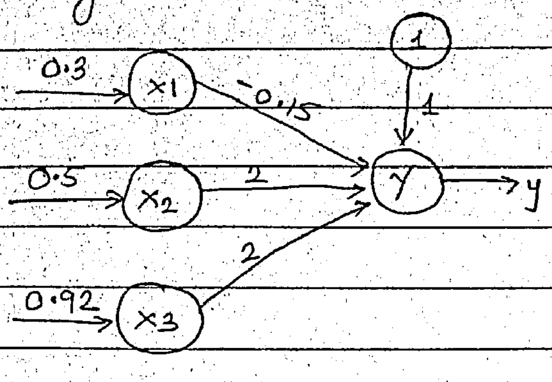
AISC

Q.I] For the given network calculate net input to the output neuron:-



Soln:- Here, in this neural network we have 3 input neurons, a bias and an output neurons.

The inputs and ~~at~~ the weights are :-

$[x_1, x_2, x_3] = [0.3, 0.5, 0.92]$

$[w_1, w_2, w_3] = [-0.15, 2, 2]$

$$\therefore \quad y_{in} = b + \sum_{i=1}^{n} x_i w_i$$

$$= 1 + (0.3)(-0.15) + (0.5)(2) + (0.92)(2)$$

$$= \underline{\underline{3.795}}$$

Therefore, $y_{in} = 3.795$ is the net input.

Q.II] For the following fuzzy sets

$$P = \left\{ \frac{0.1}{2} + \frac{0.3}{4} + \frac{0.7}{6} + \frac{0.4}{8} + \frac{0.2}{10} \right\}$$

$$Q = \left\{ \frac{0.1}{0.1} + \frac{0.3}{0.2} + \frac{0.3}{0.3} + \frac{0.4}{0.4} + \frac{0.5}{0.5} + \frac{0.2}{0.6} \right\}$$

$$T = \left\{ \frac{0.1}{0} + \frac{0.7}{0.5} + \frac{0.3}{1} \right\}$$

The following operations is to be performed:-

1) $R = P \times Q$

2) $S = Q \times T$

3) $M = R \circ S$

4) $M = R \bullet S$

Soln:- 1) $R = P \times Q$

$$R = \begin{bmatrix} 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 \\ 0.1 & 0.3 & 0.3 & 0.3 & 0.3 & 0.2 \\ 0.1 & 0.3 & 0.3 & 0.4 & 0.5 & 0.2 \\ 0.1 & 0.3 & 0.3 & 0.4 & 0.4 & 0.2 \\ 0.1 & 0.2 & 0.2 & 0.2 & 0.2 & 0.2 \end{bmatrix}$$

$\mu_R(x_1, y_1) = \min\{\mu_P(x_1), \mu_Q(y_1)\}$
$= \min\{0.1, 0.1\} = 0.1$

$\mu_R(x_1, y_2) = \min\{\mu_P(x_1), \mu_Q(y_2)\}$
$= \min\{0.1, 0.3\} = 0.1$

$\mu_R(x_1, y_3) = \min\{\mu_P(x_1), \mu_Q(y_3)\}$
$= \min\{0.1, 0.3\} = 0.1$

$\mu_R(x_1, y_4) = \min\{\mu_P(x_1), \mu_Q(y_4)\}$
$= \min\{0.1, 0.4\} = 0.1$

$\mu_R(x_1, y_5) = \min\{\mu_P(x_1), \mu_Q(y_5)\}$
$= \min\{0.1, 0.5\} = 0.1$

$\mu_R(x_1, y_6) = \min\{\mu_P(x_1), \mu_Q(y_6)\}$
$= \min\{0.1, 0.2\} = 0.1$

Illy, we can find $\mu_R(x_2, y_i)$ $\mu_R(x_3, y_i)$ $\mu_R(x_4, y_i)$ & $\mu_R(x_5, y_i)$.

2] $S = Q \times T$

$$
S = \begin{bmatrix} 0.1 & 0.1 & 0.1 \\ 0.1 & 0.3 & 0.3 \\ 0.1 & 0.3 & 0.3 \\ 0.1 & 0.4 & 0.3 \\ 0.1 & 0.5 & 0.3 \\ 0.1 & 0.2 & 0.2 \end{bmatrix}
$$

$$\mu_S(y_1, z_1) = \min\{\mu_Q(y_1), \mu_T(z_1)\}$$
$$= \min\{0.1, 0.1\} = 0.1$$

$$\mu_S(y_1, z_2) = \min\{\mu_Q(y_1), \mu_T(z_2)\}$$
$$= \min\{0.1, 0.7\} = 0.1$$

$$\mu_S(y_1, z_3) = \min\{\mu_Q(y_1), \mu_T(z_3)\}$$
$$= \min\{0.1, 0.3\} = 0.1$$

3] $M = R \circ S$ [Max-min composition]

$$
M = \begin{array}{c} \\ x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{array}
\begin{array}{c} \begin{array}{cccccc} y_1 & y_2 & y_3 & y_4 & y_5 & y_6 \end{array} \\
\begin{bmatrix} 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 \\ 0.1 & 0.3 & 0.3 & 0.3 & 0.3 & 0.2 \\ 0.1 & 0.3 & 0.3 & 0.4 & 0.5 & 0.2 \\ 0.1 & 0.3 & 0.3 & 0.4 & 0.4 & 0.2 \\ 0.1 & 0.2 & 0.2 & 0.2 & 0.2 & 0.2 \end{bmatrix} \end{array}
\circ
\begin{array}{c} \\ y_1 \\ y_2 \\ y_3 \\ y_4 \\ y_5 \\ y_6 \end{array}
\begin{array}{c} \begin{array}{ccc} z_1 & z_2 & z_3 \end{array} \\
\begin{bmatrix} 0.1 & 0.1 & 0.1 \\ 0.1 & 0.3 & 0.3 \\ 0.1 & 0.3 & 0.3 \\ 0.1 & 0.4 & 0.3 \\ 0.1 & 0.5 & 0.3 \\ 0.1 & 0.2 & 0.2 \end{bmatrix} \end{array}
$$

$$\cancel{\therefore \mu_M(x_1, z_1) = \max\{\min(\mu_R(x_1, y_1), \mu_S(y_1, z_1))\}}$$
$$\cancel{= \max\{\min(0.1, 0.1)\}}$$
$$\cancel{= \max\{0.1}$$

$$\mu_M(x_1, z_1) = \max\{\min(\mu_R(x_1, y_1), \mu_S(y_1, z_1)),$$
$$\min(\mu_R(x_1, y_2), \mu_S(y_2, z_1)),$$
$$\min(\mu_R(x_1, y_3), \mu_S(y_3, z_1)),$$
$$\min(\mu_R(x_1, y_4), \mu_S(y_4, z_1)),$$
$$\min(\mu_R(x_1, y_5), \mu_S(y_5, z_1)),$$
$$\min(\mu_R(x_1, y_6), \mu_S(y_6, z_1))\}$$

$$\therefore \mu_M(x_1, z_1) = \max\{\min(0.1,0.1), \min(0.1,0.1), \min(0.1,0.1), \min(0.1,0.1), \min(0.1,0.1), \min(0.1,0.1)\}$$
$$= \max\{0.1, 0.1, 0.1, 0.1, 0.1, 0.1\} = \underline{\underline{0.1}}$$

$$\therefore \mu_M(x_1, z_2) = \max\{\min(0.1,0.1), \min(0.1,0.3), \min(0.1,0.3), \min(0.1,0.4), \min(0.1,0.5), \min(0.1,0.2)\}$$
$$= \max\{0.1, 0.1, 0.1, 0.1, 0.1, 0.1\} = \underline{0.1}$$

$$\mu_M(x_1, z_3) = \max\{\min(0.1,0.1), \min(0.1,0.3), \min(0.1,0.3), \min(0.1,0.3), \min(0.1,0.3), \min(0.1,0.2)\}$$
$$= \max\{0.1, 0.1, 0.1, 0.1, 0.1, 0.1\} = \underline{\underline{0.1}}$$

$$\therefore M = \begin{array}{c|ccc} & z_1 & z_2 & z_3 \\ \hline x_1 & 0.1 & 0.1 & 0.1 \\ x_2 & 0.1 & 0.3 & 0.3 \\ x_3 & 0.1 & 0.5 & 0.3 \\ x_4 & 0.1 & 0.4 & 0.3 \\ x_5 & 0.1 & 0.2 & 0.2 \\ x_6 & 0.1 & & \end{array}$$

4] $M = R \circ S$

$$\mu_M(x_1, z_1) = \max\{\mu_R(x_1,y_1) \bullet \mu_S(y_1,z_1),$$
$$\mu_R(x_1,y_2) \bullet \mu_S(y_2,z_1),$$
$$\mu_R(x_1,y_3) \bullet \mu_S(y_3,z_1),$$
$$\mu_R(x_1,y_4) \bullet \mu_S(y_4,z_1),$$
$$\mu_R(x_1,y_5) \bullet \mu_S(y_5,z_1),$$
$$\mu_R(x_1,y_6) \bullet \mu_S(y_6,z_1)\}$$

$$\therefore \mu_M(x_1, z_1) = \max\{0.01, 0.01, 0.01, 0.01, 0.01, 0.01\}$$
$$= 0.01$$

$$\mu_M(x_1, z_2) = \max\{\cancel{0.01, 0.09, 0.09, 0.12, 0.15,}\ 0.01, 0.03, 0.03, 0.04, 0.05, 0.02\}$$
$$= 0.05$$

$$\mu_M(x_1, z_3) = \max\{0.01, 0.03, 0.03, 0.03, 0.03, 0.02\}$$
$$= 0.03$$

$$\therefore M = R \circ S$$

$$\begin{array}{c|ccc|}
 & z_1 & z_2 & z_3 \\
= x_1 & 0.01 & 0.05 & 0.03 \\
x_2 & 0.03 & 0.15 & 0.09 \\
x_3 & 0.05 & 0.25 & 0.15 \\
x_4 & 0.04 & 0.2 & 0.12 \\
x_5 & 0.02 & 0.1 & 0.06
\end{array}$$

Q. III

$$A = \left\{\frac{0.2}{x_1} + \frac{0.3}{x_2} + \frac{0.4}{x_3} + \frac{0.7}{x_4} + \frac{0.1}{x_5}\right\}$$

$$B = \left\{\frac{0.4}{x_1} + \frac{0.5}{x_2} + \frac{0.6}{x_3} + \frac{0.8}{x_4} + \frac{0.9}{x_5}\right\}$$

$\lambda = 0.6$ for the foll operations :-

$\overline{\underset{\sim}{A} \cup \underset{\sim}{B}}$, $\underset{\sim}{A} \cap \underset{\sim}{B}$

Solⁿ:-

$$\underset{\sim}{A} \cup \underset{\sim}{B} = \max\{\mu_{\underset{\sim}{A}}(x), \mu_{\underset{\sim}{B}}(x)\}$$

$$= \left\{\frac{0.4}{x_1} + \frac{0.5}{x_2} + \frac{0.6}{x_3} + \frac{0.8}{x_4} + \frac{0.9}{x_5}\right\}$$

$$\overline{\underset{\sim}{A} \cup \underset{\sim}{B}} = 1 - \underset{\sim}{A} \cup \underset{\sim}{B}$$
$$= \left\{\frac{0.6}{x_1} + \frac{0.5}{x_2} + \frac{0.4}{x_3} + \frac{0.2}{x_4} + \frac{0.1}{x_5}\right\}$$

$$\therefore (\overline{\underset{\sim}{A} \cup \underset{\sim}{B}})_{0.6} = \left\{\frac{1}{x_1} + \frac{0}{x_2} + \frac{0}{x_3} + \frac{0}{x_4} + \frac{0}{x_5}\right\} \text{ OR } \{x_1\}$$

$\therefore \tilde{A} \cap \tilde{B} = \min\{\mu_A(x), \mu_B(x)\}$

$$\tilde{A} \cap \tilde{B} = \left\{\frac{0.2}{x_1} + \frac{0.3}{x_2} + \frac{0.4}{x_3} + \frac{0.7}{x_4} + \frac{0.1}{x_5}\right\}$$

$\therefore (\overline{\tilde{A} \cap \tilde{B}}) = 1 - \tilde{A} \cap \tilde{B}$

$$= \left\{\frac{0.8}{x_1} + \frac{0.7}{x_2} + \frac{0.6}{x_3} + \frac{0.3}{x_4} + \frac{0.9}{x_5}\right\}$$

$$\therefore (\overline{\tilde{A} \cap \tilde{B}})_{0.6} = \left\{\frac{1}{x_1} + \frac{1}{x_2} + \frac{1}{x_3} + \frac{0}{x_4} + \frac{1}{x_5}\right\}$$

OR $\{x_1, x_2, x_3, x_5\}$

Q. IV) $\tilde{A} = \left\{\frac{0.3}{x_1} + \frac{0.4}{x_2} + \frac{0.5}{x_3} + \frac{0.7}{x_4} + \frac{1}{x_5}\right\}$

$\tilde{B} = \left\{\frac{0.7}{x_1} + \frac{0.8}{x_2} + \frac{0.7}{x_3} + \frac{1}{x_4} + \frac{0.6}{x_5}\right\}$

Determine the following :-

1) $A \cap B$ 2) $A \cup B$ 3) $\overline{A \cup B}$ 4) $\bar{A} \cup \bar{B}$ 5) $A \cap \bar{A}$

1) $\tilde{A} \cap \tilde{B} = \min\{\mu_{\tilde{A}}(x), \mu_{\tilde{B}}(x)\}$

$$= \left\{\frac{0.3}{x_1} + \frac{0.4}{x_2} + \frac{0.5}{x_3} + \frac{0.7}{x_4} + \frac{0.6}{x_5}\right\}$$

2) $\tilde{A} \cup \tilde{B} = \max\{\mu_{\tilde{A}}(x), \mu_{\tilde{B}}(x)\}$

$$= \left\{\frac{0.7}{x_1} + \frac{0.8}{x_2} + \frac{0.7}{x_3} + \frac{1}{x_4} + \frac{1}{x_5}\right\}$$

3) $\overline{\tilde{A} \cup \tilde{B}} = 1 - \tilde{A} \cup \tilde{B}$

$$= \left\{\frac{0.3}{x_1} + \frac{0.2}{x_2} + \frac{0.3}{x_3} + \frac{0}{x_4} + \frac{0}{x_5}\right\}$$

4) $\bar{\tilde{A}} \cup \bar{\tilde{B}} = \max\{\mu_{\bar{\tilde{A}}}(x), \mu_{\bar{\tilde{B}}}(x)\}$

$$\therefore \bar{\tilde{A}} = 1 - \tilde{A} = \left\{\frac{0.7}{x_1} + \frac{0.6}{x_2} + \frac{0.5}{x_3} + \frac{0.3}{x_4} + \frac{0}{x_5}\right\}$$

$$\underset{\sim}{\bar{B}} = 1 - \underset{\sim}{B}$$

$$= \left\{ \frac{0.8}{x_1} + \frac{0.2}{x_2} + \frac{0.3}{x_3} + \frac{0}{x_4} + \frac{0.4}{x_5} \right\}$$

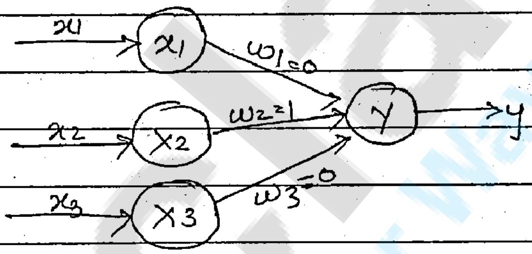
$$\therefore \underset{\sim}{\bar{A}} \cup \underset{\sim}{\bar{B}} = \left\{ \frac{0.7}{x_1} + \frac{0.6}{x_2} + \frac{0.5}{x_3} + \frac{0.3}{x_4} + \frac{0.4}{x_5} \right\}$$

5) $\underset{\sim}{A} \cap \underset{\sim}{\bar{A}} = \min\{\mu_{\underset{\sim}{A}}(x), \mu_{\underset{\sim}{\bar{A}}}(x)\}$

$$= \left\{ \frac{0.3}{x_1} + \frac{0.4}{x_2} + \frac{0.5}{x_3} + \frac{0.3}{x_4} + \frac{0.}{x_5} \right\}$$

Q.V] Truth Table

x_1	x_2	x_3	t
2	1	-1	-1
0	1	-1	1



Learning rate $(\alpha) = 1$ & let $\theta = 0$ & $b = 0$

Initial weights : $w_1 = 0$, $w_2 = 1$, $w_3 = 0$

with bipolar activation function as,

$$f(y_{in}) = \begin{cases} 1 & \text{if } y_{in} > \theta \\ 0 & \text{if } y_{in} = \theta \\ -1 & \text{if } y_{in} \le \theta \end{cases}$$

EPOCH 1:

Inputs x_1	x_2	x_3	Target (t)	Net Input (y_{in})	Calculated o/p (Y)	Weight Changes Δw_1	Δw_2	Δw_3	Weights w_1 (0)	w_2 (1)	w_3 (0)	b (0)
2	1	-1	-1	1	1	-2	-1	1	-2	0	1	-1
0	1	-1	1	-2	-1	0	1	-1	-2	1	0	0

$$\therefore y_{in} = \Sigma x_i w_i + b$$

$$= x_1 w_1 + x_2 w_2 + x_3 w_3 + 0$$

$$= (2)(0) + (1)(1) + (-1)(0) + 0$$

$$= \underline{1}$$

Since $t \neq y$ we need to calculate the updated weight as foll:

$w_1(new) = w_1(old) + \alpha t_1 x_1$
$= 0 + (1)(-1)(2)$
$= -2$

$b(new) = b(old) + \alpha t_1$
$= 0 + (1)(-1)$
$= -1$

$w_2(new) = w_2(old) + \alpha t_1 x_2$
$= 1 + (1)(-1)(1)$
$= 0$

$w_3(new) = w_3(old) + \alpha t_1 x_3$
$= 0 + (1)(-1)(-1)$
$= 1$

Now again we calculate $y_{in} = \Sigma x_i w_i + b$

$\therefore y_{in} = x_1 w_1 + x_2 w_2 + x_3 w_3 + b$
$= (0)(-2) + (1)(0) + (-1)(1) + (-1)$
$= -1 - 1 = \underline{-2}$

Since $t \neq y$ we need to calculate the updated weight :-

$w_1(new) = w_1(old) + \alpha t_2 x_1$
$= -2 + (1)(1)(0)$
$= -2$

$w_2(new) = w_2(old) + \alpha t_2 x_2$
$= 0 + (1)(1)(1)$
$= 1$

$w_3(new) = w_3(old) + \alpha t_2 x_3$
$= 1 + (1)(1)(-1)$
$= 0$

$b(new) = b(old) + \alpha t_2$
$= (-1) + (1)(1)$
$= 0$

	Inputs			Target	Net Input	Calculated O/P	Weight Changes			Weights			
										(−2)	(1)	(0)	(0)
H2:	x_1	x_2	x_3	(t)	y_{in}	y	Δw_1	Δw_2	Δw_3	w_1	w_2	w_3	b
	2	1	−1	−1	−3	−1	0	0	0	−2	1	0	0
	0	1	−1	1	1	1	0	0	0	−2	1	0	0

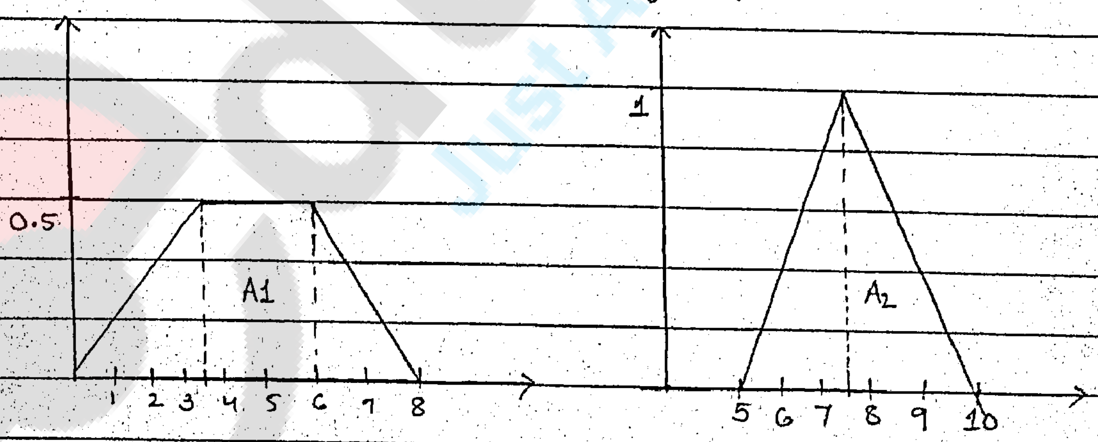
$$\therefore y_{in} = w_1x_1 + w_2x_2 + w_3x_3 + b$$
$$= (-2)(2) + (1)(1) + (0)(-1) + 0$$
$$= -4 + 1 + 0 + 0$$
$$= -3$$

Now Since, $t = y$ we do not update the weights.

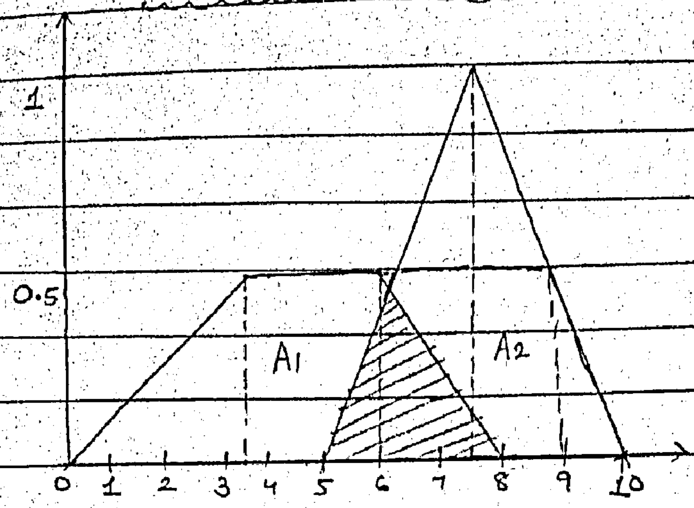
$$\therefore y_{in} = w_1x_1 + w_2x_2 + w_3x_3 + b$$
$$= (-2)(0) + (1)(1) + (0)(-1) + 0$$
$$= 0 + 1 + 0 + 0$$
$$= 1$$

Now since $t = y$ we do not update the weight.
Also since all the target values (t_i) is equal to the calculated output (y) we stop after epoch 2.

Q.VI]



Combined fuzzy Curve



1) Centroid Method :-

$$x^* = \frac{\sum A_i \bar{x}_i}{\sum A_i}$$

∴ Area I = Area of Trapezium

$$= \frac{1}{2}\left((10-0)+(9-3.5)\right)\times 0.5$$

$$= \frac{1}{2}(10+5.5)\times 0.5$$

$$= 3.875$$

∴ Area II = Area of Triangle

~~2) Centre of sums~~ $= \frac{1}{2}(9-6)\times 0.5$

$$= 0.75$$

$$\therefore x^* = \frac{(3.875)\left(\frac{22.5}{4}\right) + (0.75)\left(\frac{22.5}{3}\right)}{(3.875)+(0.75)}$$

$$= \cancel{23}\ \frac{27.421875}{4.625} = 5.929$$

2) Centre of Sums:- (Intersecting Areas are added twice)

$$x^* = \frac{\sum A_i x_c}{\sum A_i}$$

where, A_i is the area of the known geometric figures.
x_c is the center of the known geometric figures.

$\therefore$ Area of $A_1 = \frac{1}{2}((8-0)+(6-3.5)) \times 0.5$

$= \frac{1}{2}(8 + 2.5) \times 0.5$

$= \frac{1}{2}(10.5) \times 0.5$

$= 2.625$

Area of $A_2 = \frac{1}{2}(10-5) \times 1$

$= \frac{1}{2}(5) \times 1$

$= 2.5$

$$\therefore \quad x^* = \frac{A_1 x_{c_1} + A_2 x_{c_2}}{A_1 + A_2}$$

$$= \frac{(2.625)(4) + (2.5)(7.5)}{2.625 + 2.5}$$

$$= 5.707$$

3) Weighted Average:-

$$x^* = \frac{\sum \mu(x)\, x}{\sum \mu(x)}$$

$$= \frac{(4)(0.5) + (7.5)(1)}{(0.5+1)}$$

$$= 6.33$$

4) Centre of Largest Area :- (Mean value of fuzzy set having largest area)

Since Area of A_1 > Area of A_2,

$x^* = \cancel{\frac{3.5+6}{2}} = \cancel{\frac{9.5}{2}} = \cancel{4.75}$ $x^* = \frac{3.5+4+5+6}{4}$

$= 4.625$

5) Mean Max Method :-

$x^* = 7.5$

6) First of Maxima :-

$x^* = 7.5$

7) Last of Maxima :-

$x^* = 7.5$

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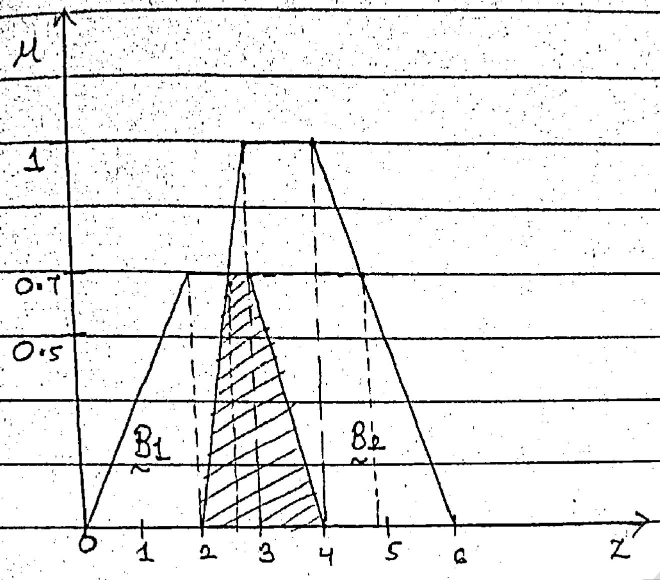

1) Centroid Method :-

$$x^* = \frac{\sum A_i \bar{x}_i}{\sum A_i}$$

$$\text{Area I} = \frac{1}{2}\left(\left((6-0)+(4.8-2)\right)\right)\times 0.7$$

$$= \frac{1}{2}(6+2.8)\times 0.7$$

$$= \underline{3.08}$$

$$\text{Area II} = \frac{1}{2}\left(\left((4.8-2.5)+(4-3)\right)\right)\times 0.3$$

$$= \frac{1}{2}(2.3+1)\times 0.3$$

$$= \underline{0.495}$$

$$\therefore x^* = \frac{A_1\bar{x}_1 + A_2\bar{x}_2}{A_1+A_2}$$

$$= \cancel{(1.75}\ \frac{(3.08)(3.2)+(0.495)(3.575)}{3.08+0.495}$$

$$= \underline{3.25}$$

2) <u>Centre of Sums :-</u> $x^* = \frac{\sum A_i x_c}{\sum A_i}$

Area of B1 $= \frac{1}{2}((4-0)+(3-2)) \times 0.7$

$= \frac{1}{2}(4+1) \times 0.7$

$= \underline{1.75}$

Area of B2 $= \frac{1}{2}((6-2)+(4-3)) \times 1$

$= \frac{1}{2}(4+1) \times 1$

$= \underline{2.5}$

$\therefore x^* = \frac{A_1 x c_1 + A_2 x c_2}{A_1 + A_2}$

$= \frac{(1.75)(2) + (2.5)(4)}{1.75 + 2.5}$

$= \underline{3.17}$

3) <u>Centre of Largest Area :-</u>

From method 2 we know that Area of B_2 is largest.

$\therefore x^* = \frac{3+4}{2} = \frac{7}{2} = \underline{3.5}$

4) <u>Weighted Average Method :-</u>

$x^* = \frac{\sum \mu(x) x}{\sum \mu(x)}$

$= \frac{(0.7)(2) + (1)(4)}{0.7+1}$

$= \underline{3.17}$

5) Mean Max Method :-

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

$$= \frac{3+4}{2} = 3.5$$

6) First of Maxima :-

$$x^* = 3$$

7) Last of Maxima :-

$$x^* = 4$$