# Fuzzy Logic Tutorial

## 2 Inputs, 9 rules

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# Fuzzy Logic Tutorial

Using the given FAMM, output values and membership functions, calculate the crisp output of the fuzzy system when **x** = -0.7 and **y** = -3 .

Assume that the fuzzy combination operator used is the **Zadeh AND**.

Outputs:
NL=-5
NS=-2.5
ZE=0
PS=2.5
PL=5.0

| y \ x | N | ZE | P |
|---|---|---|---|
| S | **NL** | **NS** | **NS** |
| M | **NS** | **ZE** | **PS** |
| L | **PS** | **PS** | **PL** |

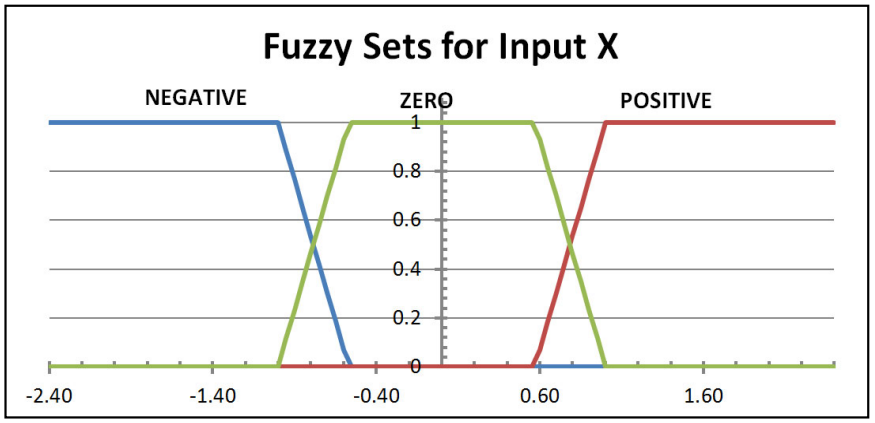
| y \ x | N | ZE | P |
|---|---|---|---|
| S | W1 | W4 | W7 |
| M | W2 | W5 | W8 |
| L | W3 | W6 | W9 |

This is used only to refer to each of the rules individually

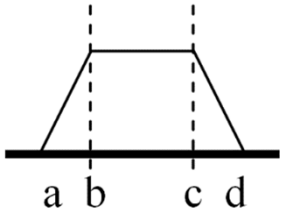
# Fuzzy Logic Tutorial

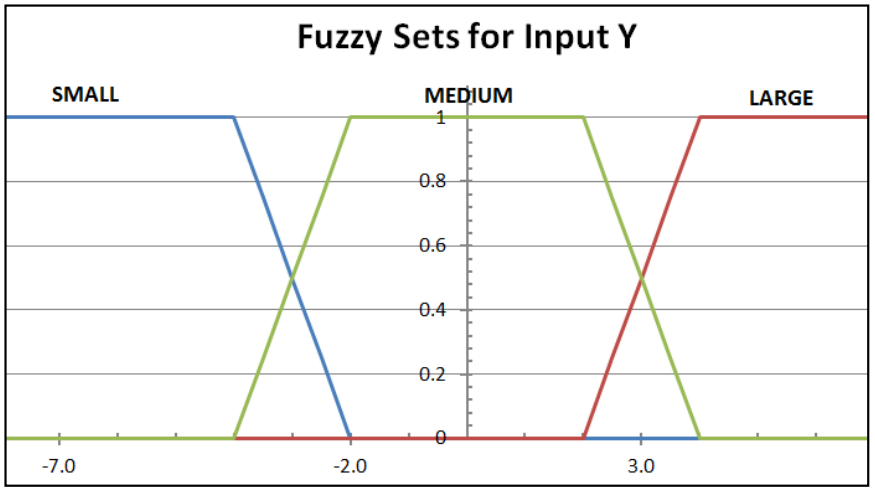
All fuzzy sets are of type trapezoidal.

| y \ x | N | ZE | P |
|---|---|---|---|
| S | NL | NS | NS |
| M | NS | ZE | PS |
| L | PS | PS | PL |




| | a | b | c | d |
|---|---|---|---|---|
| NEG | 0 | 0 | -1 | -0.57 |
| ZE | -1 | -0.57 | 0.57 | 1 |
| POS | 0.57 | 1 | 0 | 0 |

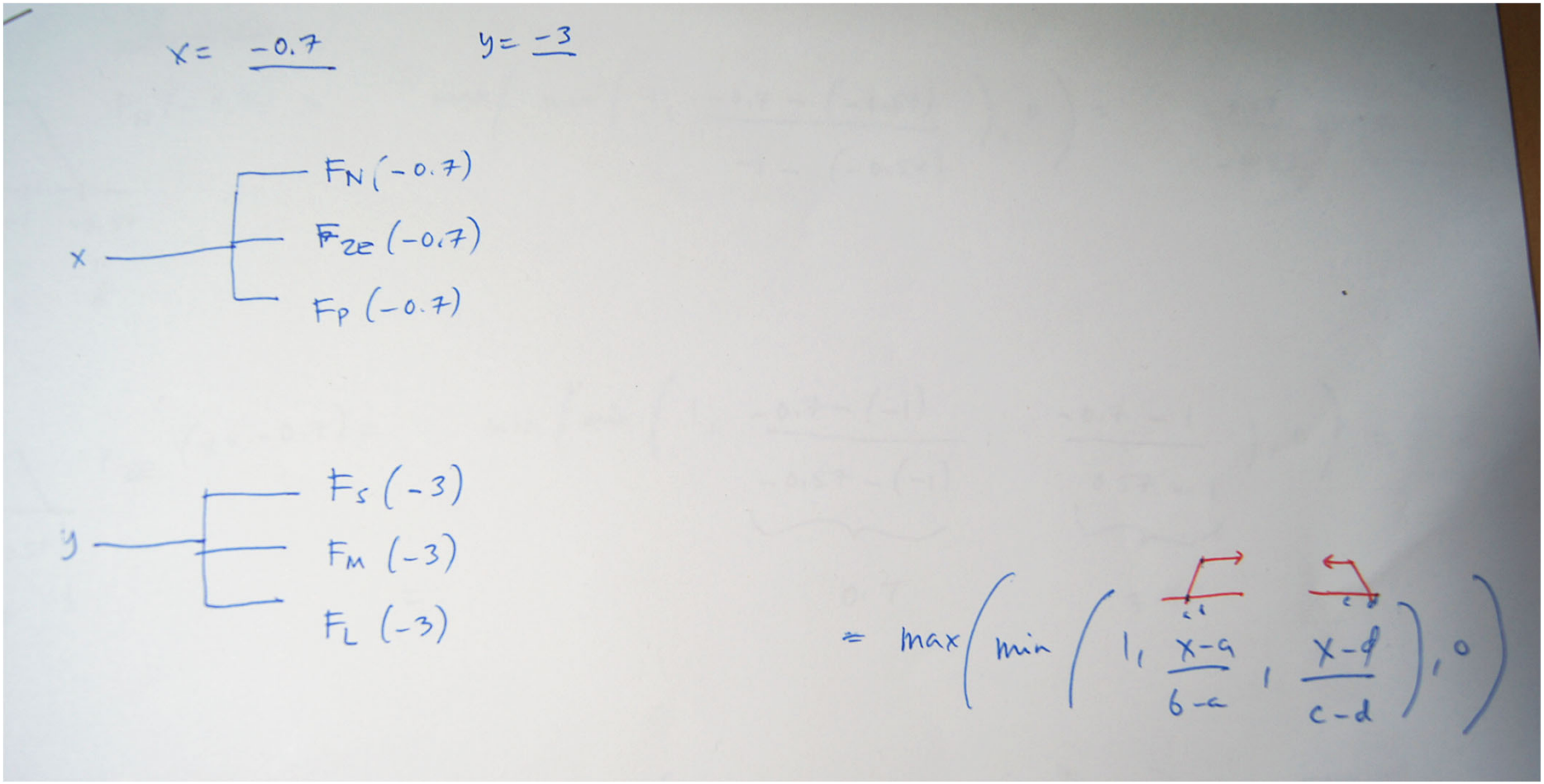



| | a | b | c | d |
|---|---|---|---|---|
| S | 0 | 0 | -4 | -2 |
| M | -4 | -2 | 2 | 4 |
| L | 2 | 4 | 0 | 0 |

# Fuzzy Logic Tutorial

Fuzzify the inputs



# Fuzzy Logic Tutorial

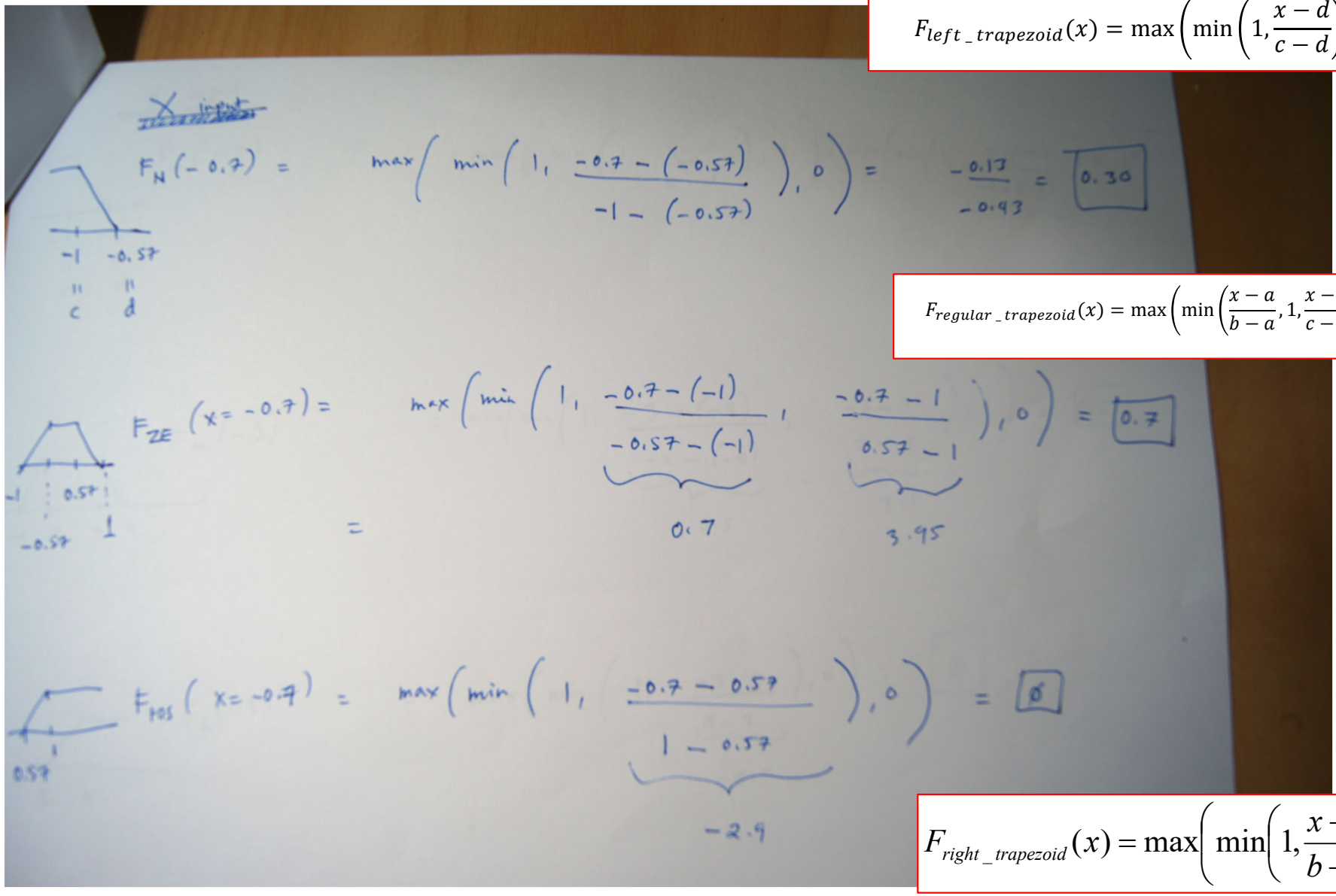
| | a | b | c | d |
|---|---|---|---|---|
| NEG | 0 | 0 | -1 | -0.57 |
| ZE | -1 | -0.57 | 0.57 | 1 |
| POS | 0.57 | 1 | 0 | 0 |

Fuzzify the inputs: **INPUT VARIABLE X**

$$F_{left\_trapezoid}(x) = \max\left(\min\left(1, \frac{x-d}{c-d}\right), 0\right)$$

$$F_{regular\_trapezoid}(x) = \max\left(\min\left(\frac{x-a}{b-a}, 1, \frac{x-d}{c-d}\right), 0\right)$$

$$F_{right\_trapezoid}(x) = \max\left(\min\left(1, \frac{x-a}{b-a}\right), 0\right)$$



# Fuzzy Logic Tutorial

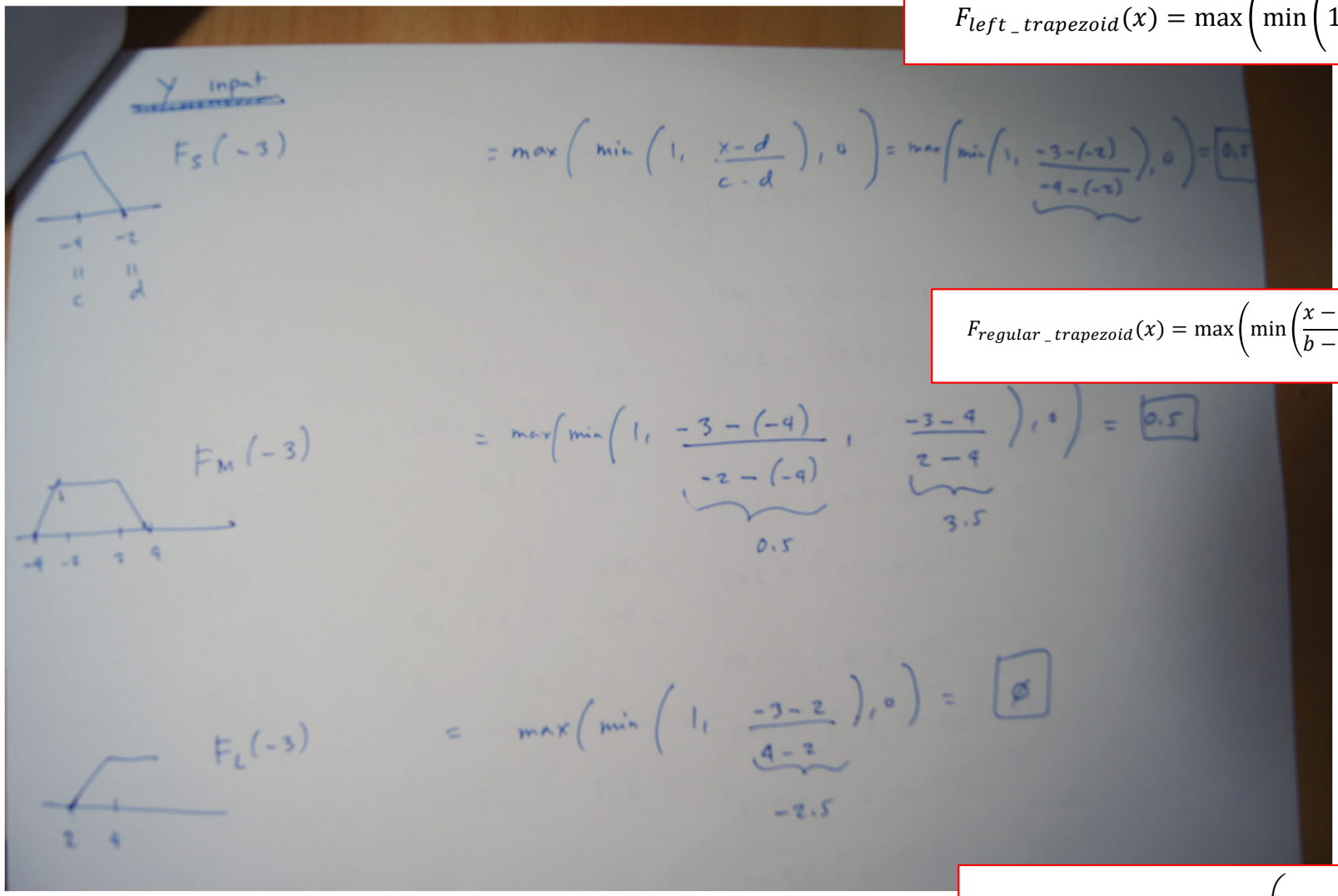
| | a | b | c | d |
|---|---|---|---|---|
| S | 0 | 0 | -4 | -2 |
| M | -4 | -2 | 2 | 4 |
| L | 2 | 4 | 0 | 0 |

Fuzzify the inputs: **INPUT VARIABLE Y**

$$F_{left\_trapezoid}(x) = \max\left(\min\left(1, \frac{x-d}{c-d}\right), 0\right)$$

$$F_{regular\_trapezoid}(x) = \max\left(\min\left(\frac{x-a}{b-a}, 1, \frac{x-d}{c-d}\right), 0\right)$$

$$F_{right\_trapezoid}(x) = \max\left(\min\left(1, \frac{x-a}{b-a}\right), 0\right)$$



# Fuzzy Logic Tutorial

Compute degree of applicability of rules: **WEIGHTS**

DEFUZZIFICATION: compute crisp output using **CENTRE OF MASS**

F_Neg(X) = 0.3023256

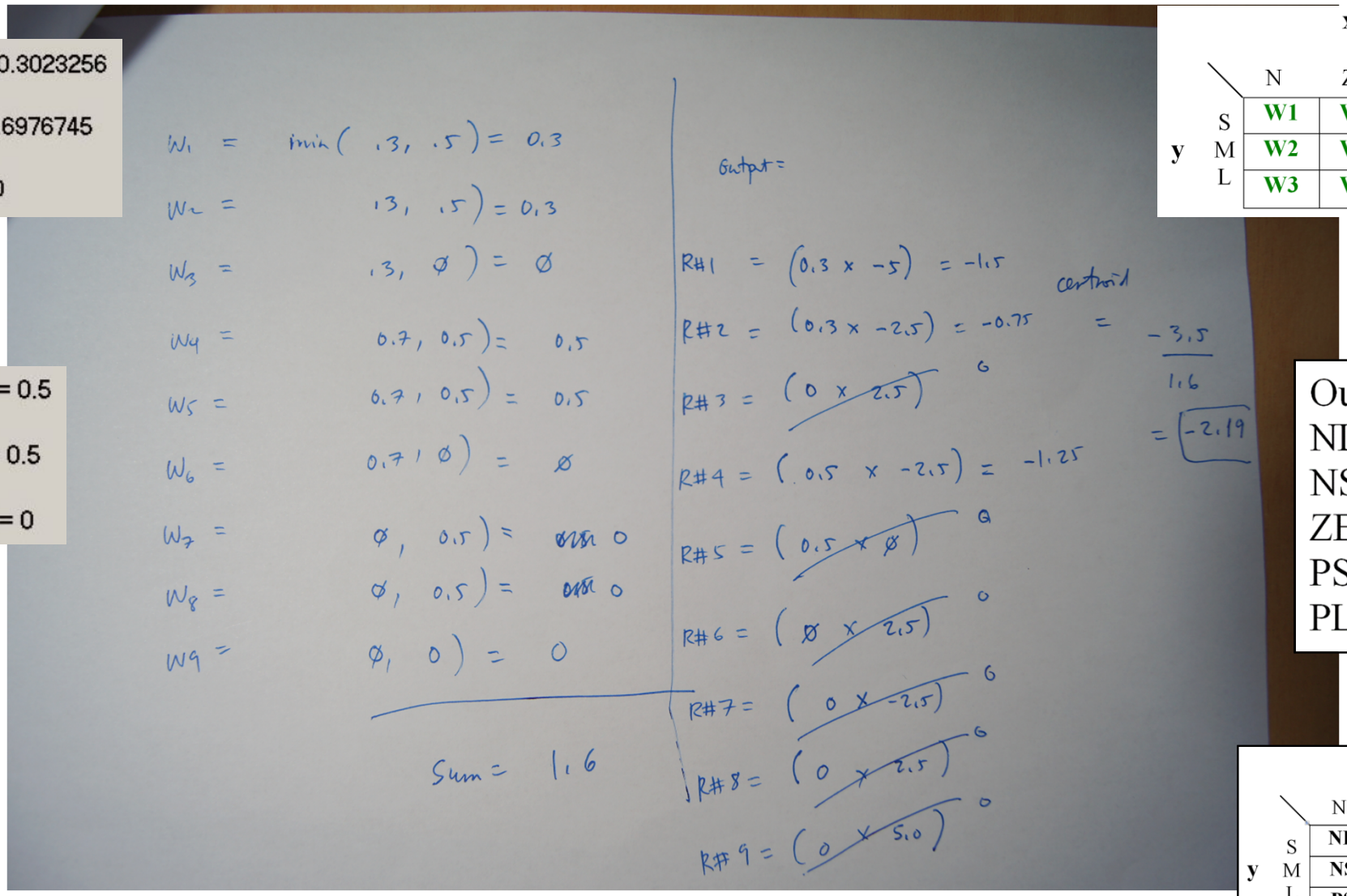
F_ZE(X) = 0.6976745

F_Pos(X) = 0

F_Small(Y) = 0.5

F_Med(Y) = 0.5

F_Large(Y) = 0




| y \ x | N | ZE | P |
|---|---|---|---|
| S | W1 | W4 | W7 |
| M | W2 | W5 | W8 |
| L | W3 | W6 | W9 |

Outputs:
NL=-5
NS=-2.5
ZE=0
PS=2.5
PL=5.0

| y \ x | N | ZE | P |
|---|---|---|---|
| S | NL | NS | NS |
| M | NS | ZE | PS |
| L | PS | PS | PL |

# Fuzzy Logic Tutorial

A) Degree of Memberships of Input X

F_Neg(X) = 0.3023256

F_ZE(X) = 0.6976745

F_Pos(X) = 0

B) Degree of Memberships of Input Y

F_Small(Y) = 0.5

F_Med(Y) = 0.5

F_Large(Y) = 0

C) Weights

Weight(1) = Min(F_Neg(X),F_Small(Y)) = Min(0.3023256, 0.5)= 0.3023256
Weight(2) = Min(F_Neg(X),F_Med(Y)) = Min(0.3023256, 0.5)= 0.3023256
Weight(3) = Min(F_Neg(X),F_Large(Y)) = Min(0.3023256, 0)= 0
Weight(4) = Min(F_ZE(X),F_Small(Y)) = Min(0.6976745, 0.5)= 0.5
Weight(5) = Min(F_ZE(X),F_Med(Y)) = Min(0.6976745, 0.5)= 0.5
Weight(6) = Min(F_ZE(X),F_Large(Y)) = Min(0.6976745, 0)= 0
Weight(7) = Min(F_Pos(X),F_Small(Y)) = Min(0, 0.5)= 0
Weight(8) = Min(F_Pos(X),F_Med(Y)) = Min(0, 0.5)= 0
Weight(9) = Min(F_Pos(X),F_Large(Y)) = Min(0, 0)= 0

D) Crisp Output

Numerator/Denominator = -3.517442/1.604651

CrispOutput = -2.192029

INPUT VALUES

X -0.7 Y -3

Summary of steps