BITS Pilani, Dubai Campus
Dubai International Academic City, Dubai

IV Year (CHEM/EEE/MECH/CS/EIE)
Second Semester, 2010-2011

Comprehensive Examination

Course No: EA C482 | **Course Title: Fuzzy Logic and Applications**
Date: 05.06.2011 | **Weightage: 40%**
Duration: 3 Hours | **Max. Marks. 80**

Note: Answer Parts A and B on separate answer books.
Answer the questions (with parts) in the sequential order.
Use graph sheet for PART-A Q4(a) and Q4(c).
Assume suitable data if required.

PART – A

1. a) Define Core(A), Support(A), Boundary(A), where A is a fuzzy set.
For the fuzzy set A defined on U = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12} as

$$A=\left\{\frac{0.0}{1}+\frac{0.15}{2}+\frac{0.3}{3}+\frac{0.5}{4}+\frac{0.75}{5}+\frac{0.9}{6}+\frac{1}{7}+\frac{1}{8}+\frac{0.85}{9}+\frac{0.6}{10}+\frac{0.4}{11}+\frac{0.0}{12}\right\}$$

Find the Core (A), Support (A), Boundary (A). **[3M]**

b) Given a fuzzy set A, the core (A) is a crisp set. Justify your answer. **[2M]**

c) Draw the membership function of the following, along with the necessary expressions
i) Triangular Membership Function and
ii) Trapezoidal Membership Function **[5M]**

2. a) What are the different types of fuzzy statements, Give example for each type of statement. **[3M]**

b) The formation of algal solution depends on temperature and oxygen content of water. Let X, Y be the fuzzy sets that shows the dependency of the algal formation on Temperature (T={40,45,50,55,60}) and Oxygen content (O={1,2,3,4,5}) respectively:

$$X=\left\{\frac{0.1}{40}+\frac{0.2}{45}+\frac{0.6}{50}+\frac{1}{55}+\frac{0.8}{60}\right\};Y=\left\{\frac{0.8}{1}+\frac{1}{2}+\frac{0.5}{3}+\frac{0.3}{4}+\frac{0.2}{5}\right\}$$

(i) Find the Cartesian product represented by the relation R = X x Y **[2M]**
Now, suppose we have a second fuzzy set of Temperatures "about 50°F" which is defined as follows

$$Z=\left\{\frac{0.2}{40}+\frac{0.4}{45}+\frac{0.6}{50}+\frac{1}{55}+\frac{0.7}{60}\right\}$$

Find $S = Z_{1\times5} \circ R_{5\times5}$ using
(ii) max-min composition and
(iii) max-product composition **[5M]**

3. a) Distinguish between Proportional Integral (PI) like Fuzzy Logic Controller (FLC), and Proportional Derivative (PD) like Fuzzy Logic Controller (FLC). Which of these is being used in practice? Justify your answer. (Write only key points). **[4M]**

b) Following linguistic terms are defined on the universe of temperature $T = \{10, 20, 30, 40, 50\}$

$$Hot = \left\{\frac{0}{10} + \frac{0.2}{20} + \frac{0.4}{30} + \frac{0.8}{40} + \frac{1.0}{50}\right\}; Cold = \left\{\frac{1}{10} + \frac{0.7}{20} + \frac{0.5}{30} + \frac{0.2}{40} + \frac{0}{50}\right\}$$

Obtain the fuzzy sets for the following linguistic terms with hedges

(i) very very Cold or very very Hot **[1M]**

(ii) Intensely Hot **[2M]**

4. a) Two membership functions A and B are shown below in Figures 1 & 2. Find the defuzzified output for the logical union of the 2 membership functions.**(use graph paper)** **i)** Centroid Method (using integration) and **ii)** Weighted Average Method **[4M + 2M]**

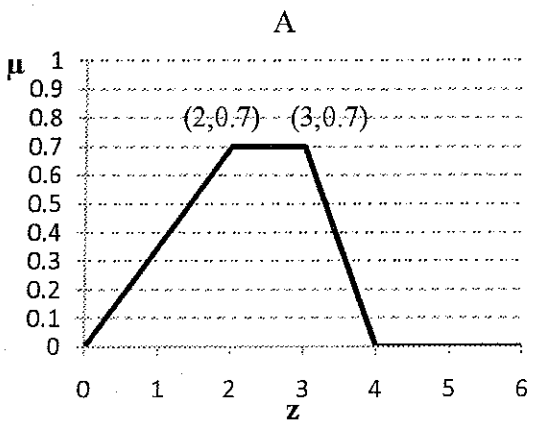

Figure 1

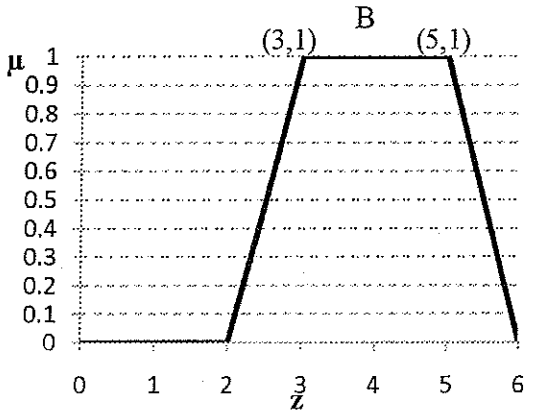

Figure 2

b) What are the advantages of using a fuzzy logic based Anesthetic depth controller, over conventional techniques? (write only key points.) **[2M]**

c) A Mamdani type fuzzy logic based Anesthetic depth controller has 2 input variables, Blood Pressure (BP), Pulse Rate (PR) and one output variable Anesthesia Output (AO). All the variables are partitioned into 3 fuzzy sets, Low, Normal and High. A trapezoidal membership function characterizing the output fuzzy variable AO is given below.

$\mu_{Low} = (AO; 0, 0.5, 0.8, 1)$, $\mu_{Normal} = (AO; 0.8, 1, 2.5, 3)$, $\mu_{High} = (AO; 2.5, 3, 3.5, 4)$

The Fuzzy Rule Base is as follows.

Rule1: if BP is Low and PR is Normal then AO is Low

Rule2: if BP is Normal and PR is Normal then AO is Normal

Rule3: if BP is Low and PR is High then AO is High

Given that for BP = 95 mm-Hg; $\mu_{Low}(BP) = 0.8$ and $\mu_{Normal}(BP) = 0.6$ and for PR = 80 pm^{-1}; $\mu_{Normal}(PR) = 0.3$ and $\mu_{High}(PR) = 0.5$,

Draw the aggregated fuzzy ouput AO recommended by the rules. (**use graph paper**) (no deffuzification is required) **[5M]**

PART – B

1. Discuss the classification of neural network based on training, architecture and activation function. **[6M]**

2. What are the merits and demerits of back propagation algorithm? Write only key points in your answer. **[4M]**

3. A neural network consists of a single neuron with 3 inputs x_1, x_2, x_3. The training patterns are as follows
(0,-1,1),(0,1,-1),(0,0,1),(0,0,-1),(0,1,0),(1,0,1),(1,0,-1),(1,-1,0),(1,0,0),(1,1,0), (0,-1, 0) and (1,1,1).
Consider weight values for inputs x_1, x_2, x_3 as (0,-2, 2) respectively. Assume that both bias and threshold are 0. The target output is 1
(i) Explain in brief what concept you can use by segregating it into correct, incorrect and undetermined.
(ii) Identify the response of network by segregating it into correct, incorrect and undetermined. **[6M]**

4. Consider a Bidirectional Associative Memory network (with bipolar vectors) to map two simple letters (given by 5× 3 patterns) to the following bipolar target codes as shown in Figures 1 and 2

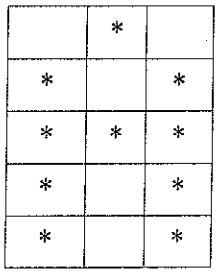

Figure 1

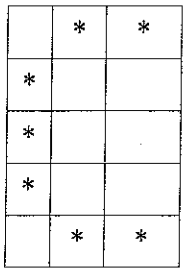

Figure 2

(a) Letter A → target code (-1, 1)

(b) Letter C → target code (1, 1)

(i) Find the total weight matrix with input patterns A and C.
(ii) Obtain the response of the net with A and C as inputs
(iii) Test the response of the net for the signals sent from output layer (Y) to Input layer (X), using target code (-1, 1).
(iv) Test the response of the network when the net is given a Y vector as input which is a noisy version of one of the training Y vectors and no information is given about the corresponding X vectors. The noisy version of Y is given by [0, 1]. **[5M]**

5. A three layered back propagation algorithm has inputs (0.9, 0.2) with target as 0.5. Weights from input to hidden layer are given by $\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$. Weights from hidden layer to output layer are $\begin{bmatrix} 1 \\ 1 \end{bmatrix}$. Assume all the bias weights connected to hidden units and output unit as 0.4 and learning rate as 0.7. Use binary sigmoid activation function and consider steepness parameter as 1. For the details given above, draw the architecture and find the new weights for one epoch. Limit your calculations up to four decimal places. **[15M]**

6. Consider a kohonen net with two cluster units and five input units as shown in Figure 3.

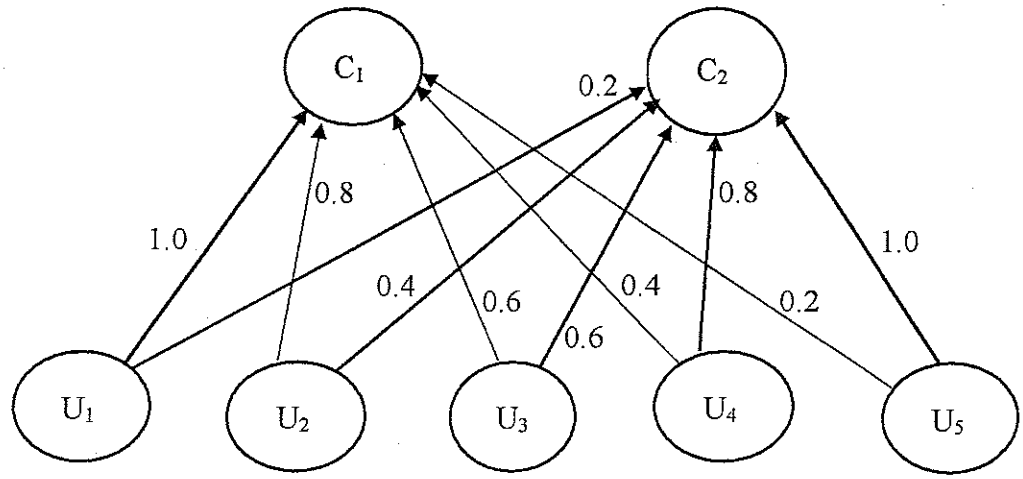

Figure 3

Using the square of the Euclidean distance, find the winning cluster unit for the input vector x = (0.5, 1.0, 0.5, 0.0, 0.0) for a learning rate of 0.2 and hence find the new weights for the winning unit. **[4M]**

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IV Year (CHEM/EEE/MECH/CS/EIE)
Second Semester, 2010-2011

Test 2 (Open Book)

Course No: EA C482 | **Course Title: Fuzzy Logic and Applications**
Date: 17th Apr 2011 | **Weightage: 20%**
Duration: 50 minutes | **Max. Marks. 40**

(Answer the questions (with part) in the sequential order)
(This question paper has 2 pages and 3 questions)
(Use graph sheet for Question 1)

1. A Mamdani type fuzzy logic controller is used to choose appropriate output spatial resolution (SR) for Global Information System (GIS), based on two inputs digital elevation (DE) and area of coverage (AC). The fuzzy sets characterizing DE, AC and SR are shown in the Figures 1.1 – 1.3. The rule table is shown in Table 1.1. **[15M]**
   a) Obtain the induced decision table for DE = 1200m and AC = 7000m^2.
   b) Draw the aggregated fuzzy output recommended by the rules which are fired.
   c) Find the defuzzified output value of the spatial resolution (SR).Use Centroid method for defuzzification.(Use graph paper)

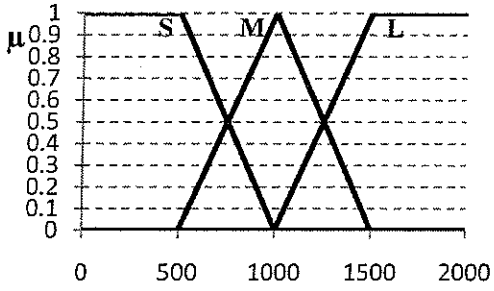

Figure 1.1 Digital Elevation (DE)(m)

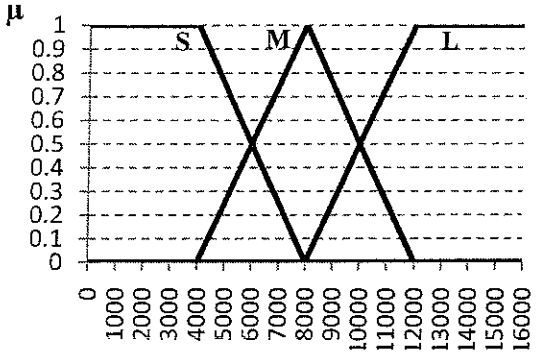

Figure 1.2 Area of Coverage (AC) (m^2)

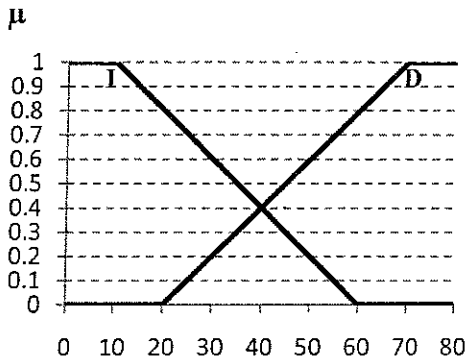

Figure 1.3 Spatial Resolution (SR) (m)

Table 1.1 Rule Table

	DE		
AC	L	M	S
L	D	I	I
M	I	D	I
S	D	D	D

P.T.O

2. Consider a Kohonen net with two cluster units and three input units as shown in Figure 2.1. The weight vector for the cluster units are (0.9, 0.7, 0.6) and (0.4, 0.3, 0.5). **[10 M]**

a) Find the wining cluster unit for the input vector (0.4, 0.2, 0.1).

b) Use a learning rate of 0.2, find the new weights for the winning unit.

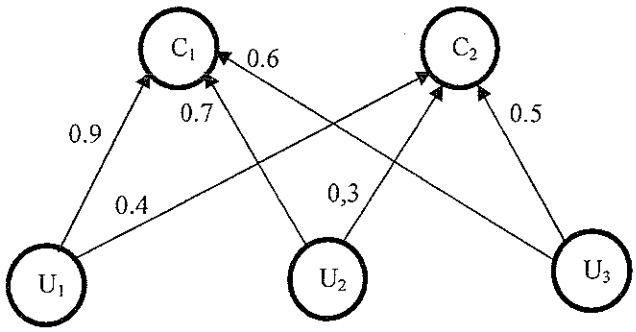

Figure 2.1

3. Figure 3.1 shows a backpropagation neural network presented with the input pattern (x_1=1, x_2=0) and target output is 0.9. Slove the given problem for the following stages.

(i) Feed Forward stage and (ii) Backpropagation of error

Use learning rate of α = 0.35, steepness parameter σ=1 and binary sigmoidal activation function. Limit your calculations to four decimal places.

[15M]

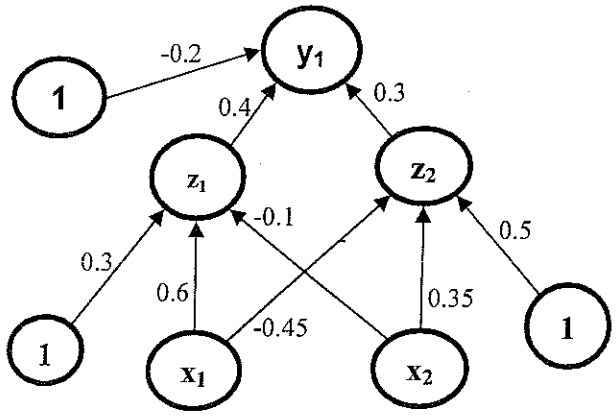

Figure 3.1

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IV Year (CHEM/EEE/MECH/CS/EIE)
Second Semester, 2010-2011

Test 1 (Closed Book)

Course No: EA C482	**Course Title: Fuzzy Logic and Applications**
Date: 27th Feb 2011	**Weightage: 25%**
Duration: 50 minutes	**Max. Marks. 50**

(Answer the questions in the sequential order)
(Answer all the parts of a question together)
(This question paper has 2 pages and 4 questions)
(Use graph sheet for Question 4(b))

1. **a)** It is known that for an electronic circuit the operating temperature is directly related to the operating frequency. Also the operating temperature has direct impact on the reliability of the circuit. Given fuzzy sets T, F, and R representing operating temperature, operating frequency and reliability, show how the relation between operating temperature(T) and reliability (R) can be computed using fuzzy Cartesian product and fuzzy composition? **(4M)**

b) A bioreactor is used in water treatment process to remove biodegradable organic matter. The important parameters biological oxygen demand (B), retention time (T) and Utilization rates (U) are represented using fuzzy sets with the following membership functions.

$$\mu_B = \left\{\frac{0.5}{60} + \frac{0.7}{40} + \frac{1.0}{20}\right\}; \mu_T = \left\{\frac{0.9}{10} + \frac{0.7}{8} + \frac{0.5}{6}\right\}; \mu_U = \left\{\frac{1.0}{0.9} + \frac{0.8}{0.8} + \frac{0.6}{0.7} + \frac{0.4}{0.6}\right\}$$

i. Find the Cartesian product R = B x T **(2M)**
ii. Find the Cartesian product S = T x U **(2M)**
iii. Find W = R ∘ S using the max-min composition **(3M)**
iv. Find W = R ∘ S using the max-product composition **(3M)**

2. **a)** Explain the properties of fuzzy sets using necessary expressions (any 2). What are the properties that hold well for crisp sets but not for fuzzy sets. **(4M)**

P.T.O

b) Fig. 1 and Fig 2. show the sagittal diagrams of the interconnection between 4 cities a, b, c, and d. In Fig 1, the distances between the cities are represented as crisp relation whereas in Fig 2, the distances are represented as fuzzy relation.

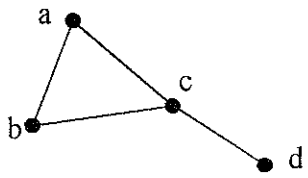


Fig 1

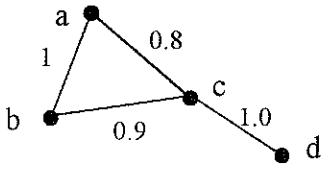


Fig 2

Obtain the Crisp Relational Matrix and Fuzzy Relational Matrix for the distance between the cities from the above figures. Assume all the cities are connected to itself. **(8M)**

3. **a)** A four-person family wants to buy a house. An indication of how comfortable they want to be is 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) $C \cap I$ **(2M)**

(ii) $C \cup I$ **(2M)**

(iii) Clearly comment on the interpretation of the results in (i) & (ii) **(4M)**

b) Mention the advantages of rule-based systems in the design of fuzzy logic controller. Clearly mention 4 key points in your answer. **(4M)**

4. **a)** How is the crossover point and the height defined based on the membership function? Draw a neat sketch for the above definitions. **(4M)**

b) The age of people is divided into 5 fuzzy sets with linguistic values: Very Young, Young, Medium, Old and Very Old. The Universe of Discourse of age is 0-75 years. Use triangular membership function to represent the above fuzzy sets with following ranges.

Very Young = 0-15 with membership grade of 1 at age =0 and 0 at at age =15.
Young = 12-30, with membership grade of 1 at age=20, and 0 at ages 12 and 30.
Medium = 25-50, with membership grade of 1 at age=35, and 0 at ages 25 and 50.
Old = 45-65, with membership grade of 1 at age=52, and 0 at ages 45 and 65.
Very Old = 60-75, with membership grade of 1 at age=70 to 75, and 0 at age = 60.
Plot the membership function diagram representing all the fuzzy sets as specified above, using graph sheets. **(5M)**

c) Draw the functional block diagram of Mamdani type Fuzzy Logic Controller. **(3M)**

BITS PILANI, DUBAI CAMPUS
SECOND SEMESTER 2010 – 2011
FOURTH YEAR (CHEM/EEE/MECH/CS/EIE)
QUIZ 2

A

Course Code: EA C482 | Date: 02.05.11
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. 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, 10, 5 and 20 respectively. Assume that bias is 0. The output will be: **[1M]**
   a. 238.
   b. 76
   c. 119
   d. 236

   Ans : ☐

2. Which of the following systems mimics human thinking? **[1M]**
   a. Artificial Intelligence
   b. Intelligent Agent
   c. Bot
   d. Database Management System.

   Ans : ☐

3. Which Intelligent Agent will monitor systems and report back to you when there is a problem? **[1M]**
   a. Shopping bot.
   b. Buyer agent
   c. Information agent
   d. Predictive agent

   Ans : ☐

4. Which structures in the brain are responsible for *sending* information to neurons? **[1M]**

5. Define bias in a neural network? **[1M]**

6. What is the function of Synaptic Gap in a biological neuron model? **[1M]**

P.T.O

7. Define Threshold in a neural network? **[1M]**

8. What are the different modes of training in neural networks? **[1M]**

9. Define Learning in a neural network? **[1M]**

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

11. Write the weight updation step used in perceptron network? **[2M]**

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

(a) Letter I → target code (-1, 1)

(b) Letter C → target code (1, 1)

♣♣♣♣♣

BITS PILANI, DUBAI CAMPUS
SECOND SEMESTER 2010 – 2011
FOURTH YEAR (CHEM/EEE/MECH/CS/EIE)
QUIZ 1

A

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

Date: 21.03.11
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. Which of the following is not true regarding the principles of fuzzy logic? **[1M]**
   a. Fuzzy logic is a concept of `certain degree'.
   b. Fuzzy logic follows the principle of Aristotle and Buddha
   c. Japan is currently the most active users of fuzzy logic
   d. Boolean logic is a subset of fuzzy logic

   Ans : ☐

2. 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 & iii
   b. i & ii only
   c. i, iii only
   d. ii & iii.

   Ans : ☐

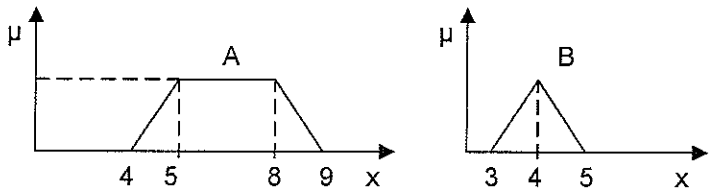
3. What is the main difference between probability and fuzzy logic? **[1M]**
   a. Fuzzy logic is probability in disguise.
   b. Fuzzy logic is the likelihood of an event occurring and probability is the extent of that event.
   c. Probability is ADDITIVE, meaning all its values must add up to one.
   d. Probability dissipates with decreasing information.

   Ans : ☐

4. What are the following sequence of steps taken in designing a fuzzy logic controller? **[1M]**
   a. Fuzzification->Rule evaluation->Defuzzification
   b. Rule evaluation->Fuzzification->Defuzzification
   c. Fuzzy Sets->Defuzzification->Rule evaluation
   d. Defuzzification->Rule evaluation->Fuzzification

   Ans : ☐

5. Given 2 fuzzy graphs for membership functions, sketch the resulting graph for the operation A AND B. **[1M]**



6. Write the rule format for sugeno type of Fuzzy Logic Controller. **[1M]**

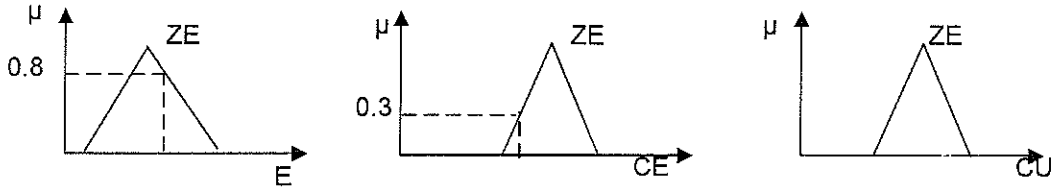
P.T.O

7. How is the excluded middle law different for the fuzzy set and the classical set? Draw a neat sketch for both cases. Use triangular membership function for fuzzy set. **[2M]**

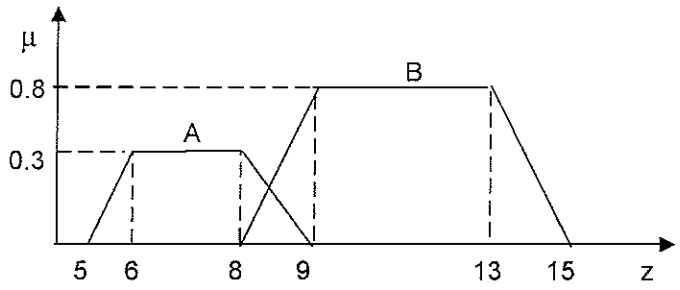
8. How is it that fuzzy systems have been successfully applied to such a wide variety of applications? (Write only key points in your answer) **[2M]**

9. List out any 4 defuzzification methods in the design of fuzzy logic controller? **[2M]**

10. For a FLC there are two input variables Error (E), Change In Error (CE) and one output variable Change In Controller Output (CU). Assuming that the fuzzy rule which is being fired is **IF E is ZE AND CE is ZE, THEN CU is ZE**, infer the output contributed by the rule, for the input conditions shown in the graph. **[1M]**



11. Find the crisp output for the following membership functions, using weighted average method? **[3M]**



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