BITS, Pilani – Dubai
Dubai International Academic City, Dubai

IV Year (EEE/ME/CS/EIE)
First Semester, 2008-2009

Test 1 (Closed Book)

Course No: EA UC482 | **Course Title: Fuzzy Logic and Applications**
Date: 5th Oct 2008 | **Weightage: 20%**
Duration: 50 minutes | **Max. Marks. 20**

(Answer the questions in the sequential order.)
(Answer all the parts of a question together.)

1. Fuzzy sets A, B, and C on the universe U = {a, b, c, d} are defined below.
   A = (0.2, 0.5, 0.4, 0.9)
   B = (0.1, 0.4, 0.7, 1.0)
   C = (0.0, 0.3, 0.5, 0.7)
   Find the following fuzzy sets using standard operations.
   a. $A \cup (B \cap C)$
   b. $(A \cap B)'$
   c. $(A \cup B) \cap (A \cup C)$

   (3x1 = 3 marks)

2. For fuzzy sets with standard operations prove the following.
   a. $A \cap (B \cup C) = (A \cap B) \cup (A \cap C)$
   b. $(A \cup B)' = A' \cap B'$

   (2+2 = 4 marks)

3. Give one nonstandard definition each for the union and intersection operations on fuzzy sets. Prove that your definitions are generalisations of the corresponding operations on crisp sets.

   (1 + 2 = 3 marks)

4. Consider U = {a,b,c,d} and a fuzzy set A on U given by
   $A = 0.7/a + 0.5/b + 1/c + 0.2/d$
   Show that the crisp sets A_1, A_2, A_3, and A_4 are the distinct non-empty α–cuts of set A, where $A_1 = U$, $A_2 = \{a, b, c\}$, $A_3 = \{a, c\}$, and $A_4 = \{c\}$. Find the values of α's corresponding to the above sets and show that
   $A = \sum (\alpha_i)(A_i)$

   (2.5 marks)

5.
   a. State the extention principle for a function f from U x V to Y.
   b. U = {a, b, c}, Y = {x, y, z},
      $f : U \rightarrow Y$ be defined by f(a) = x, f(b) = y, f(c) = x,
      A = (0.7, 0.2, 0.5), B = (0.1, 0.4, 0.6)
      Find f(A), f(B), and f(A U B). Verify that $f(A \cup B) = f(A) \cup f(B)$

   (2.5 marks)

[P.T.O.]

6. Define Concentration (CON), Dilation (DIL), and Contrast Intensification (INT) operations. If A = 0.2/1 + 0.5/2 + 0.8/4 + 0.9/5, then obtain CON(A), DIL(A), and INT(A)

(2.5 marks)

7. Show the graphical representation of Triangular and Trapezoidal membership functions and write down the mathematical definitions of these functions clearly mentioning the number of parameters needed to describe them completely.

(2.5 marks)

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BITS, Pilani – Dubai
Dubai International Academic City, Dubai

IV Year (EEE/ME/CS/EIE)
First Semester, 2008-2009

Test 2 (Open Book)
Text Book and Class Notes may be used

Course No: EA C482
Date: 16th Nov 2008
Duration: 50 minutes

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

(Answer the questions in the sequential order.)
(Answer all the parts of a question together.)

1. Using truth table method prove the following. **[1.5 Marks]**
   $F \leftrightarrow G = (F \wedge G) \vee (\neg F \wedge \neg G)$

2. Use the resolution method to prove that $\{F, \neg F\} \Rightarrow C$ **[1.5 Marks]**

3. Prove the following using the rules of inference:
   a. $\neg [(Ax)\ P(x)] = (Ex)\ [\neg P(x)]$
   b. $(Ex)\ [P(x) \vee Q(x)] = [(Ex)\ P(x)] \vee [(E(x)\ Q(x)]$ **[4 Marks]**

4. Consider the three WFFs F, G, and H, where
   F : P(f (x, a), b) G : (Ex) P(f(x, a), b) H : (Ax) P(f(x, a), b)
   Let $D_1 = \{2, 3, 5\}$ and D_2 = the set of all natural numbers. Let I_1 and I_2 be the interpretations over D1 and D_2 respectively :
   In I_1, P "is equal to" and f is given by the following table [hereunder]
   In I_2, P "is equal to" and f is +
   Note: a is 2 and b is 5 in both I_1 and I_2

x \ y	2	3	5
2	5	5	3
3	5	3	2
5	5	2	5

   a. Show that F, G and H are valid in I_1
   b. Show that G and $\neg H$ are valid in I_2. What about F? **[3 Marks]**

[P.T.O.]

5. Find the clausal form of:

$$(Ex)\,[(Ey)\,\{P(x, y) \vee R(x)\} \rightarrow (Ez)\,Q(z,x)]$$

[2 Marks]

6. Either prove $(S \circ R)_\alpha = S_\alpha \circ R_\alpha$ or give a counter example to show that it is not true.

[3 Marks]

7. Give an example of a fuzzy relation that is both reflexive and symmetric, and another relation that is transitive.

[2 Marks]

8. Consider the ternary fuzzy relation T on U x V x W given by
$T = 0.1 / (a, x, \&) + 1/(b, x, \&) + 0.3 / (a, y, \&) + 0.7 / (a, y, *) + 0.2 / (b, y, *)$
where $U = \{a, b\}$, $V = \{x, y, z\}$ and $W = \{\&, *\}$
Compute
   a. projections T_{12}, T_{23}, and T_{13}
   b. cylindrical extensions T_{12}^{3}, T_{23}^{1}, and T_{13}^{2}
   c. cylindrical closure of the three projections of part (a)

[3 Marks]

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BITS,PILANI-DUBAI CAMPUS
Academic City, Dubai
Year III – semester I 2008-2009
Quiz 1

Course No. EA C482
Date : September 14,2008 Course Title : fuzzy logic
Time 15 minutes Max Mrks=5

NAME:----------
ID:.....

Q 1: [1 Mark]

Consider the fuzzy set A=(0.2,0.5,0.8,0.9) and B=(0.1,0.5,0.7,1) on U={a,b,c,d}. Verify that $A\alpha = B\alpha$ for $\alpha = 0.5$ even though $A \neq B$.

Q2: [2 Marks]

A and B are fuzzy sets on U={a,b,c,d} given by A=(0.2,0.5,0,0.8) and B=(0.6,0,0.8,0.3)

-a- Find FC(A), FC(B) and $FC(A \cap B)$

-b-do you observe any relation between these 3 fuzzy numbers?

Q3: [2 Marks]

Let x be linguistic variable that measures a university's academic excellence , which take the values from the universe of discourse {1,2,3,4,5,6,7,8,9}.Suppose the linguistic values for that variable includes Excellent, Good, Fair , and Bad

The membership functions of these linguistic labels are listed below:

Excellent(x) ={(8,0.2),(9,0.6),(10,1)}
Good(x) ={(6,0.1),(7,0.5),(8,0.9),(9,1),(10,1)}
Fair(x) ={(2,0.3),(3,0.6),(4,0.9),(5,1),(6,0.9), (7,0.5),(8,0.1)}
Bad(x) ={(1,1),(2,0.7),(3,0.4),(4,0.1)}

Construct the membership function of the following compound sets

a- Not Bad but Not Very Good
b- Good but Not Excellent

BITS, Pilani – Dubai
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IV Year (EEE/Mech/CS/EIE)
First Semester, 2008-2009

Quiz 1

Course No: EA UC482
Date: 23rd Sep 2008
Duration: 20 minutes

Course Title: Fuzzy Logic and Applications
Weightage: 5%
Max. Marks. 5

ID No. **Name:**

A = (0.0, 0.3, 0.2, 0.8, 0.1) is a fuzzy set on the universe U = {a, b, c, d, e}. Find the following.

1. A', the complement of A.

2. $A_{0.3}$, the α-cut of A.

3. ht(A), the height of A.

4. A_N, the normalisation of A.

5. core(A), the core of A.

6. supp(A), the support of A.

7. L(A), the level set of A.

8. 0.5A, the restricted scalar multiple of A.

9. con(A), concentration of A.

10. FC(A), the fuzzy cardinality of A.

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BITS,PILANI-DUBAI CAMPUS
Academic City, Dubai
Year IV – semester I 2008-2009
Quiz 2

Course No. EA C482 Course Title : fuzzy logic
Date : October 16,2008 Time 15 minutes Max Mrks=5

NAME:---------- ID:.....

Q 1: [1 Mark]

Let R be $\begin{bmatrix} 0.7 & 0.4 \\ 0.4 & 0 \end{bmatrix}$ show that :

$$R = 0.2 \times \begin{bmatrix} 0 & 0 \\ 1 & 0 \end{bmatrix} \cup 0.7 \times \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix} \cup 0.4 \times \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \cup \times 0.1 \begin{bmatrix} 1 & 1 \\ 1 & 0 \end{bmatrix}$$

Q2: [1 Mark]

A given relation is defined as a binary relation on domain U such that
$R: U \times U \longrightarrow [0,1]$ and $U = \{x_1, x_2, x_3, x_4, x_5\}$

$$R = \begin{bmatrix} 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 1 \end{bmatrix}$$

Check whether R is equivalent or not [verify your answer]

Q3: [1.5Marks]

A binary relation between $X = \{ x_1, x_2, x_3 \}$ and $Y = \{ y_1, y_2, y_3, y_4 \}$ is defind with the help of the following Relation Matrix :

	y_1	Y_2	Y_3	Y_4
x_1	0.1	0.2	0.3	0.2
x_2	0.2	0.1	0.5	0.7
x_3	0.5	1.0	0.8	0.6

Obtain :

1- Projection $[R \downarrow X]$ AND $[R \downarrow Y]$ [2X1.25 Marks]

2- Cylindrical Extention $[R \uparrow X]$ And $[R \uparrow Y]$

BITS, Pilani – Dubai
Dubai International Academic City, Dubai

IV Year (EEE/Mech/CS/EIE)
First Semester, 2008-2009

Quiz 2 Version A

Course No: EA UC482 | **Course Title: Fuzzy Logic and Applications**
Date: 28th Oct 2008 | **Weightage: 5%**
Duration: 20 minutes | **Max. Marks. 5**

ID No. **Name:**

1. A BFR R on U x V where U = {a, b, c} and V = {x, y} is defined by
   R = 0.6/(a,x) + 1.0/(a,y) + 0.3/(b,x) + 0.5/(b,y) + 0.4/(c,x) + 0.2/(c,y)
   What is R_2?
   a. (1, 0.5, 0.4)
   b. (0.6, 0.3, 0.2)
   c. (0.3, 0.2)
   d. (0.6, 1.0)

2. R is a fuzzy relation on U x V and S is a fuzzy relation on V x W where U = {a, b}, V = {x, y}, and W = {&, *}, given by
   R = 1.0/(a,x) + 0.4/(a,y) + 0.3/(b,x) + 0.0/(b,y)
   S = 0.7/(x,&) + 0.1/(x,*) + 0.2/(y,&) + 0.9/(y,*)
   What is S o R?
   a. 0.2/(a,&) + 0.1/(a,*) + 0.0/(b,&) + 0.1/(b,*)
   b. 0.2/(a,&) + 0.7/(a,*) + 0.3/(b,&) + 0.1/(b,*)
   c. 0.7/(a,&) + 0.4/(a,*) + 0.3/(b,&) + 0.1/(b,*)
   d. 0.9/(a,&) + 0.2/(a,*) + 0.3/(b,&) + 0.0/(b,*)

3. A BFR R is defined by

$$R = \begin{matrix} 0.0 & 0.2 & 0.1 \\ 0.2 & 1.0 & 0.5 \\ 0.1 & 0.5 & 0.3 \end{matrix}$$

   Then R is
   a. Reflexive but not symmetric
   b. Symmetric but not reflexive
   c. Both reflexive and symmetric
   d. Neither reflexive nor symmetric

4. S is a ternary fuzzy relation with six cylindric extensions S_1^{23}, S_2^{13}, S_3^{12}, S_{13}^{2}, S_{12}^{3}, S_{23}^{1}. How many cylindric closures can be constructed from these?
   a. 6
   b. 15
   c. 30
   d. 57

5. If R is BFR on U x V, then the α-cut R_α of R is a
   a. Fuzzy set on U x V
   b. Fuzzy set on U
   c. Fuzzy set on V
   d. Crisp set on U x V

6. $F \rightarrow G$ is false only when
   a. F and G are False
   b. F is False and G is true
   c. F is true and G is False
   d. F and G are True

7. How many possible interpretations can be given to a set of n propositional symbols?
   a. 2
   b. n
   c. 2n
   d. 2^n

8. Which of the following is not true?
   a. $\neg C$ is a tautology
   b. $T \equiv \neg C$
   c. $p \vee q \rightarrow p$
   d. Every propositional symbol is valid in an interpretation

9. What is the name of the inference rule $[(F \rightarrow G) \wedge (\neg G)] \rightarrow (\neg F)$?
   a. Modus Ponens
   b. Modus Tollens
   c. Syllogism
   d. Resolution

10. Which of the following is not correct?
   a. Every contradiction is equivalent to C
   b. All tautologies are equivalent to one another
   c. A contradiction is invalid
   d. All of these are correct

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BITS,PILANI-DUBAI CAMPUS
Academic City, Dubai
Year IV– semester I 2008-2009
Quiz 3

Course No. EA C482 Course Title : fuzzy logic
Date : November 11 ,2008 Time 20 minutes Max Mrks=5 [Equally Distributed]

NAME:----------
ID:.....

Q 1: [1 Mark]
Using truth table method prove the following
a- F v (¬F) = T
b- ¬ (F ⟶ G) = F ^ (¬G)

Q2: calculate the truth value for the following WFF
G: P⟶ (q ⟶ r) given I(p) = True ,I(q)= False , I(r) =True

Q3: Consider the following reasoning :
If it is raining then I'll carry an umbrella
I am not carrying an umbrella
It is not raining
Is it valid reasoning ?

Q4:

[ ]

1- Consider the WFF F: P(x,c) v Q(y) , where c is a constant .Let D = {a,b} and I be an interpretation over D such that I(c) =a and I(P) and I(Q) are given by the following table

	x	y	I(P)	I(Q)
σ_1	a	a	1	1
σ_2	a	b	1	0
σ_3	b	a	0	1
σ_4	b	b	0	0

a- prove that $v(F)(\sigma_1) = 1$

b- Compute the values of $v(F)(\sigma_2)$, $v(F)(\sigma_3)$, $v(F)(\sigma_4)$.

Q5: consider the following two WFFs P(f (x) ,y) and P (f(a),w).Check if the following is a unifiers of the above WFFs:

U = [x/a,y/b,w/b]

BITS, Pilani – Dubai
Dubai International Academic City, Dubai

IV Year (EEE/Mech/CS/EIE)
First Semester, 2008-2009

Quiz 3 – Version A

Course No: EA UC482
Date: 25th Nov 2008
Duration: 20 minutes

Course Title: Fuzzy Logic and Applications
Weightage: 5%
Max. Marks. 10

ID No. **Name:**

1. Which of the following is the correct definition of $\leftrightarrow$ in many-valued logic?
   a. $T(p \leftrightarrow q) = \max\{(T(p), T(q)\}$
   b. $T(p \leftrightarrow q) = \min\{1, 1-T(p)+T(q)\}$
   c. $T(p \leftrightarrow q) = \max\{1, 1-T(q)+T(p)\}$
   d. $T(p \leftrightarrow q) = 1 - |T(p) - T(q)|$

2. Which of the following is NOT a possible definition of $\rightarrow$ in Fuzzy Logic?
   a. $T(p \rightarrow q) = 1$, if $T(p) \leq T(q)$ and 0, otherwise.
   b. $T(p \rightarrow q) = 1$, if $T(p) \leq T(q)$ and $T(q)$, otherwise.
   c. $T(p \rightarrow q) = \max\{T(p), T(q)\}$
   d. $T(p \rightarrow q) = \min\{1, T(p) / T(q)\}$

3. What is the name given to the following rule of inference?

   If p then q
   p'
   ---
   q'
   ---

   where p, q, p', and q' are fuzzy propositions.
   a. Fuzzy Modus Tollens (FMT)
   b. Generalised Modus Ponens (GMP)
   c. Fuzzy Syllogism (FS)
   d. Fuzzy Inference Mechanism (FSM)

4. What is a necessary and sufficient condition for L_m to be contained in L_n?
   a. $m \leq n$
   b. m divides n
   c. (n-1) divides (m-1)
   d. (m-1) divides (n-1)

5. Which of the following is NOT a tautology in L_3?
   a. $[(\neg F) \rightarrow F] \rightarrow F$
   b. $F \rightarrow F$
   c. $(F \wedge G) \rightarrow (G \wedge F)$
   d. $F \rightarrow [\neg(\neg F)]$

6. If $\rightarrow$ is defined by $T(p \rightarrow p) = \min \{1, 1\text{-}T(p)+T(q)\}$ in three-valued logic, then which operation in set theory corresponds to $\rightarrow$?
   a. $\cup$
   b. $\cap$
   c. $\subseteq$
   d. $'$

7. Which of the following law of classical logic is NOT satisfied in multi-valued logic?
   a. DeMorgan's law (DM)
   b. Distributive laws (D)
   c. Law of exclude the Middle (LEM)
   d. Associative laws (A-1 and A-2)

8. Which of the following is the definition of Mamdani implication?
   a. $T[P(x) \rightarrow Q(y)] = \max [P(x), Q(y)]$
   b. $T[P(x) \rightarrow Q(y)] = \min [P(x), Q(y)]$
   c. $T[P(x) \rightarrow Q(y)] = \max \{1, 1 - P(x) + Q(y)\}$
   d. $T[P(x) \rightarrow Q(y)] = \min \{1, 1 - P(x) + Q(y)\}$

9. What operation is used in the Fuzzy Inference Mechanism (FIM) to combine the effect of all the rules in the rule base?
   a. aggregation
   b. disjunction
   c. conjunction
   d. None of these

10. The defuzzification operator MoM stands for
   a. Mean of Medians
   b. Mean of Minima
   c. Maxima of Means
   d. Mean of Maxima

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BITS, Pilani – Dubai
Dubai International Academic City, Dubai

IV Year (EEE/ME/CS/EIE)
First Semester, 2008-2009

Comprehensive Examination

Course No: EA C482 | **Course Title: Fuzzy Logic and Applications**
Date: 23rd Dec 2008 | **Weightage: 40%**
Duration: 3 Hours | **Max. Marks. 40**

(Answer Parts A and B on separate answer books.)
(Answer the questions in the sequential order.)
(Answer all the parts of a question together.)

PART – A

1. (a) Verify whether the following formulas are tautologies or contradictions.
   (i) $((\neg Q \wedge P) \wedge Q)$
   (ii) $((P \rightarrow (Q \rightarrow R)) \rightarrow ((P \rightarrow Q) \rightarrow (P \rightarrow R)))$
   (iii) $((\neg P \rightarrow Q) \rightarrow (Q \rightarrow P))$ **[3 Marks]**

   (b) Rewrite the following formulas using $\wedge$ and $\neg$ only.
   (i) $\neg (P \rightarrow (Q \rightarrow (P \vee R)))$
   (ii) $((P \vee Q) \wedge R) \rightarrow (P \vee R)$ **[2 Marks]**

   (c) Prove the following, where NOR(F, G) = $\neg$ (F $\vee$ G).
   (i) F $\vee$ G = NOR [NOR(F, G), NOR(F, G)]
   (ii) F $\wedge$ G = NOR [NOR(F, F), NOR(G, G)] **[2 Marks]**

2. (a) Find the truth values of
   (i) (Ax) (P(x) $\vee$ Q(x)), where P(x) : x = 1, Q(x) : x = 2, and the universe of discourse is {1, 2}.
   (ii) (Ax) (P $\rightarrow$ Q(x)) $\vee$ R(a), where P : 2 > 1, Q(x) : x $\leq$ 3, R(x) : x > 5, and a : 5, with the universe of discourse being {-2, 3, 6}.

   (b) Show that from **[2 Marks]**
   (i) (Ex) (F(x) $\wedge$ S(x)) $\rightarrow$ (Ay) (M(y) $\rightarrow$ W(y)) and
   (ii) (Ey) (M(y) $\wedge \neg$ W(y))
   the conclusion (Ax) (F(x) $\rightarrow \neg$ S(x)) follows. **[3 Marks]**

3. (a) Show by an example that supp(A') = [supp(A)]' and by another example that supp(A') $\neq$ [supp(A)]'. What is your conclusion? **[2 Marks]**

   (b) A and B are fuzzy sets on U = {a, b, c, d} given by
   A = (0.2, 0.5, 0, 0.8), B = (0.6, 0, 0.8, 0.3)
   (i) Find FC(A), FC(B), FC(A $\cap$ B).
   (ii) Do you observe any relation between these fuzzy sets? **[2 Marks]**

[P.T.O.]

4. Prove the following, where α is in [0, 1].
   (i) $(A \cup B)_\alpha = A_\alpha \cup B_\alpha$
   (ii) $\alpha(A \cap B) = \alpha A \cap \alpha B$

[4 Marks]

PART – B

5. Suppose, in a biotechnology experiment, three potentially new strains of bacteria have been detected in the area around an anaerobic corrosion pit on new aluminum – lithium alloy used in the fuel tanks of a new experimental aircraft. In order to propose methods to eliminate the biocorrosion caused by these bacteria , the three strains must first be categorized. One way to categorize them is to compare them to one another. In a pair wise comparison ,the following "similarity" relation R is developed. For example in [column 1] , first strain has a strength of similarity to second strain of 0.8 , and to the third strain a strength of 0(i.e., no relation).

$$R=\begin{bmatrix} 1 & 0.8 & 0.0 \\ 0.8 & 1 & 0.4 \\ 0.0 & 0.4 & 1 \end{bmatrix}$$

(a) Check if Similarity relation is equivalence or not?
(b) If not equivalence, convert it into equivalence.

[5 Marks]

6. A certain type of virus attacks cells of human body. The infected cells can be visualized using a special microscope. The microscope generates digital images that medical doctors can analyze and identify the infected cells . the virus causes the infected cells to have a black spot , within darker grey region.

   A digital image process can be applied to the image .This processing generates two variables: the first variable, P is related to black spot quantity (black pixels), and the second variable S is related to the shape of the black spot, i.e. if they are circular or elliptic. In these images it is often difficult to actually count the number of black pixels, or to identify a perfect circular cluster of pixels: hence, both these variables must be estimated in linguistic way.

   Let P and S the two fuzzy sets representing the number of black pixel and the shape of black pixel clusters respectively.

   $P=\{ 0.1/C_1 + 0.5/C_2 + 1.0/C_3\}$ AND $S = \{0.3/S_1 + 0.8/S_2\}$

   Where C_1 none with black pixels , C_2 a few with a black pixels , C_3 a lot of black pixels

   S_1 is an ellipse and S_2 is a circle. Find:

(a) The relation R between P and S, such that $R = P \times S = \text{Min}\,(\mu_p(C_i), \mu_s(S_j))$ [i=1…3 & j= 1..2].
(b) Suppose another microscope image is taken as $P'=\{ 0.4/C_1 + 0.7/C_2 + 1.0/C_3\}$ what will be the new fuzzy set of pixels cluster shapes?

[5 Marks]

[P.T.O.]

7. A factory process control operation involves two linguistic (atomic) parameters consisting of pressure and temperature in fluid delivery system. Nominal pressure limits from 400psi minimum to 1000 psi maximum. Nominal temperature limits are 130 to 140 F. We characterize each parameter in fuzzy linguistic terms as follow:

"Low Temperature " = {1/131 , 0.8/132 , 0.6/133 , 0.4/134 , 0.2/135 , 0/136}
"High Temperature " = { 0/134 , 0.2/135 , 0.4/136 , 0.6/137 , 0.8/138 , 1/139}
"High Pressure " = {0/400 , 0.2/600, 0.4/700 , 0.6/800 , 0.8/900 , 1/1000}
" Low Pressure" = { 1/400 , 0.8/600 , 0.6/700 , 0.4/800 , 0.2/900 , 0/1000}

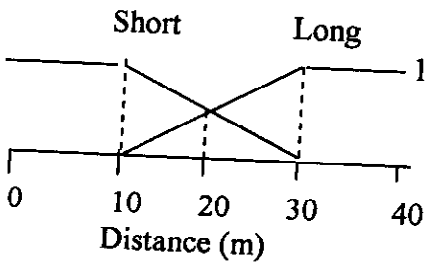
Find the following membership functions:
(a) Temperature not very low.
(b) Pressure intensely low.
(c) Temperature not very low and not very high.
(d) Pressure slightly low or low.

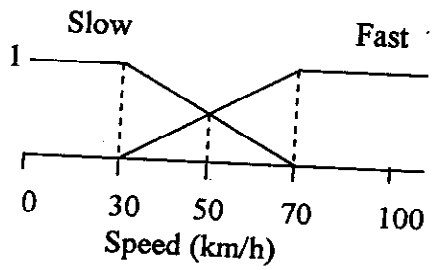
[5 Marks]

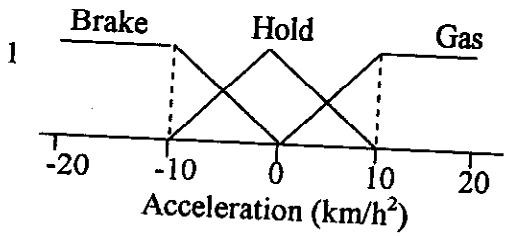
8. In applying the fuzzy logic to an automotive driving situation , we are considering the speed and distance between cars. Assume the following rules for this logic:

Rule 1: IF	distance between cars is short
AND	speed is low,
THEN	hold the gas pedal steady (maintain the speed).
Rule 2 : IF	distance between cars is short
AND	speed is fast,
THEN	step on the brake (reduce the speed).
Rule 3 : IF	distance between cars is long
AND	speed is slow,
THEN	step on the gas pedal (increase the speed).
Rule 4 : IF	distance between cars is long
AND	speed is fast,
THEN	hold the gas pedal steady (maintain the speed).

The membership functions for driving are given below:







a- Determine the linguistic variables and their domains.
b- Determine the linguistic value for each variable.
c- Construct the Rule table for driving.
d- Based on Madman's Direct Method ,sketch roughly the Reasoning process for the following input [distance between cars 15m and the speed 60km/h].Guess linguistically the conclusion .

[5 Marks]

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