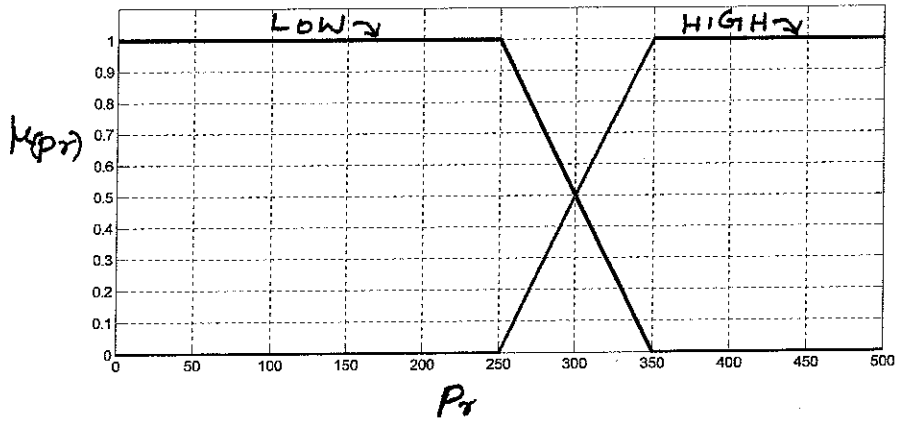

Fig.2

The output variable *Nu* is described by triangular membership functions as given below:

μ_{low}= (*Nu*; 375 475 575) and μ_{medium} = (*Nu*; 525 625 725) (Use the range as 350 to 750 in the graph sheet). For this problem, conduct a Mamdani graphical inference and obtain the induced decision table for the inputs: *Re* = 19.65 × 10^3 and *Pr* = 275. Draw the aggregated fuzzy output recommended by the governing rules .Also find the defuzzified value of *Nu* using

2A) Centroid (integration) method

2B) Center of Sums method and

2C) Comment on your results, briefly. **[20 M]**

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BITS Pilani, Dubai Campus

II Semester (EEE/ECE/EIE/CS/BIO-TECH/MECH/CHEM)

Test 1(Closed Book)

Duration:50 Minutes **Course Title: Fuzzy Logic and Applications**
Weightage: 25% **Course No:EA C482** **Max Marks: 50 Marks** **Date: 29/02/2012**

This question paper has 2 pages and 4 questions. Answer all questions. Use graph paper for Qn 3(b).

1(a)Write down the expressions for union of fuzzy sets and power of a fuzzy set. [2M]

(b) Consider fuzzy relations R and S as follows:

$$R = \begin{array}{c} \\ 1 \\ 2 \\ 3 \end{array} \begin{array}{c} \begin{array}{cccc} a & b & c & d \end{array} \\ \begin{bmatrix} 0.1 & 0.2 & 0.0 & 1.0 \\ 0.3 & 0.3 & 0.0 & 0.2 \\ 0.8 & 0.9 & 0.1 & 0.4 \end{bmatrix} \end{array} \qquad S = \begin{array}{c} \\ a \\ b \\ c \\ d \end{array} \begin{array}{c} \begin{array}{ccc} \alpha & \beta & \gamma \end{array} \\ \begin{bmatrix} 0.9 & 0.0 & 0.3 \\ 0.2 & 1.0 & 0.8 \\ 0.8 & 0.0 & 0.7 \\ 0.4 & 0.2 & 0.3 \end{bmatrix} \end{array}$$

(i) Draw the saggital diagram for the above relations [3M]

(ii) Find T = R°S using Max-Min Composition and also draw the saggital diagram for T = R°S. [5M]

2. (a) A new optical microscope camera uses a lookup table to relate voltage readings (which are related to illuminance) to exposure time. The fuzzy set "around 3 Volts" on a universe of voltage readings in V is given by

$$V(\text{volts}) = \left\{ \frac{0.1}{2.98} + \frac{0.3}{2.99} + \frac{0.7}{3} + \frac{0.4}{3.01} + \frac{0.2}{3.02} \right\}$$

and a fuzzy set "around 1/10 second" on a universe of exposure time in seconds is given by

$$T(\text{Seconds}) = \left\{ \frac{0.1}{0.05} + \frac{0.3}{0.06} + \frac{0.3}{0.07} + \frac{0.4}{0.08} + \frac{0.5}{0.09} + \frac{0.2}{0.1} \right\}$$

Find the Cartesian product represented by the relation R = VxT [3M]

Now define a third universe of "stops". In photography stops are related to making the picture some degree lighter or darker than the "average" exposed picture. The fuzzy set on this universe is defined as

$$Z = \text{a little bit lighter} = \left\{ \frac{0.1}{0.0} + \frac{0.7}{0.5} + \frac{0.3}{1} \right\}$$

(i) Find the Cartesian product S = TxZ [3M]

(ii) Find M = R°S using Max-product composition [4M]

P.T.O

2(b) Draw the membership function for the following along with necessary expressions

(i) Bell shaped Membership function and
(ii) Sigmoidal Membership function [5M]

3(a) Two fuzzy sets A and B are defined by the membership functions

$$\mu_A(x) = \frac{x}{x+1} \quad \& \quad \mu_B(x) = \frac{x^2}{x^2+1}$$

Where $x = \{0,1,2,3,4,5,6,7,8,9,10\}$. Verify Demorgan's laws for the fuzzy Sets. Limit your calculation to three decimal places. [8M]

3(b) The mass of an object is divided into 3 fuzzy sets with linguistic variables Small, Medium and Large. The universe of discourse of mass (m) is 0-500 kg. Plot the triangular membership functions to represent the fuzzy sets with following ranges

Small = 0 – 250 kg with membership grades of 1 at mass = 0 and 0 at mass=250kg.
Medium = 200-300kg with membership grades of 1 at mass=250kg and 0 at mass of 200 & 300kg.
Large = 250-350kg with membership grades of 1 at mass=300kg and 0 at mass of 250 & 350kg.
Very Large = 300-500kg with membership grades of 1 at mass =400kg and 0 at mass of 300 & 500kg.
(Use graph sheet.). [5M].

4(a) There are several vacuum cleaners on the market that uses fuzzy logic. Consider two inputs as type of surface and type of dirtiness and output as force of vacuuming. The fuzzy subsets for the surface can be defined as wood, Curtain, Carpet and for dirtiness as Almost Clean, Dirty, Soiled , Filthy. The strength of vacuuming can be defined by the fuzzy subsets Very weak, Weak, Normal, Strong, Very Strong. Form a fuzzy control rules (5 rules) for a vacuum cleaner so that it is logically correct..

[5M]

4(b) A process control system involves the monitoring of two linguistic parameters temperature (from 134 to 138 °F) and pressure (from 400 to 900 psi).The parameters are characterized by linguistic terms as follows:

High Temperature = $\{\frac{0}{134} + \frac{0.4}{135} + \frac{0.6}{136} + \frac{0.8}{137} + \frac{1.0}{138}\}$

High Pressure = $\{\frac{0}{400} + \frac{0.2}{600} + \frac{0.6}{700} + \frac{0.8}{800} + \frac{1.0}{900}\}$

Obtain the fuzzy sets for the following linguistic terms:

(i) Dilation of High Temperature
(ii) Intensification of high Pressure
(iii) Very Very High Temperature [2M+3M+2M]

Limit your calculation to three decimal places.

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BITS, PILANI – DUBAI

SECOND SEMESTER 2011 – 2012

FOURTH YEAR (EEE/CS/EIE/ECE/BIO-TECH/CHEM/MECH)

QUIZ 2 (CLOSED BOOK)

A

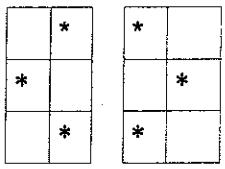
Course Code: EA C482
Course Title: Fuzzy Logic and Applications
Duration: 20 minutes

Date: 20.05.2012
Max Marks: 14
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 for rough work.Answer all Questions.

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



(a) Character < → target code (-1, 1)

(b) Character > → target code (1, 1)

2. In a Bidirectional Associative Memory (BAM), if a signal is sent from x-layer to y-layer, the weight matrix is W and when a signal is sent from y-layer to x-layer, the weight matrix is _____. **[1M]**

3. The input to a single-input neuron is 2.0 and its weight is 2.3, bias is -3. What is the output if binary activation function is used? Assume σ=1 **[3M]**

4. The non-dynamic function in a static artificial neuron is assumed to be _____ in most applications. [1M]

5. In the simple static artificial neuron model, the cell body is known by the term _____ and is represented by _____ operation and the activation function. **[2M]**

6. The processing in an artificial neural network is _____ in nature while in a biological neural network, it is massively _____ **[2M]**

7. Write the expression for decision process for selecting the winning neuron of the topology preserving maps. **[1M]**

8. Unsupervised learning is a means of modifying the weights of a neural net without specifying _____ for the input vectors. **[1M]**

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BITS, PILANI – DUBAI

SECOND SEMESTER 2011 – 2012

FOURTH YEAR (EEE/CS/EIE/ECE/BIO-TECH/CHEM/MECH)

QUIZ 2 (CLOSED BOOK)

B

Course Code: EA C482 Date: 20.05.2012
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 for rough work.Answer all Questions.

1. Unsupervised learning is a means of modifying the weights of a neural net without specifying _____ for the input vectors. **[1M]**

2. Write the expression for decision process for selecting the winning neuron of the topology preserving maps. **[1M]**

3. The processing in an artificial neural network is _____ in nature while in a biological neural network, it is massively _____ **[2M]**

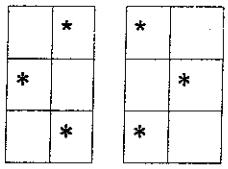
4. In the simple static artificial neuron model, the cell body is known by the term _____ and is represented by _____ operation and the activation function. **[2M]**

5. The non-dynamic function in a static artificial neuron is assumed to be _____ in most applications. [1M]

6. The input to a single-input neuron is 2.0 and its weight is 2.3, bias is -3. What is the output if binary activation function is used? Assume σ=1 **[3M]**

7. In a Bidirectional Associative Memory (BAM), if a signal is sent from x-layer to y-layer, the weight matrix is W and when a signal is sent from y-layer to x-layer, the weight matrix is _____. **[1M]**

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



(a) Character < → target code (-1, 1)

(b) Character > → target code (1, 1)

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BITS, PILANI – DUBAI

SECOND SEMESTER 2011 – 2012

FOURTH YEAR (EEE/CS/EIE/ECE/BIO-TECH/CHEM/MECH)

QUIZ 1 (CLOSED BOOK)

A

Course Code: EA C482 Date: 29.03.2012
Course Title: Fuzzy Logic and Applications Max Marks: 16
Duration: 20 minutes 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 for rough work..

1. The question of whether a glass of water is half-full or half-empty is an age-old philosophical issue. Sketch membership functions for the fuzzy sets ''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 sets "Full" and "Empty". [4M]

   Sketch Equations

2. A fuzzy set for a major storm event in Mumbai could be described as a rainstorm in a subdivision that raised the level of the storm-water pond to within 60% of its design capacity. The membership function for a major storm set could be described as having full membership when 60% of the pond volume has been reached but varying from Zero membership to full membership at 40% capacity and 60% capacity respectively. Draw a typical membership function as it is described. [2M]

3. For the fuzzy set A defined on U = {a, b, c, d } as
   $A = 0/a + 0.4/b + 0.6/c + 1/d$
   find the Core of A. [1M]

4. Distinguish between discrete fuzzy set and continuous fuzzy set by membership diagram. Assume any 5 arbitrary values for universe of discourse. [1M]

BITS, PILANI – DUBAI

SECOND SEMESTER 2011 – 2012

FOURTH YEAR (EEE/CS/EIE/ECE/BIO-TECH/CHEM/MECH)

QUIZ 1 (CLOSED BOOK)

B

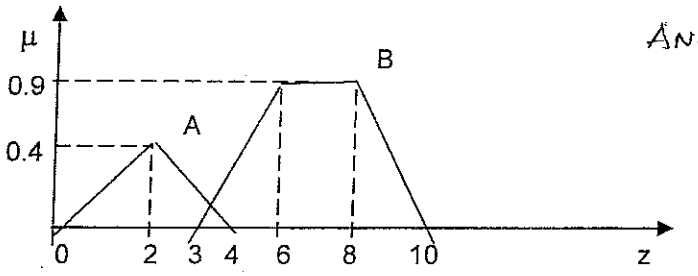
Course Code: EA C482 Date: 29.03.2012
Course Title: Fuzzy Logic and Applications Max Marks: 16
Duration: 20 minutes Weightage: 8%

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 for rough work.

1. A simple fuzzy system is given, which models the brake behavior of a car driver depending on the car speed. The inference machine should determine the brake force for a given car speed. The speed is specified by the two linguistic terms ``low" and ``medium", and the brake force by ``moderate" and ``strong". Form a fuzzy rule based system (two rules) such that it is logically correct. [2M]

2. Find the crisp output for the following membership functions, using center of sums method? [4M]



ANSWER

3. For a FLC there are two input variables and one output variable represented by linguistic variable Temp, Pressure and FanSpeed respectively. One of the fuzzy rules governing the FLC is as follows: if Temp is Low and Pressure is High, then FanSpeed is Medium. Obtain the rough graph of the output variable for the input condition shown in the graph. [1M]