AY: 2022-2023	**Full Name:** .....
M1-S1: Dept. of Electrical Engineering	**ID:** .....
Midterm Exam | AI-ECUE122	**Class:** **RAIA** .....
01/12/22 (10:30→11:30)	**Room:** .....
Teacher: A. Mhamdi	**Time Limit:** **1h**

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This document contains **4** pages numbered from **1/4** to **4/4**. As soon as it is handed over to you, make sure that it is complete. The **2** tasks are independent and can be treated in the order that suits you.

The following rules apply:

❶ **A handwritten double-sided A4** sheet is permitted.

❷ **The use of any electronic material**, except basic calculator, is prohibited.

❸ **Mysterious or unsupported answers** will not receive full credit.

❹ **If the provided space** is not sufficient, feel free to attach an additional sheet.

Do not write anything in this table.

Task	Points	Score
1	10	
2	10	
Total	20	

Task N°1

⌛ 25mn | (10 points)

Perform the following arithmetic operations.

(a) (1 point) $[2,\ 5] + [1,\ 3] =$ [3, 8]

(b) (1 point) $[2,\ 5] - [1,\ 3] =$ [-1, 4]

(c) (1 point) $[-1,\ 1] \times [-2,\ 0.5] =$ [-2, 2]

(d) (1 point) $[-1,\ 1] \div [-2,\ -0.5] =$ [-2, 2]

(e) (6 points) Given the code snippet below. Draw the corresponding graphs.

```
using Plots, Fuzzy
x = 5:.1:8
y = Dict(
          "VS" => TrapezoidalMF(5, 5, 5.5, 6),
          "S" => TriangularMF(5, 6, 7),
          "B" => TrapezoidalMF(6, 7, 7.5, 8),
          "VB" => TriangularMF(7.5, 8, 8.5)
          )
xy = chart_prepare(y, x)
```

Do not write anything here

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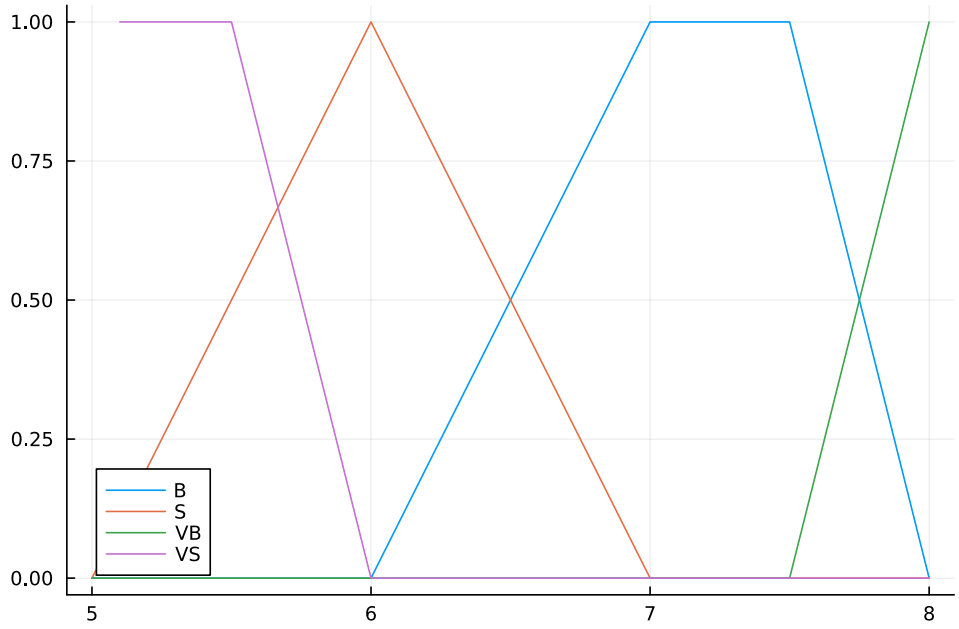
```
plot(x, xy["values"], label=xy["names"], legend=:bottomleft)
```



Task N°2 ⏳ 35mn | (10 points)

Consider a fuzzy logic system used to control the speed of a DC motor. The two inputs are SP (Speed) and SC (Speed Change rate). The output is V (Voltage) to apply to the motor. We suppose that the voltage V can vary by a step of 0.1 volts. The membership functions of the fuzzy variables are described below.

- SP $\in [500,\ 1000]$:

  Slow (S) $\mathcal{L}(600,\ 750)$

  Normal (N) $\Delta(600,\ 750,\ 900)$

  Fast (F) $\Gamma(750,\ 900)$.

- SC $\in [0,\ 10]$:

  Low (L) $\mathcal{L}(2,\ 4)$

  Medium (M) $\Pi(2,\ 4,\ 6,\ 8)$

  High (H) $\Gamma(6,\ 8)$.

- V is in $[2.5,\ 3.5]$. It is described as:

  Slow Down (SD) $\mathcal{L}(2.7,\ 2.8)$

  No Change (NC) $\Delta(2.9,\ 3,\ 3.1)$

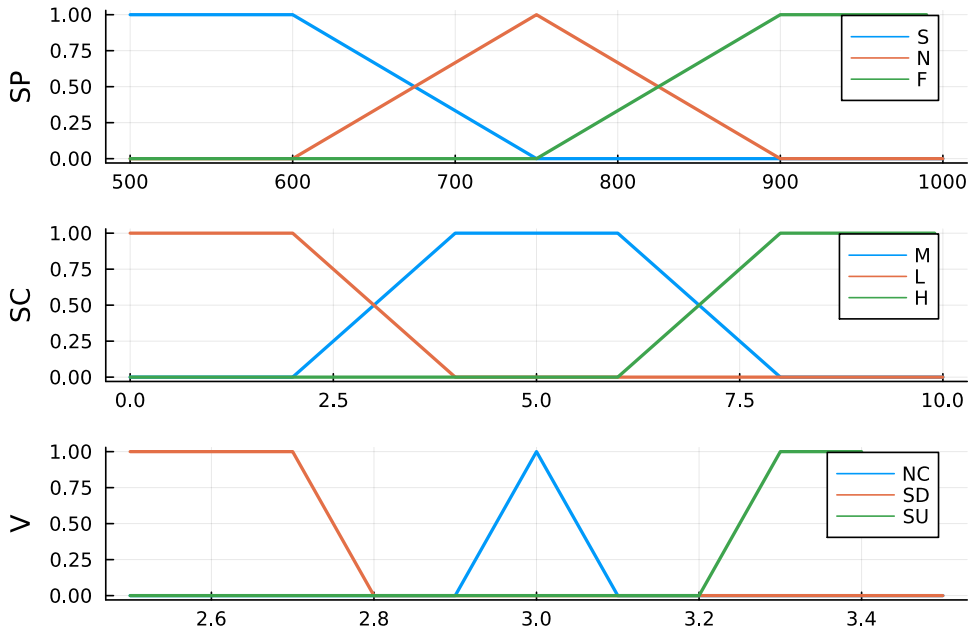
  Speed Up (SU) $\Gamma(3.2,\ 3.3)$.

Table 1: Rule Base - case of $\wedge$

SC \ SP	S	N	F
L	SU	NC	NC
M	SU	NC	NC
H	NC	SD	SD

Find the control voltage V if SP $= 910$ rpm and SC $= 6.5$ rpm/mn.

(a) ($4\frac{1}{2}$ points) Draw the membership functions



(b) ($3\frac{1}{2}$ points) Out of the rules, which ones to be fired if SP $= 910$ rpm and

SC $= 6.5$ rpm/mn.

1. If SP is **F** and SC is **M** then V is **NC**
2. If SP is **F** and SC is **H** then V is **SD**

(c) (2 points) Compute the output V using the **COG** method.

The voltage incerement is $\Delta V = 0.1$ volts.

$$V^\star = \frac{(2.5 + 2.6 + 2.7) \times 0.25 + 3 \times 0.75}{0.25 \times 3 + 0.75} = \frac{1.95 + 2.25}{1.5} = 2.8 \text{ volts}$$