Assignment-01

Course Code: CSE 6131

Course Title: Computational Intelligence

Section: M

Submitted by

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Ans To The Q. No - 1 (a)

Fuzzy Logic: Fuzzy logic is an approach to variable Processing that allows for multiple Possible truth values to be Processed through the same variable. Fuzzy logic attempts to solve Problems with an open, imprecise spectrum of data and heuristics that makes it Possible to obtain an array of accurate Conclusions

Distinguishment between Crisp and Fuzzy Logic

Crisp Logic	Fuzzy Logic
i. The degree of truth is 0 or 1.	i. The degree of truth is between 0 and 1.
ii. Elements is either the member of a set or not.	ii. Elements are allowed to be Partially included in set.
iii. It Can't deal with representation of human intelligence.	iii. It Can deal with representation of human intelligence.
iv. Elements is either the member of a set or not.	iv. Elements are allowed to be Partially included in set.
v. Used in Digital Design	v. Used in fuzzy Controllers.
vi Binary Logic.	vi Continuous valued logic.

Ans To The Q.No → 1 (b)

fuzzy logic based system is largely used in modern Control systems such as expert systems. Fuzzy logic is used with Neural Networks, because it can mimic how a person would make decisions only much fasten. The importance of fuzzy based logic system in real life described below

i. Simplicity
ii. Rapid Prototyping
iii. Easier to design
iv. Increased Robustness
v. Simple knowledge representation
vi. Few rules for great Complexity

Ans To The q.No - 1(c)

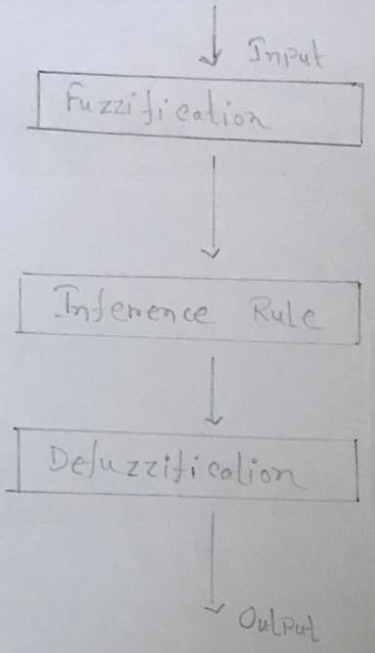
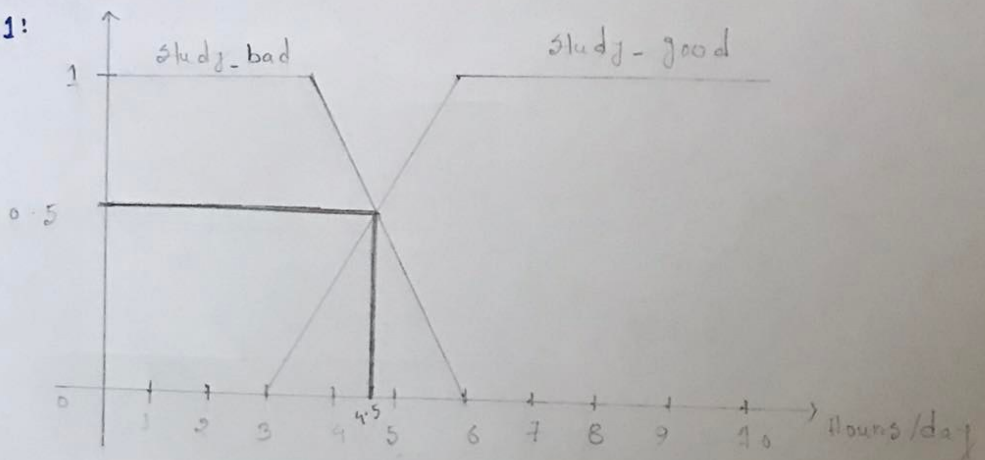


Fig: Diagram of a Fuzzy Logic System

The fuzzy logic system can be divided into three parts. In Fuzzification, the Component transforms raw inputs into fuzzy sets. In rule of inference, set theory is closely related to the truth finding logical statements. In defuzzification fuzzy sets are transformed into explicit output. Membership function is a graphical representation of a fuzzy set. The whole thing is explained with an example. Let's say a Problem statement given to find obtained mark of a student who studied 4.5 hours & slept 7.5 hours in a day. Regarding this three sets are given with graphs STUDY_HOUR {study_bad, study_good}, SLEEPING_HOUR {under_sleep, well_sleep, over_sleep} & STUDENT {GOOD, BAD}.

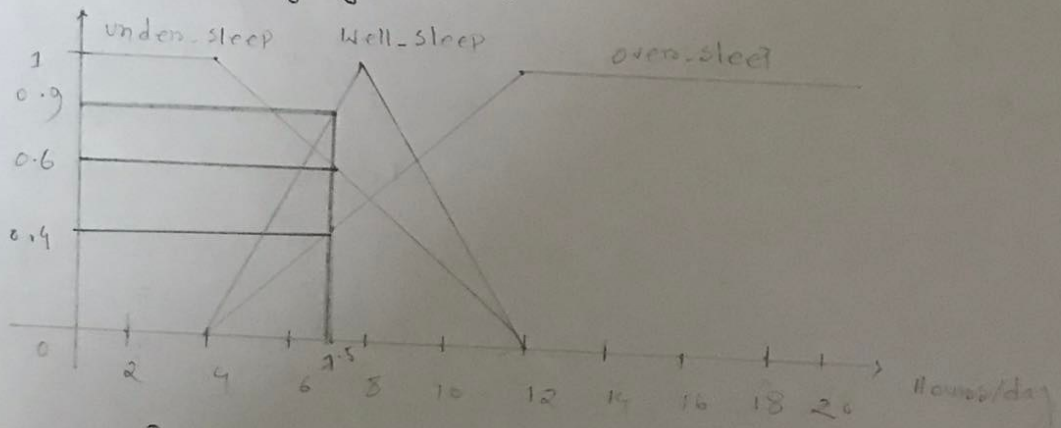
At first from graphs we will find out Degree of Membership. Which means Fuzzification Technique will be applied.

Step 1:



Degree:

study_bad = 0.5
study_good = 0.5



Degree:

well_sleep = 0.9
Under_sleep = 0.6
Over_sleep = 0.4

Step 2:

For Inference Rule, Lets assume 2 rules been given.

Rule 1: If a student studies & sleeps well, he will be a good student.

According to Rule 1:

study_good $\wedge$ well_sleep = $0.5 \wedge 0.9$
= min (0.5, 0.9)
= 0.5 (good)

Rule 2: If a student studies bad, and sleeps bad or over, he will be bad student.

According to Rule 2:

Study_bad ∧ (under_sleep ∨ over_sleep) = 0.5 ∧ (0.6 ∨ 0.

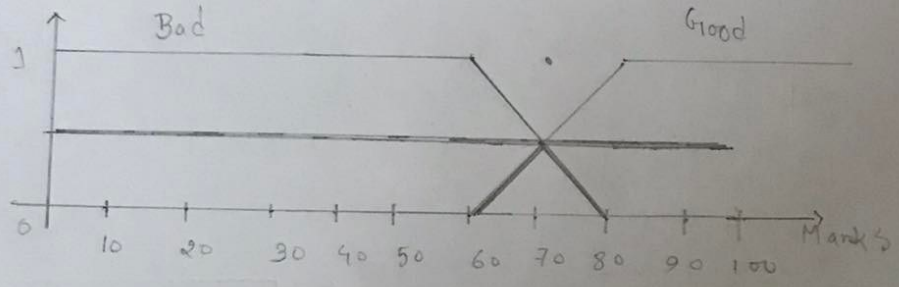
~~= 0.5 ∧ (0.6~~

= 0.5 ∧ 0.6

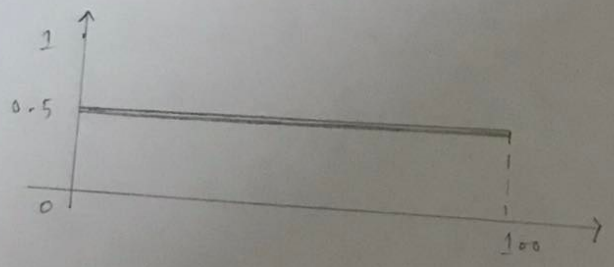
= min(0.5, 0.6)

= 0.5 (bad)

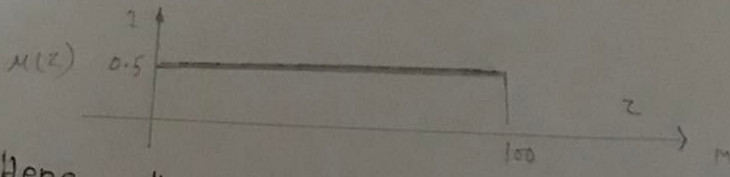
From Membership Function of a STUDENT, in the graph now we will draw envelop.



After ORing operation



Step 3: Applying Centroid defuzzification



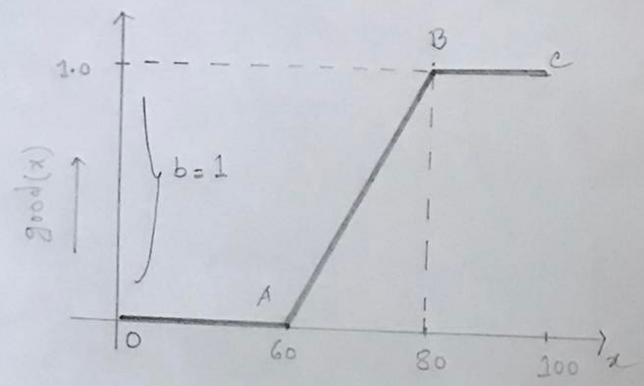
Here the graph represents a Rectangular area so, obtained Marks = $\mu(z) * z$

= 0.5 * 100

= 50

Ans To The Q.No - 2(a)

Fuzzification of good(x):



$$good(x) = \begin{cases} OA, & \text{where } 0 \le x \le 60 \\ AB, & \text{where } 60 < x < 80 \\ BC, & \text{where } 80 \le x \le 100 \end{cases}$$

For OA

OA is on x-axis

So, the equation of OA:

$$Y = 0$$

$$\Rightarrow good(x) = 0$$

For AB

$$A \equiv (60, 0)$$
$$B \equiv (80, 1)$$

Equation of AB:

$$\frac{Y - Y_1}{Y_1 - Y_2} = \frac{x - x_1}{x_1 - x_2}$$

$$\Rightarrow \frac{Y - 0}{0 - 1} = \frac{x - 60}{60 - 80}$$

$$\Rightarrow \frac{Y}{-1} = \frac{x - 60}{-20}$$

$$\Rightarrow \frac{Y}{1} = \frac{x - 60}{20}$$

$$\Rightarrow 20Y = x - 60$$

$$\Rightarrow Y = \frac{x - 60}{20}$$

$$\Rightarrow good(x) = \frac{x - 60}{20}$$

For BC

BC is Parallel to x axis

Equation of BC:

$y = b$

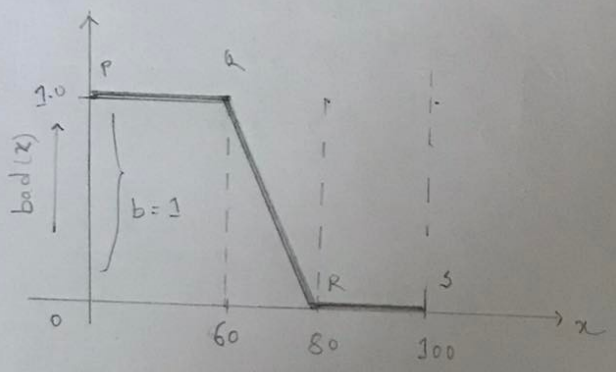
$\Rightarrow y = 1$

$\Rightarrow good(x) = 1$

So,

$$good(x) = \begin{cases} 0 & 0 \le x \le 60 \\ \frac{x-60}{20} & 60 < x < 80 \\ 1 & 80 \le x \le 100 \end{cases}$$

Fuzzification of bad(x):



$$bad(x) = \begin{cases} PQ, & \text{where } 0 \le x \le 60 \\ QR, & \text{where } 60 < x < 80 \\ RS, & \text{where } 80 \le x \le 100 \end{cases}$$

For PQ

PQ is Parallel to x-axis

So, the equation of PQ:

$y = b$

$\Rightarrow bad(x) = 1$

For QR

$Q \equiv (60, 1)$

$R \equiv (80, 0)$

So, the equation of QR:

$$\frac{y - y_1}{y_1 - y_2} = \frac{x - x_1}{x_1 - x_2}$$

$$\Rightarrow \frac{y - 1}{1 - 0} = \frac{x - 60}{60 - 80}$$

$$\Rightarrow \frac{Y-1}{1} = \frac{x-60}{-20}$$

$$\Rightarrow -20Y + 20 = x - 60$$

$$\Rightarrow 20Y = -x + 60 + 20$$

$$\Rightarrow 20Y = 80 - x$$

$$\Rightarrow Y = \frac{80-x}{20}$$

$$\Rightarrow bad(x) = \frac{80-x}{20}$$

For RS

RS is on x-axis

So, the equation of RS:

$$Y = 0$$

$$\Rightarrow bad(x) = 0$$

So,

$$bad(x) = \begin{cases} 1 & 0 \le x \le 60 \\ \frac{80-x}{20} & 60 < x < 80 \\ 0 & 80 \le x \le 100 \end{cases}$$

good (73)

where $x = 73$

which means $60 < x < 80$ is applicable

$$good(x) = \frac{x-60}{20}$$

$$= \frac{73-60}{20}$$

$$= \frac{13}{20}$$

$$= 0.65$$

bad (52)

where $x = 52$

which means $0 \le x \le 60$ is applicable

$$bad(x) = 1$$

So, NOT (good(73) AND bad(52))

= NOT (0.65 AND 1)

= NOT (0.65)

= 0.35 [NOT (0.65) = 1 - 0.65 = 0.35]

Ans To The Q. No - 2(b)

Maximum defuzzification technique is also called the height method. It's only accurate for peaked output. Mean of Max is closely related to the Max Membership Principle.

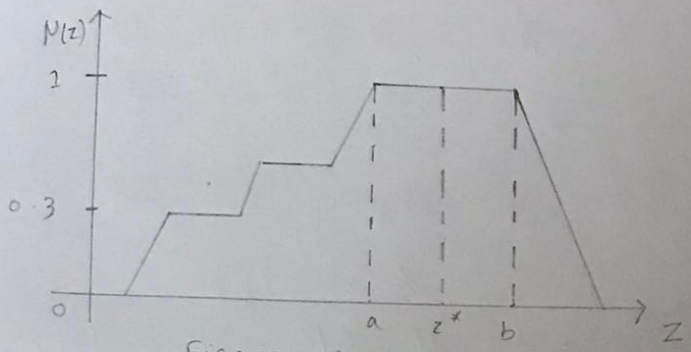


Fig: Max & Mean of Max Defuzzification

For Maximum Defuzzification

$\mu(z^*) \geq \mu(z)$ for all $z \in Z$

z^* is the defuzzified value

For Mean of Maximum Defuzzification

$$z^* = \frac{a+b}{2}$$

z^* is the defuzzified value.

Ans To The Q. No - 2(c)

Given,

The mixture of apples & oranges in the ratios 0:6, 1:5, 2:4, 3:3, 4:2, 5:1 and 6:0

For the given Problem,

Crisp set = {No, No, No, No, No, No, YES}
= {0, 0, 0, 0, 0, 0, 1}

Fuzzy set = {No, slightly, somewhat, sort of, Few, Mostly, Absolutely}
= {0, 1/6, 2/6, 3/6, 4/6, 5/6, 6/6}

Ans To The Q. No - 3

Step 1: Fuzzification or Membership Function Construction

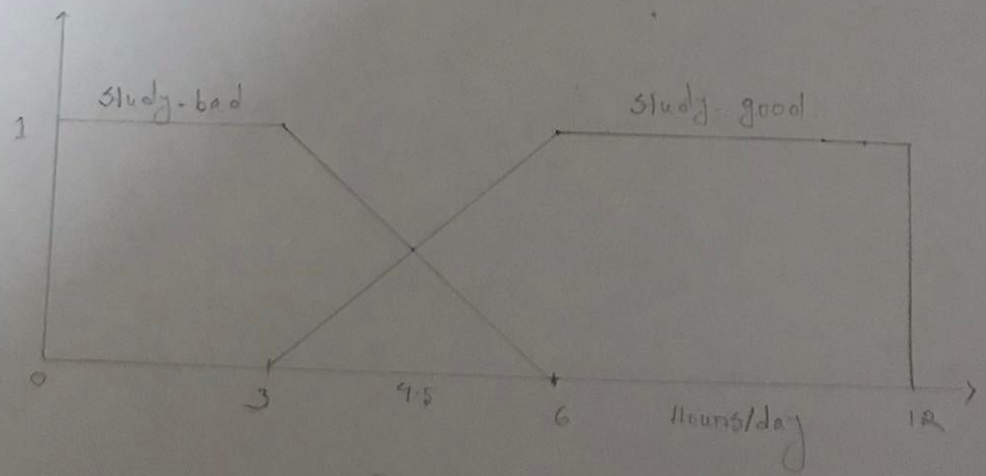


Fig. Membership function for STUDY_HOUR

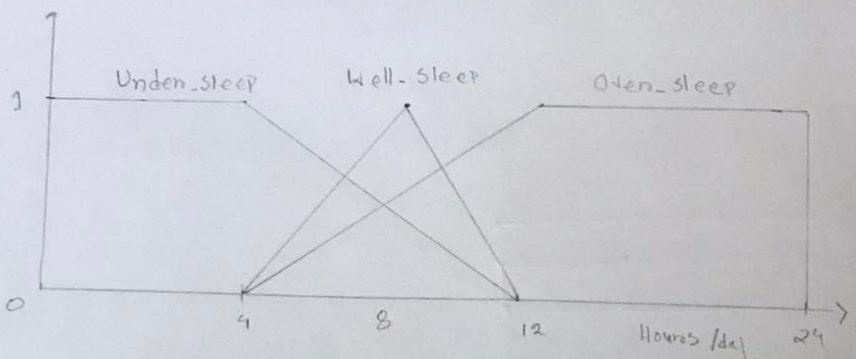


Fig: Membership function for SLEEPING_HOUR

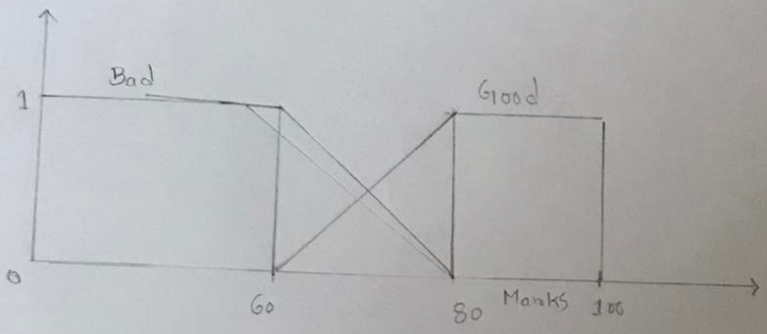
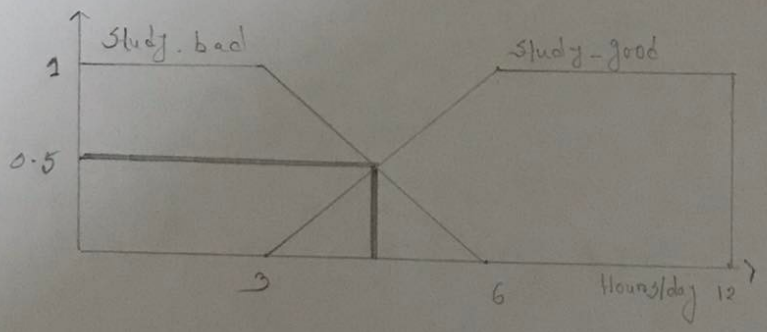


Fig: Membership function for a STUDENT

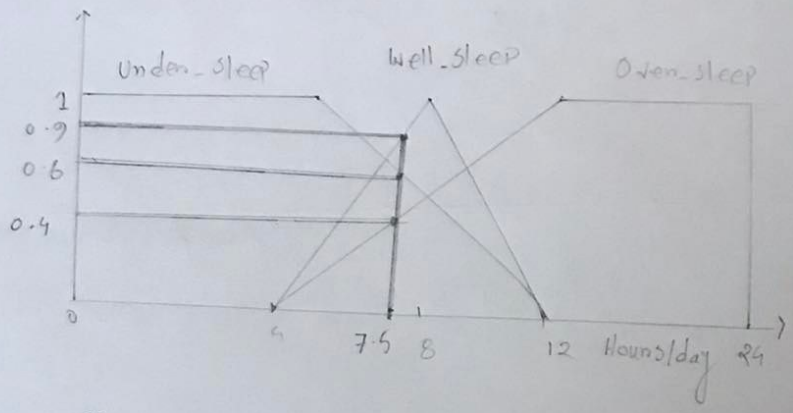
STUDY_HOUR {study_bad, study_good}



Degree:

study_bad = 0.5
study_good = 0.5

SLEEPING_HOUR {Under_Sleep, Well_Sleep, Over_Sleep}



Degree:

Under_Sleep = 0.6
Well_Sleep = 0.9
Over_Sleep = 0.4

Step 2: Applying Fuzzy Rule

Rule 1: If a student studies and sleeps well, he will be good student.

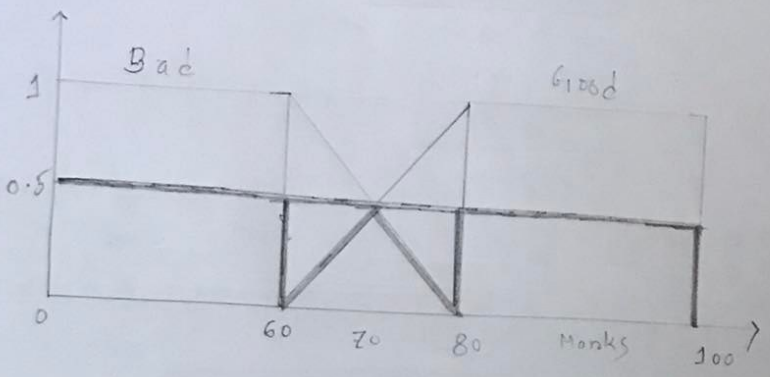
Rule 2: If a student studies bad, and sleeps bad or over, he will be bad student.

According to Rule 1:

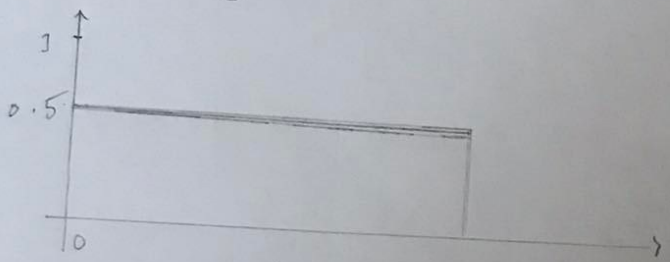
Study_good ∧ Well_Sleep = 0.5 ∧ 0.9
= min (0.5, 0.9)
= 0.5 (good)

According to Rule 2:

~~Study_good~~
Study_bad ∧ (Under_Sleep ∨ Over_Sleep) = 0.5 ∧ (0.6 ∨ 0.4)
= 0.5 ∧ 0.6
= min (0.5, 0.6)
= 0.5 (bad)

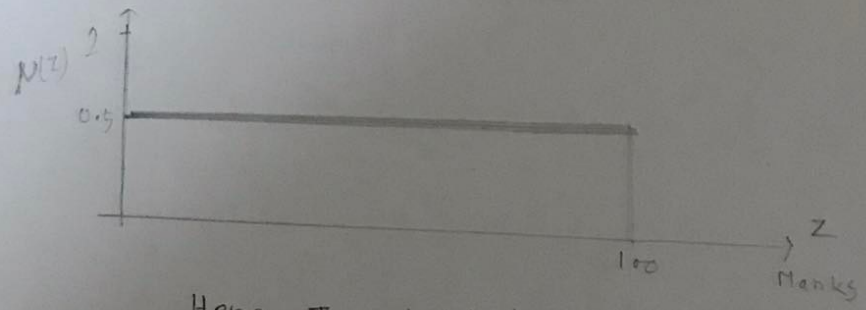


After OR ing Operation



Step 3: Defuzzification Technique

We are applying Centroid Defuzzification Technique.



Here, The bold horizontal line is Parallel to Z axis

So,

$Y = b$

$\Rightarrow \mu(z) = 0.5$

$$\text{Obtained Marks} = \frac{\int_0^{100} z\, N(z)\, dz}{\int_0^{100} N(z)\, dz}$$

$$= \frac{\int_0^{100} z\, 0.5\, dz}{\int_0^{100} 0.5\, dz}$$

$$= \frac{N}{D}$$

N = Numeration $= \int_0^{100} z\, 0.5\, dz$

$$= 0.5 \int_0^{100} z\, dz$$

$$= 0.5 \left[\frac{z^2}{2}\right]_0^{100}$$

$$= 0.5 \left[\frac{(100)^2}{2} - \frac{(0)^2}{2}\right]$$

$$= 0.5 \times \frac{10000}{2}$$

$$= 0.5 \times 5000$$

$$= 2500$$

D = Denomination $= \int_0^{100} 0.5\, dz$

$$= 0.5 \int_0^{100} dz$$

$$= 0.5 \left[z\right]_0^{100}$$

$$= 0.5 \left[100 - 0\right]$$

$$= 0.5 \times 100$$

$$= 50$$

So Obtained Marks $= \frac{N}{D} = \frac{2500}{50}$

$$= 50$$

Ans To the q.No - 4(a)

Given, $A = \{0.8, 0.9, 0.1\}$ and $B = \{0.9, 0.5, 0.8\}$

Fuzzy logic in Multi element sets:

$A \equiv (0.8 \quad 0.9 \quad 0.1)$

$B \equiv (0.9 \quad 0.5 \quad 0.8)$

Operation	Fuzzy logic
$A \cup B$	$(0.9 \quad 0.9 \quad 0.8)$
$A \cap B$	$(0.8 \quad 0.5 \quad 0.1)$
$B \subset A$	(NO YES NO)
$A \mid B$	$(0 \quad 0.4 \quad 0)$
A^c	$(0.2 \quad 0.1 \quad 0.9)$
B^c	$(0.1 \quad 0.5 \quad 0.2)$

Crisp logic in Multi element sets:

From $A \cup B$ we got $(0.9 \quad 0.9 \quad 0.8)$ [Above Table]
In Crisp set it would be $(1 \quad 1 \quad 1)$

From $A \cap B$ we got $(0.8 \quad 0.5 \quad 0.1)$ [Above Table]
In Crisp set it would be $(1 \quad 1 \quad 0)$

From $B \subset A$ we got (NO YES NO) [Above Table]
In Crisp set it would be $(0 \quad 1 \quad 0)$

From $A \mid B$ we got $(0 \quad 0.4 \quad 0)$ [Above Table]
In Crisp set it would be $(0 \quad 1 \quad 0)$

From A^c we got $(0.2 \quad 0.1 \quad 0.9)$ [Above Table]
In Crisp set it would be $(0 \quad 0 \quad 1)$

From B^c we got $(0.1 \quad 0.5 \quad 0.2)$ [Above Table]
In Crisp set it would be $(0 \quad 1 \quad 0)$

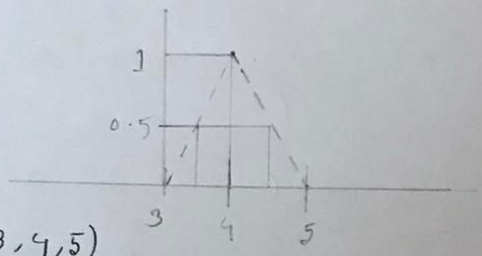
Ans To the Q.No - 4(b)

Given $((a^3+b^3)/(a-b))$

also

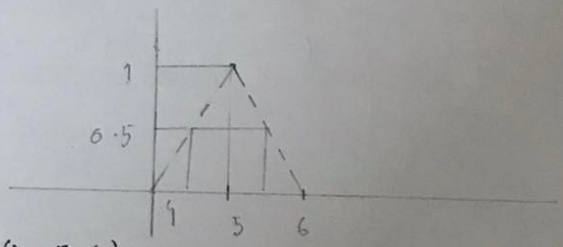
a = fuzzy 4 and b = fuzzy 5

A Fuzzy 4 with a triangular Membership Function



So, a = (3, 4, 5)

A Fuzzy 5 with a triangular Membership Function



So, b = (4, 5, 6)

Here,

$$((a^3+b^3)/(a-b)) = \frac{a^3+b^3}{a-b}$$

a^3 means, a x a x a

b^3 means, b x b x b

So, a x a = (16 - 2, 16, 16 + 2) = (14, 16, 18)

Now

(a x a) x a = (64 - 3, 64, 64 + 3) = (61, 64, 67)

Again

b x b = (25 - 2, 25, 25 + 2) = (23, 25, 27)

Now

(b x b) x b = (125 - 3, 125, 125 + 3) = (122, 125, 128)

So, a^3 = (61, 64, 67) and b^3 = (122, 125, 128)

$a^3 + b^3 = (189 - 6 , 189 , 189 + 6)$

$= (183, 189, 195)$

$a - b = (-1 - 2 , -1 , -1 + 2)$

$= (-3, -1, 1)$

Now

$$\frac{a^3 + b^3}{a - b} = (-189 - 8, -189, -189 + 8)$$

$= (-197, -189, -181)$

(Showed)

Ans To The Q.No - 4(c)

Given

Fuzzy 4 as (3, 4, 5)

fuzzy 5 as (4, 5, 6)

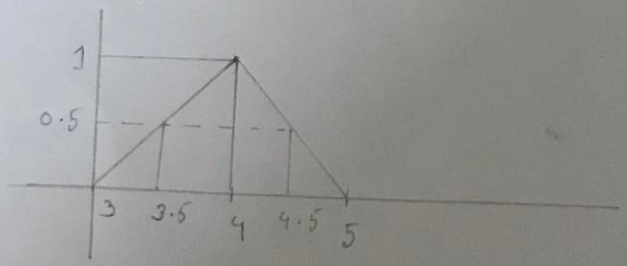


Fig: Fourness with a triangular Membership Function

Membero	Degree ~~Me~~ of Membership (μ)
3	0
3.5	0.5
4	1
4.5	0.5
5	0

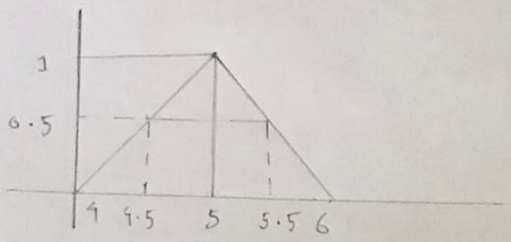


Fig: Fiveness with a triangular Membership function

Member	Degree of Membership (μ)
4	0
4.5	0.5
5	1
5.5	0.5
6	0

So, $\mu(3.5) + \mu(5.5) = 0.5 + 0.5 = 1$

[Value of $\mu(3.5)$ got from first table, Value of $\mu(5.5)$ got from second table)

So, $\mu(3.5) + \mu(5.5) = 1$.

Ans To The Q.No - 4(d)

Fuzzy Inference Rule: It is a method that interprets the values in the input vector and based on some sets of rules, assigns values to the output vector.

Importance of fuzzy inference rule

i. Computationally efficient
ii. Functions well with linear technique

Ans To The Q. No - 4(e)

Diagrams of different Fuzzification Techniques on Membership function.

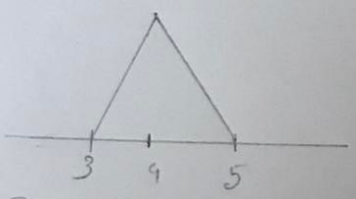


Fig: Triangular

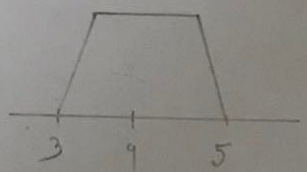


Fig: Trapezoid

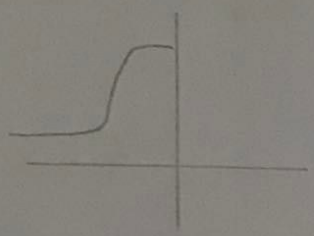


Fig: s function

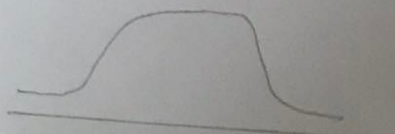


Fig: Pi function

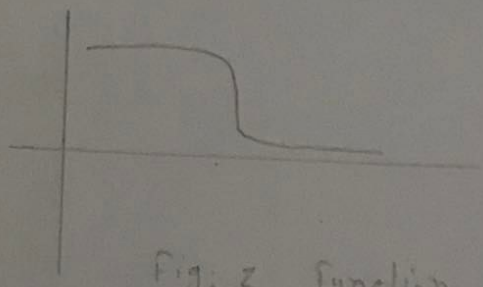


Fig: z function
