First Name:

Family Name:

2019/2020 Academic year

Session 2019-1

Final Exam - 1 hour

GTL

Module S43b

Teacher : Alain ETIENNE

Number of pages and exercises:	3 independent exercises
Allowed materials:	Personal notes Course materials Calculator Dictionary
Instructions:	Do not hesitate to explain or justify your choices! Good luck and good work!

1. Constraint Satisfaction Problem (≈40%):

This exercise considers a beverage-selling machine. The user inserts coins for a total of *T* cents of euros and then selects a drink; the price of this drink is *P* cents of euros (*T* and *P* being multiples of 10 cents of euros).

Then the machine calculates the change to be given, knowing that the distributor has in its reserve *E2* coins of 2€, *E1* coins of 1€, *C50* coins of 50 cents, *C20* coins of 20 cents and *C10* coins of 10 cents. The goal is to minimize the number of coins given back by the machine.

Question 1.1: Perform the mathematical modeling (as defined by Montanari) of this Constraint Satisfaction Problem by identifying: What are the variables in this problem? What are their respective domains?

Question 1.2: Detail mathematically the relationship(s) and so the constraint(s) linking the variables identified and modelled in the previous question.

The user after paying 2€, selects a beverage of 1.20€. The machine contains 7 coins of 2€, 1 coin of 1€, 3 coins of 50 cents, 2 coins of 20 cents and 5 coins of 10 cents.

Question 1.3: Detail and justify the four first steps of backtracking algorithm applied to this problem. Represent this solution exploration in the tree representation as the one we performed during the lecture. For the selection of the value to consider for the variable assignment, you can select the first available in the remaining domain.

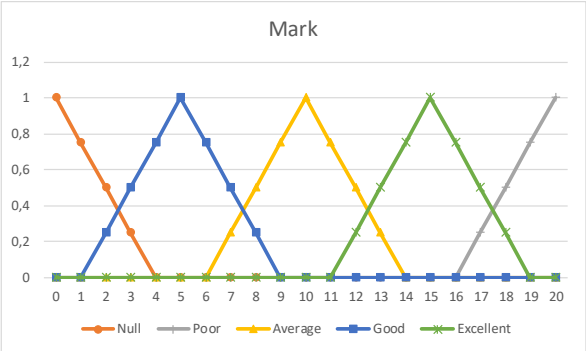
Question 1.4: Express in MiniZinc's language the definition of one of your variables and the expression of one constraint.

2. Fuzzy Logic (≈30%):

We want to evaluate the final report of an internship by using a fuzzy logic approach. In this exercise are considered only two input parameters and one output parameter:

- Input parameters, *Justification* and *Amount of work*, are described with the following definitions:

- Output parameter, *Report mark*, is described in this manner:



- We use the fuzzy operators defined by Mamdami (AND, OR…)
- The aggregator operator is: **Max**
- The fuzzy laws are defined in the matrix above:

		Justification		
		Poorly	Partially	Completely
Work amount	Null	Null	Null	Poor
	Poor	Null	Poor	Average
	Good	Average	Good	Excellent
	Excellent	Average	Good	Excellent

Figure 1 : Fuzzy rules to consider in this exercise

Question 2.1: In the case: **Justification = 4 and Work amount = 7.5**, identify what are the memberships of the input parameters and evaluate them. After triggering the fuzzy rules, synthetize their results and draw the shape of the output parameter *Mark*.

Question 2.2: By using the defuzzycation operator "Center of Gravity", estimate the mark of the internship report in that case.

3. Expert Systems (≈30%):

The rule base of an order 0 expert system is composed by this set of rules:

R1	IF A THEN B AND C
R2	IF C THEN E
R3	IF M THEN C
R4	IF I AND K THEN A
R5	IF M AND L THEN A
R6	IF I AND B THEN D
R7	IF E AND (D OR L) THEN F
R8	IF K AND F THEN H

Figure 2: Rules base

The selection step of the expert system follows these meta-rules:

- **P1**: Priority to the rule having the most numerous conditions,
- **P2**: If the first criterion is not enough, priority to the rule having the most numerous conclusions,
- **P3**: If the two first criteria are not enough; the priority is given regarding the order of the rule in the rule base (the number in the first column in Figure 2).

The initial facts base is composed by the two facts **{I, K}**.

Question 3.1: By using the forward chaining in this priority strategy, detail all steps followed by the expert system from the initial fact base (and detail the facts base for each step).

Question 3.2: By using backward chaining, and the priority strategy, detail the AND/OR tree followed by the algorithm leading to the fact **F**.

Question 3.3: Express in CLIPS Language the rule **R7**.