

**Note: Answer each question (1, 2, 3 and 4) in separate exam sheets.**

1. [4 points] A farmer needs to traverse a river carrying a fox, a chicken and a corn basket. He has got a small boat in which he can transport, in any direction, a maximum of one thing at a time; he may not leave the fox alone with the chicken, neither the chicken with the corn basket.

- Draw the state space with the legal problem states and their transitions. Represent the initial state in the form  $RGMB|$ , which indicates that the fox (R), the chicken (G), the corn basket (M) and the boat (b) are in the initial river margin. Other examples: the farmer has traversed the river with the chicken ( $RM|GB$ ); the final state:  $|RGMB$ .
- Suggest an admissible heuristic function (non-trivial, i.e.,  $h=0$  does not count) that can be applied to this problem to evaluate each state, where we want to minimize the number of river traversals. Show the value of your function in the states identified in the previous question.
- Draw the search tree obtained by applying the **greedy search strategy**, using the heuristic function defined in your previous answer. Next to each node in the tree, show the value of the heuristic function, and show the solution found. You may avoid representing transitions that correspond to cycles.

2. [4 points] We want to optimize a production plan in a factory with 3 machines: M1, M2, M3. Production includes manufacturing products A, B, C, D and E, which require the usage of different machines and have a specific time to produce (as shown in the table). A machine can only produce a single machine at the same time. We need to allocate the products to machines, with the goal of minimizing the total production time.

Prod	Machine	Duration
A	M1 ou M2	10
B	M1 ou M3	7
C	M2 ou M3	11
D	M2 ou M3	12
E	M1 ou M2 ou M3	8

- Suppose we start with the allocation  $S_1 = \{A-M1, B-M1, C-M2, D-M2, E-M1\}$ . Compute the cost of this allocation,  $C(S_1)$ .
- Consider a neighborhood function (to generate successor states) that changes the machine of a single product. Identify all successors of  $S_1$ . According to the “*steepest ascent*” variant of “*hill-climbing*”, which is the chosen successor of  $S_1$ ? Justify with calculations.
- Consider that the neighborhood function generates successors in a deterministic way, by changing first the machine for product A, then for B, then for C, then for D and finally for E. Using a temperature  $t=10$ , determine which successor of  $S_1$  will be adopted by **simulated annealing**, justifying with calculations. If necessary, use the following random numbers: 0.55, 0.89, 0.12, 0.45, 0.11, 0.66, 0.75.

3. [4 points] In the summer, you need to be careful with the sun. The table shows what happened to 8 people, taking into account their physiognomic data, and knowing whether they have used a sub block lotion.

Name	Hair	Height	Weight	Lotion	Result
Sarah	blonde	average	light	no	sunburned
Dana	blonde	tall	average	yes	none
Alex	brown	short	average	yes	none
Annie	blonde	short	average	no	sunburned
Emily	red	average	heavy	no	sunburned
Pete	brown	tall	heavy	no	none
John	brown	average	heavy	no	none
Katie	blonde	short	light	yes	none

- Calculate the average amount of information related with the classification of the examples.
- Using the ID3 algorithm, determine which attribute should be placed in the root of the decision tree, justifying with calculations.
- The C4.5 algorithm uses the gain ratio criteria to build the decision tree. In this case, determine which attribute should be placed in the root of the tree, justifying with calculations.
- Calculate the error ratio in each of the leaves of the tree that contains the single decision node identified in your previous answer.

4. [8 points] Answer six (6) of the following seven (7) questions (each in 5-10 lines).

- a) In a search problem with a high branching factor, we know there are many solutions, all of them at similar depths, from which we know the maximum depth. We want to obtain any solution as fast as we can. Which uninformed search strategy would you choose? Why?
- b) We know of a heuristic function  $h$  that it exceeds no more than 10% the real cost. Based on  $h$ , define the best possible admissible heuristic function.
- c) A computer technician has decided to restore old PCs to create a cloud. His confidence on the solution can be represented by the following rules: IF recent sw THEN cloud works (CF=0.8); IF computers good\_condition THEN cloud works (CF=0.7); IF checkup ok THEN computers good\_condition (CF=0.75). The used software (sw) is recent, and the checkup seems to indicate ok (CF=0.9). What to conclude, and with what certainty factor?
- d) While applying a genetic algorithm to a maximization problem, you have obtained a population with chromosomes C1, C2, C3 and C4, with values 10, 15, 27 and 30, respectively. Determine the selection probability of each chromosome.
- e) In the figure, identify which nodes will be cut by applying alpha-beta cuts to the minimax search algorithm.
- f) An agent has complete knowledge of the environment, applying such knowledge in a rule-based system. Is this kind of inference based on causal rules or diagnostic rules? Explain.
- g) Draw a simple neural network that is able to implement the parity function for 3 binary inputs. The network's output should be 1 if and only if there is an odd number of 1 inputs.

