BITS Pilani, Dubai Campus
Dubai International Academic City, Dubai

IV Year (ALL)
First Semester, 2012-2013

No of Questions: 9
No of Pages: 4

Comprehensive Examination (CLOSED BOOK)

Course No: EA C482 **Course Title: Fuzzy Logic and Applications**
Date: 10th Jan 2012 **Weightage: 40%**
Duration: 3 Hours **Max. Marks. 40**

(Use Graph Sheet Q4(b). Assume suitable data if required)

1) Two fuzzy sets A, B are defined on the universe of discourse U = { 1, 2, 3, 4, 5, 6 }, as

$$A=\left\{\frac{0.1}{1}+\frac{0.3}{2}+\frac{0.5}{3}+\frac{0.6}{4}+\frac{0.4}{5}+\frac{0.2}{6}\right\}, B=\left\{\frac{0.3}{1}+\frac{0.2}{2}+\frac{0.6}{3}+\frac{0.8}{4}+\frac{0.9}{5}+\frac{0.7}{6}\right\}$$

The operations for union, intersection are defined as follows,

(A U B)(x) = min (1, A(x)+B(x)) for all x □ U

(A ∩ B)(x) = max (0, A(x)+B(x)-1) for all x □ U

a) Find the (A U B), (A ∩ B) **[2M]**

b) Verify the following statement
Concentration of the union of A and B is equal to the union of the concentration of A and concentration of B. **[2M]**

2) The fuzzy sets representing the fracture strength (F) and temperature (T) of clay bricks are represented by the following fuzzy sets

$$F=\left\{\frac{1.0}{B1}+\frac{0.8}{B2}+\frac{0.6}{B3}+\frac{0.5}{B4}+\frac{0.3}{B5}+\frac{0.1}{B6}\right\}, T=\left\{\frac{0.2}{20}+\frac{0.4}{25}+\frac{0.5}{30}+\frac{1.0}{35}+\frac{0.6}{40}+\frac{0.3}{50}\right\}$$

a) Find the Cartesian product relation *R* between *F* and *T*. **[1M]**

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

$$M=\left\{\frac{0.4}{B1}+\frac{0.5}{B2}+\frac{0.6}{B3}+\frac{0.8}{B4}+\frac{0.9}{B5}+\frac{1.0}{B6}\right\}$$

b) Use max min composition to find S = M ○ R **[2M]**

c) Use max product composition to find S = M ○ R **[2M]**

3) Three membership functions A, B and C are shown in the Figures 1, 2, and 3. Find the defuzzified output for the logical union of the 3 membership functions.

i) Centroid Method (using integration) (only equation is sufficient-no need of final result of integration) **[3M]**

ii) Weighted Average Method. (final result is required) **[2M]**

P T O

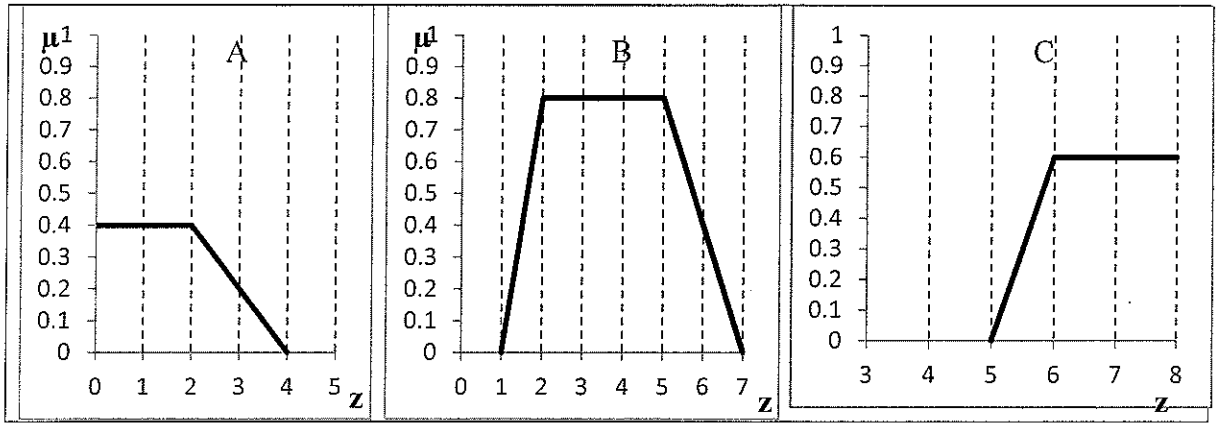


Figure 1 Figure 2 Figure 3

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). **[2M]**

b) A Mamdani type fuzzy logic based cruise controller has 2 input variables Speed of Vehicle (Speed) and Acceleration of Vehicle (Acc) and one output variable Throttle Control (TC).
Speed is partitioned into 4 trapeziodal fuzzy sets: Negative Large (NL), Negative Medium (NM) , Positive Medium (PM) and Positve Large (PL) viz. NL = (Speed: 0, 0, 10, 20), NM = (Speed: 10, 20, 30, 40), PM = (Speed: 30, 40, 50, 60), PL = (50, 60, 70, 70)

Acc is partitioned into 3 triangular fuzzy sets: Negative Medium(NM), Zero (ZE) and Positive Medium (PM) viz. NM = (Acc; -20, -20, 0), ZE = (Acc; -10, 0, 10), PM = (Acc; 0, 20, 20)

TC is partitioned into 5 triangular fuzzy sets: Negative Large (NL), Negative Medium(NM) , Zero (ZE), Positive Medium (PM) and Positve Large (PL). viz NL = (TC; 0, 0, 10), NM = (TC; 5, 10, 15), ZE = (TC; 10, 15, 20), PM = (TC; 15, 20, 25), PL = (TC; 20, 30, 30)

The fuzzy rule base is as follows.
R1: IF Speed is NL AND Acc is NM THEN TC is PL
R2: IF Speed is NL AND Acc is ZE THEN TC is PL
R3: IF Speed is NL AND Acc is PM THEN TC isPM
R4: IF Speed is NM AND Acc is NM THEN TC is PM
R5: IF Speed is NM AND Acc is ZE THEN TC is ZE
R6: IF Speed is NM AND Acc is PM THEN TC is ZE
R7: IF Speed is PM AND Acc is NM THEN TC is ZE
R8: IF Speed is PM AND Acc is ZE THEN TC is ZE
R9: IF Speed is PM AND Acc is PM THEN TC is NM
R10: IF Speed is PL AND Acc is NM THEN TC is NM
R11: IF Speed is PL AND Acc is ZE THEN TC is NL
R12: IF Speed is PL AND Acc is PM THEN TC is NL

Given that the input variable have values Speed = 12 Km & Acc = -3 Km/hr^2, draw the aggregated fuzzy output TC recommended by the rules **(use graph paper)**.
(Note: No deffuzification is required) **[4M]**

5) Draw a neat diagram of the structure of single artificial neuron; explain the different part of the artificial neuron Also write the necessary equation to calculate the output of the neuron. **[3M]**

6) A single neuron perceptron network is used to implement the following boolean function shown in Table 1. Assume initial weights and bias to be 0, $\alpha = 1$, and $\theta = 0$.

Table 1: Truth Table of the Boolean function

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

(a) Find the updated weights and bias after the first iteration. Draw the decision boundary diagram for the same. Should the training continue? Why? **[2M]**

(b) Comment on the convergence of the network after a large number of iterations, with justification. **[2M]**

7) A back propagation neural network has 3 input neurons, 2 hidden layer neurons and 1 ouptut layer neuron. The weight matrix from input to hidden layer and hidden to output layer are

$$\begin{bmatrix} 0.3 & -0.2 \\ -0.1 & 0.4 \\ 0.6 & -0.5 \end{bmatrix} \text{ and } \begin{bmatrix} -0.5 \\ 0.2 \end{bmatrix} \text{ respectively}$$

All the bias weights connected to the hidden units is -0.2 and that to the output unit is 0.1.Use binary sigmoidal activation function with learning rate of $\alpha = 1$ and steepness parameter $\sigma = 1$.

For the inputs $x_1 = 0.6$, $x_2 = 0.4$ and $x_3 = -0.2$, the desired output is 0.8.

a) Draw the labeled network for the details given above network. **[1M]**

b) Find the output (feed forward stage only) of the network (Limit the accuracy of the calculations up to 3 decimal places).Justify as to whether the back propagation of error will occur for this network **[4M]**

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

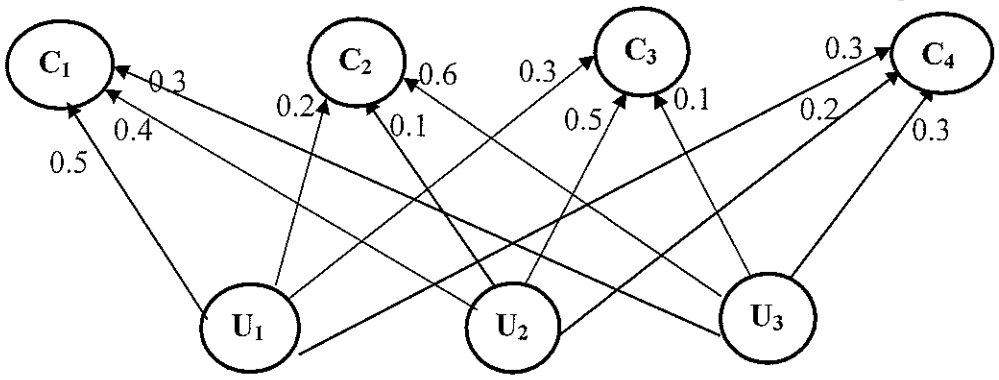


Figure 4

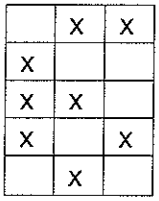
a) Use the square of the Euclidean distance, find the cluster unit that is closer to the input vector.(0.1, 0.4, 0.5) **[1M]**

b) Using a learning rate $\alpha = 0.3$, find the new weights for the winning cluster unit. **[1M]**

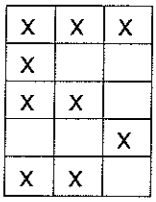
c) If units before and after the winning cluster unit are also allowed to learn the input pattern, find their new weights. **[2M]**

P T O

9) A Bidirectional Associative Memory network (with bipolar input and target codes) is used to recognize two digits 6 and 5 (given by 5 x 3 patterns) as shown in Figure 5 and 6. (x = 1 and Space = -1, in the figure shown below)



Target code for 6 = (-1, 1)
Figure 5



Target Code for 5 = (1, 1)
Figure 6

a) Find the total weight matrix stored the network for the input patterns **[1M]**
b) Obtain the response of the net with digit 3 inputs **[1M]**
c) Given the noisy input pattern [1 0 0 0 -1 0 1 0 -1 -1 0 0 1 0 0] , find the digit predicted by the network. Is it likely to be the correct prediction, Why. **[2M]**

♣ ♣ ♣ ♣ ♣

BITS Pilani, Dubai Campus
Dubai International Academic City, Dubai

IV Year (ALL)
First Semester, 2012-2013

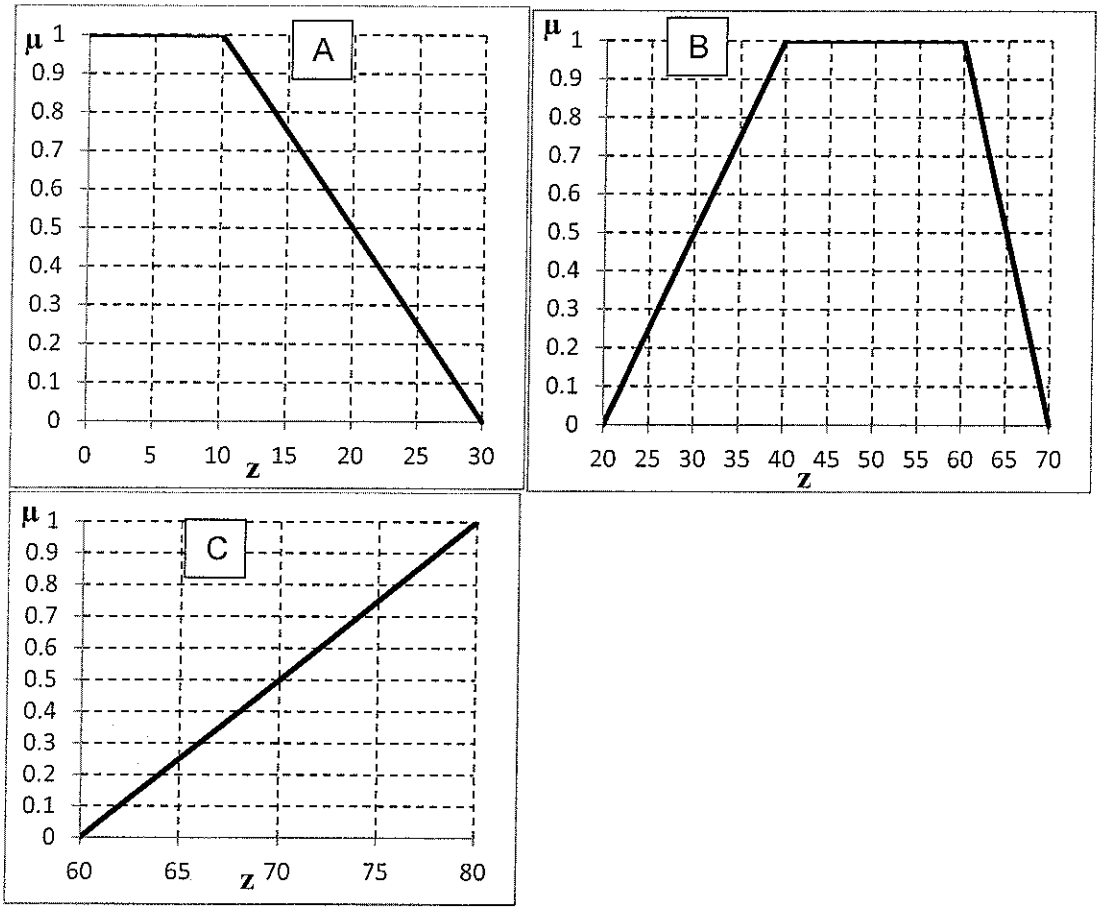
No of questions : 3
No of Pages : 2

Test 2 (Open Book)

Course No: EA C482
Date: 19th Dec 2012
Duration: 50 minutes

Course Title: Fuzzy Logic and Applications
Weightage: 20%
nMax. Marks. 20

1. Three membership functions A, B, and C are shown in the Figure below. Find the defuzzified output for the logical union of the membership functions, using the centroid method (integration) method. (**use graph paper**)



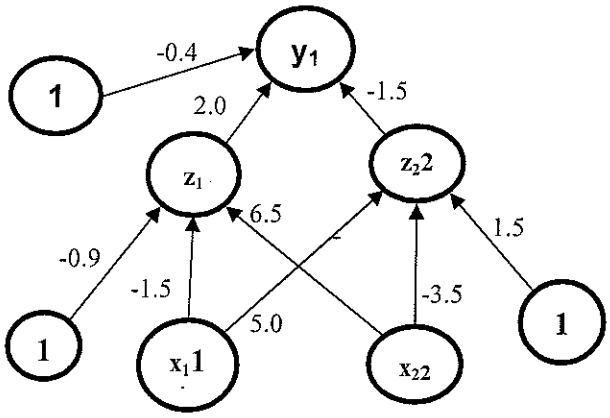
i) Draw the final graph (logical union of membership functions A,B,C) **[2M]**
ii) Obtain the equation for finding the defuzzified value **[3M]**
iii) Simplification of the equation & obtain the defuzzified value **[2M]**

2. A backpropagation neural network shown in the figure below is given the input pattern $x_1 = 1, x_2 = 1$. The target output is 1. Solve the network for the following stages using the binary sigmoidal activation function.

i) Feed Forward Stage and

ii) Backpropagation of error.

Assume the learning rate $\alpha = 0.2$, steepness parameter $\sigma=1$. Use 3 decimal places for the calculations. **[3.5M+3.5M]**



3. A BAM network (with bipolar input vectors and bipolar target codes) are used to recognize 2 letters Y and A, represented by 5x3 grid as shown below. (Assume x = 1 and - = -1, in the figure shown below)

x	-	x
x	-	x
-	x	-
-	x	-
-	x	-

Target code for Y = (-1, 1)

-	x	-
x	-	x
x	x	x
x	-	x
x	-	x

Target Code for A = (1, 1)

i) Find the total weight matrix stored in the network for above input patterns

ii) Using the weight matrix computed in i, test if the network recognizes the letters Y and A correctly. **[3M+3M]**

♣ ♣ ♣ ♣ ♣

BITS Pilani, Dubai Campus
Dubai International Academic City, Dubai

IV Year (ALL)
First Semester, 2012-2013

No of questions : 4
No of Pages : 2

Test 1 (Closed Book)

Course No: EA C482 | **Course Title: Fuzzy Logic and Applications**
Date: 07th Nov 2012 | **Weightage: 25%**
Duration: 50 minutes | **nMax. Marks. 25**

(Use Graph Sheet for Q3)

1. Let A = { 1, 2, 3, 4 } be an Universe of Discourse (UOD). Form a fuzzy relation R on A x A, using the following membership function $\mu_R(a,b) = \begin{cases} 0, & a \le b \\ e^{-(a-b)}, & a > b \end{cases}$, where a,b □ A.

a) Obtain the relation R in the form of a matrix **[2M]**
b) Draw the saggital diagram representing the relation R. **[2M]**
c) What is the relationship between elements of A, captured by R. **[1M]**

2. An optical camera uses a lookup table to relate voltage readings to exposure time. A fuzzy set "about 3 volts" is defined on universe of Voltage (V), and another "around 1/10 second" is defined on the universe of exposure time (T)

$$\mu_{about\ 3\ volts} = \left\{ \frac{0.1}{2.98} + \frac{0.3}{2.99} + \frac{0.7}{3} + \frac{0.4}{3.01} + \frac{0.2}{3.02} \right\}$$

$$\mu_{around\ 1/10\ second} = \left\{ \frac{0.1}{0.05} + \frac{0.3}{0.06} + \frac{0.3}{0.07} + \frac{0.4}{0.08} + \frac{0.5}{0.09} + \frac{0.2}{0.1} \right\}$$

Another fuzzy set "a little bit higher" is defined on the universe of stops (used to make the picture lighter or darker).

$$\mu_{a\ little\ bit\ lighter} = \left\{ \frac{0.1}{0} + \frac{0.7}{0.5} + \frac{0.3}{1} \right\}$$

Find R = "about 3 volts" x "around 1/10 second" **[2M]**
Find S = "around 1/10 second" x "a little bit lighter" **[2M]**
Find M = R o S using max-min composition **[2M]**

3. A fuzzy logic based microwave oven selects the Cooking Time (CT) based on the Quantity of Food (QF) and Type of Food (TF). The fuzzy sets characterizing the different variables are as follows

i) Input Variable Quantity of Foof (QF: 0-500 grams) is divided into 3 Fuzzy Sets *viz.* Small , Medium and Large with trapeziodal membership functions
$\mu_{Small} = (QF; 0,25,125,175)$, $\mu_{Medium} = (QF; 125,175,275,350)$,
$\mu_{Large} = (QF; 275,350,475,500)$

ii) Input variable Type of Food (TF:0-80) is divided into 3 Fuzzy Sets *viz.* Soft, Medium, Hard with triangular membership functions.

$\mu_{Soft} = (TF; 0,20,40)$, $\mu_{Medium} = (TF; 20,40,60)$, $\mu_{Hard} = (TF; 40,60,80)$

iii) Output variable Cooking Time(CT: 0-40 mins) is divided into 4 Fuzzy Sets *viz.* Low, Medium Low, Medium High, High with trapezoidal membership functions

$\mu_{Low} = (CT; 0,2,8,12)$, $\mu_{MediumLow} = (CT; 8,12,18,22)$,
$\mu_{MediumHigh} = (CT; 18,22,28,32)$, $\mu_{High} = (CT; 28,32,38,40)$,

The fuzzy rule base is as follows

a) if QF is Small and TF is Soft the CT is Low
b) if QF is Small and TF is Medium the CT is Low
c) if QF is Small and TF is Hard the CT is Medium Low
d) if QF is Medium and TF is Soft the CT is Medium Low
e) if QF is Medium and TF is Medium the CT is Medium Low
f) if QF is Medium and TF is Hard the CT is Medium High
g) if QF is Large and TF is Soft the CT is Medium High
h) if QF is Large and TF is Medium the CT is High
i) if QF is Large and TF is Hard the CT is High

a) Draw the membership functions for the QF, TF and CT. **[4M]**
b) Obtain the induced decision table for QF = 160gms, TF = 55 and graph for the aggregated fuzzy output for the variable CT. **[6M]**

4. Give the block diagram of Mamdani type FLC and briefly explain the major parts of the block diagram (only key points are required). **[4M]**

♣ ♣ ♣ ♣ ♣

BITS PILANI, DUBAI CAMPUS
FIRST SEMESTER 2012 – 2013
FOURTH YEAR (ALL)
QUIZ 2

No of Questions: 04
No of Pages : 2

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

Date: 24.12.12
Max Marks: 07
Weightage: 7%

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

Instructions: Use back side if necessary for calculations.

1. **a)** A single layer perceptron with two inputs x_1, x_2 and single output y is used to realize the following Boolean function. Assume initial weights and bias to be 0, $\alpha = 1$, and $\theta = 0$. Show the answer in the following tabulated form. **[2M]**

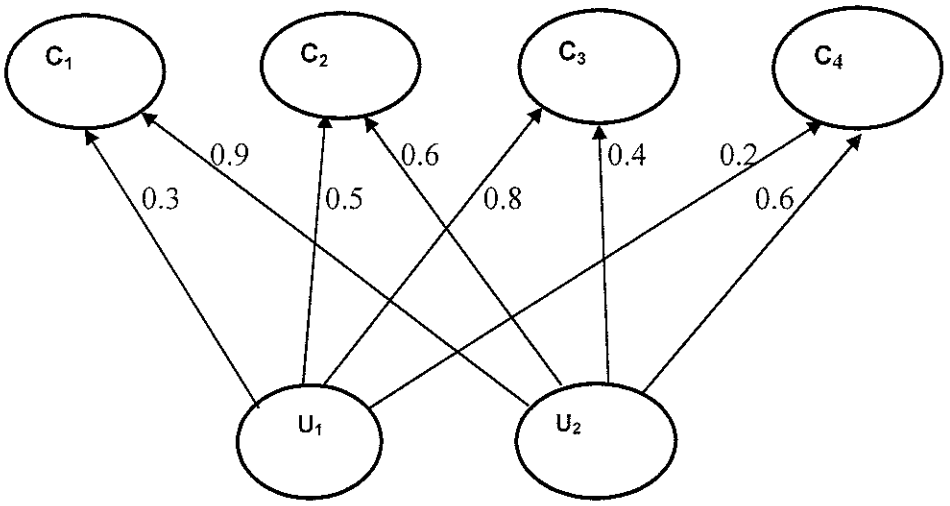
Inputs			Net(Y_{in})	Out (y)	Target (t)	Weight Changes			Weights		
x_1	x_2	1							w_1	w_2	b
1	1	1			1						
1	0	1			-1						
0	1	1			-1						
0	0	1			-1						

b) After the first epoch, can you say that the network has converged, why? **[1M]**

2. What is generalization in neural networks? What is its significance **[1M]**

3. Explain what **content addressable memory** is with a suitable example. **[1M]**

4. A Kohanen self organizing map is shown below. Find the cluster unit that is closest to the input vector $U_1 = 0.5$, $U_2 = 0.6$. (Use square of Euclidean distance as the distance measure) **[2M]**



BITS PILANI, DUBAI CAMPUS
FIRST SEMESTER 2012 – 2013
FOURTH YEAR (ALL)
QUIZ 1

No of Questions: 07
No of Pages : 2

B

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

Date: 10.10.12
Max Marks: 08
Weightage: 8%

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

Instructions: Write your answers in the blank space provided after each question.

1. Given the fuzzy sets A =(0, 0.2, 0,8) and B = (0.15, 0.45, 0.7), find the fuzzy set C which represents the product of the fuzzy sets A and B. **[1M]**

2. For the fuzzy set A defined on the interval U = [0,5] with membership function $\mu(x) = \frac{x^2}{x^2+1}$, obtain the fuzzy set representing intensification of A.(Use increments of 1 for x) **[1M]**

3. Sketch the triangular membership function along with the necessary expressions **[1M]**

4. Define support of a fuzzy set and give an example for the same **[1M]**

5. Given 2 fuzzy sets A = $\left\{\frac{0}{a}+\frac{0.1}{b}+\frac{0.5}{c}+\frac{0.9}{d}\right\}$ and B = $\left\{\frac{0.2}{a}+\frac{0.3}{b}+\frac{0.05}{c}+\frac{0.09}{d}\right\}$, verify any **one** DeMorgan's Law (show individual steps) **[2M]**

6. Is the core of a fuzzy set a crisp set? Justify **[1M]**

7. Distinguish between discrete fuzzy set and continuous fuzzy set (with equations for membership functions) **[1M]**

♣ ♣ ♣ ♣ ♣