Exercise 1 (Course questions / 04 points)

1) **In a genetic algorithm, what action (operation or step) performs the intensification?**
2) **In a bee colony algorithm, what action performs the diversification?**
3) **Why do genetic programming solutions need to be coded in Lisp?**
4) **What action shows the stochastic aspect of the ant colony algorithm?**
5) **What property distinguishes the ant colony algorithm from other metaheuristics?**
6) **Assume that we have a multi-objective minimization problem of $f_1, f_2, \dots, f_k$.**
   Briefly define each of the terms: "a dominates b"; "Efficient solution"; "Pareto front".

Exercise 2 (08 points)

Consider the ACO algorithm to solve the symmetric TSP with n=4 cities A, B, C, D such that: AB=3, AC=5, AD=2, BC=2. BD=4, CD=3 and the following parameter configuration: Q=10, α =1, β =1, τ_0=1; ρ = 0.8; m = 4 ants.

1) **Write all possible solutions (tours, Hamiltonian cycles).**
2) **Suppose an ant has started from city C and it is at city C. Calculate the probabilities of moving to each of the remaining cities.**
3) **Suppose it then moves to city A, calculate the probabilities of moving to each of the remaining cities.**
4) **Suppose it then moves to city D, calculate the probabilities of moving to each of the remaining cities.**
5) **Assume that after the first iteration, the 4 ants have found the following tours: CADB, ABCD, ACBD, ABCD. Determine the new quantities of pheromones ($\tau_{AB}, \tau_{AC}, \dots$) on the 6 edges.**

Exercise 3 (08 points)

We propose to solve the simple (0/1) knapsack problem with n items using the PSO method.
A position is thus a string of n bits and its velocity is a set of k integers less than n corresponding to the bits to be inverted in this position (we take k ≤n).
Example: for $n = 6$: $a\ position = 100111$ and its velocity $= \{2, 5\}$.

1) **Write the algorithm to create an initial population of m random positions with their respective velocities (also random).**
2) **The sum of a position x and a velocity v, denoted by $x \oplus v$ is a position obtained by inverting the bits of x whose numbers are cited in v (from the left).**
   Calculate $x \oplus v$ for $x = 110101$ and $v = \{2, 5\}$.
   Write the algorithm $ADD(x, v)$ that returns $x \oplus v$.
3) **The subtraction of two positions x_1 and x_2 , denoted $x_1 \ominus x_2$ is the velocity v_1 such that $x_1 \oplus v_1 = x_2$ (i.e. the bits of x_1 which were inverted to obtain x_2).**
   Calculate $x_1 \ominus x_2$ for $x_1 = 100111$ and $x_2 = 000100$
   Write the algorithm SUB(x_1, x_2) which returns $x_1 \ominus x_2$.
4) **The sum of two velocities $v_1\ et\ v_2$, denoted $v_1 \boxplus v_2$ is the union of the two sets v_1 and v_2.**
   Calculate $v_1 \boxplus v_2$ for $v_1 = \{2, 5\}$ and $v_2 = \{1, 4, 5\}$.
   Write the algorithm SUM(v_1, v_2) which returns $v_1 \boxplus v_2$.
5) **The product of a velocity v by a real number a denoted $a \otimes v$ is the set containing the first int (a+1) elements of v (int (a+1) is the integer part of a+1) .**
   Calculate $a \otimes v$ for $a = 1.4$ and $v = \{1, 4, 5\}$.
   Write the algorithm PROD(a, v) which returns $a \otimes v$.