HEURISTIC METHODS EXAMPLE QUESTIONS

Question 1

"A constructive heuristic with a more sophisticated priority index will always outperform another with a less sophisticated index". Do you agree with this statement? Justify your answer.

Question 2

"A constructive heuristic never generates an optimal solution". Do you agree with this statement? Justify your answer.

Question 3

Consider the following problem. A firm has one machine, as well as several products, ordered by customers, that have to be made on that machine. Each product requires a given processing time on that machine. Each product also has a due date, that is, a date on which it should ideally be ready for delivery to the customer.

The tardiness incurred in a product is 0 if the product is finished by its due date. If a product is only completed after its due date, the tardiness is equal to the difference between the completion time and the due date. Thus, and as an example, if the due date of a job is 20, we have: 1) if the job is completed on 18, the tardiness is 0; if the job is completed on 25, its tardiness is 5.

The firm wants to determine the order in which it will process the products, in order to minimize the total tardiness (that is, the sum of the tardiness of the products). Describe the steps of one constructive heuristic for this problem. Justify the way in which, at each iteration, you select the next element (product) to add to the current partial solution.

Question 4

Consider a knapsack problem where the knapsack can hold a maximum weight of 20 kg. The following items are available:

item:	1	2	3	4	5	6	7	8	9	10
weight:	4	3	1	2	5	4	6	5	2	6
utility:	5	10	7	4	8	5	3	6	9	9

Consider the following infeasible solution (weight = 24 > 20), represented by a binary encoding (1 = included; 0 = not included):

item:	1	2	3	4	5	6	7	8	9	10
	1	0	1	0	1	0	1	0	1	1

Also consider the following procedure for turning an infeasible solution into a feasible solution:

1. Remove the item with the highest weight.
    a. If two or more items have the same highest weight, remove the one with the lowest utility.
        i. If two or more items have the same highest weight, and also the same lowest utility, remove one of them at random.
2. If the solution is feasible, stop. Otherwise, return to step 1.

Describe the application of this procedure to the above solution, until a feasible solution is obtained.

Question 5

"Applying an elementary move to a current solution to obtain a neighbour should greatly modify the structure of the current solution". Do you agree with this statement? Justify your answer.

Question 6

"For some problems, and when using some neighbourhoods, it is possible that some of the neighbours of a solution are infeasible". Do you agree with this statement? Justify your answer.

Question 7

"A local search procedure that uses a larger neighbourhood will always find a better solution than another procedure which uses a smaller neighbourhood". Do you agree with this statement? Justify your answer.

Question 8

Consider a minimization problem and the basic version of the Simulated Annealing metaheuristic. Assume this Simulated Annealing algorithm uses the Boltzmann–type acceptance probability function.

a) Assume that: 1) the objective function value of the current solution is equal to 2275; 2) the objective function value of a neighbour solution is equal to 2920; 3) the current temperature is equal to 1250. Write the expression from which we can calculate the probability of accepting this neighbour, as well as the value of that probability.

b) Consider the calculation of the initial temperature T_0. Assume that we have already determined that the value 5250 is an estimate of the absolute value of the maximum possible change in the objective function value between two solutions. Also assume that, at the initial temperature, we wish that a neighbour that is worse by that value (5250) will have a 40% probability of being accepted. Write the expression from which we can calculate the value of the initial temperature, and calculate that value.

Question 9

Consider the basic version of the Simulated Annealing metaheuristic.

a) "The best solution found by the basic version of the Simulated Annealing metaheuristic might not be a local optimum". Do you agree with this statement? Justify your answer.

b) Describe at least two ways in which local search could be added to the basic Simulated Annealing algorithm.

c) Suppose the initial temperature was incorrectly set at a very low value. How would this affect the behaviour and performance of the Simulated Annealing algorithm? Justify your answer.

Question 10

Consider a minimization problem and the basic version of the Tabu Search metaheuristic.

Assume the tabu list currently holds the following two items:

1. The element “5” cannot be exchanged with the element “3”.
2. The element “8” cannot be exchanged with the element “4”.

Now consider the following move:

current solution:	1 **3** 4 **5** 8 2 7 6	objective function value: 1739

neighbour solution:	1 **5** 4 **3** 8 2 7 6	objective function value: 1683

Could this move be performed by the basic version of the Tabu Search algorithm? Justify your answer.

Question 11

Consider a Genetic Algorithm procedure for a minimization problem. Also consider the following information concerning the current population.

solution number	objective function value
1	1237
2	1576
3	1638
4	1641
5	1645
6	1768
7	1770
8	1781
9	1800
10	1805

a) Consider the elitist strategy, and assume %_elite = 20%. Indicate the solutions that will be automatically copied to the new population. Justify your answer.

b) Consider the 4–tournament selection method. Illustrate the application of this procedure to select one parent. (Keep it simple: it is enough to present the solutions initially chosen, and then the solution that is selected to be a parent, justifying why this solution was selected among those initially chosen).

Question 12

Consider the permutation encoding and the reproduction method 2-point crossover. Also consider the two parents given below, and assume that positions 3 and 8 were selected. Write the two children that would be generated by the crossover procedure, with these positions, when applied to these two parents.

1st parent:	3	5	1	10	9	2	6	8	4	7
2nd parent:	8	1	7	6	2	10	3	4	5	9

Question 13

Consider a Genetic Algorithm which uses the n-tournament selection method to select the parents for the reproduction operation. Suppose n is set at a very high value. What effect could this have on the behaviour and performance of the Genetic Algorithm? Justify your answer.

Question 14

Consider a basic Iterated Local Search (ILS) procedure for a minimization problem, consisting of the following steps.

1. $S_{best} = \emptyset, ofv_{best} = \infty$.
2. S_{curr} = **initial solution**.
3. S_{curr} = apply **local search** to S_{curr}.
4. Set S_{best} = S_{curr} and ofv_{best} = ofv_{curr}.
5. S_{mod} = **modify** S_{curr}.
6. S_{mod} = apply **local search** to S_{mod}.
7. S_{curr} = S_{mod}.
8. If ofv_{curr} < ofv_{best}, S_{best} = S_{curr} and ofv_{best} = ofv_{curr}.
9. If the **stop criterion** has been **met**, **stop**. Otherwise, **return to 5**.

a) Explain the strategy that ILS uses in order to prevent the search from becoming stuck on a local optimum. Also explain, and justify, in which ways ILS intensifies and diversifies the search.

b) Propose, describe and justify, two components / elements / strategies that are used in other metaheuristics that could be added to ILS and used in the context of this metaheuristic.

Question 15

Consider a basic Greedy Randomized Adaptive Search Procedure (GRASP) metaheuristic for a minimization problem, consisting of the following steps.

1. $S_{best} = \emptyset$, $ofv_{best} = \infty$.
2. S_{curr} = **greedy randomized construction**.
3. S_{curr} = apply **local search** to S_{curr}.
4. If ofv_{curr} < ofv_{best}, S_{best} = S_{curr} and ofv_{best} = ofv_{curr}.
5. If the **stop criterion** has been **met**, **stop**. Otherwise, **return to 2**.

a) In this basic version, which step ensures diversification? Also, which step ensures intensification? Justify your answer.

b) Consider step 2 (greedy randomized construction). Using only this step, and without adding any other components (such as long term memory!) to the basic version of GRASP, describe how you could implement intensification and diversification phases (remember: use only step 2). You do not need to consider how to switch between phases; you just need to describe how intensification and diversification could be achieved / performed using only step 2.