

## EXAM TDT4136 HØST-2018 ORDINARY.

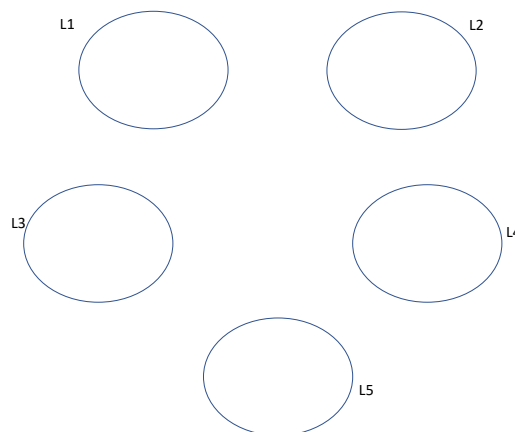
### QUESTIONS and ANSWERS (at the very end) Problem 1: CSP (10 POINTS)

In a 2-days seminar, there are 5 lectures to be allocated to 3 professors. Each professor can teach at most 1 lecture on a day. Each professor has knowledge to teach only a subset of the lectures. The following table shows which professor has the knowledge to teach which lectures where “L” means “lecture”:

Prof. Arne	L1, L2, L3
Prof. Berit	L1, L2, L5
Prof. Carl	L2, L4, L5

There are some constraints about the sequence that the lectures can be given:  $\text{Day}(L1) < \text{Day}(L2)$ , i.e., Lecture 1 must be taught the day before the day of Lecture 2, and  $\text{Day}(L3) < \text{Day}(L5)$ . Each lecture will be assigned to a professor and to a day.

- 1) Complete the following drawing to a constraint graph that represents this problem. Nodes represent the lectures that are the Variables in this Constraint Satisfaction Problem. You will draw the links between the nodes in the graph.



2. Write down the domains of the variables. Each value in the domain of a variable shows the combination of a professor that can teach the course and the time it can be taught. Instead of the whole name of a professor use only the first letter of his/her name, i.e., A, B, C shows the three professors. A domain value, hence looks like this: A2 (i.e., Arne on Day=2), B1 (i.e., Berit on Day=1. You can write the domain values by filling in the curly brackets for each variable ( L1,..., L5).

L1: { ..... }

L2: { }

L3: { }

L4: { }

L5: { }

2) Write down all the constraints, as implicit constraints, for this problem. Hint: You can use n-ary Alldiff to represent one type of the constraints you need.

3) Is this initial constraint graph arc-consistent? If not, apply AC-3 arc consistency algorithm and find the reduced domains. Write these domains for each variable in the form:

L1: { ..... }

L2: { }

L3: { }

L4: { }

L5: { }

5) Apply Backtracking on this arc-consistent graph without forward checking. Use Minimum Remaining Value for variable ordering (tie breaking in numerical order), and Least Constraining Value for value ordering (tie breaking alphanumerically). What order are the variables are assigned and what are their values? Your answer will look like this:

The 1. assigned variable is ....., and its value is .....

The 2. assigned variable is ....., and its value is .....

The 3. assigned variable is ....., and its value is .....

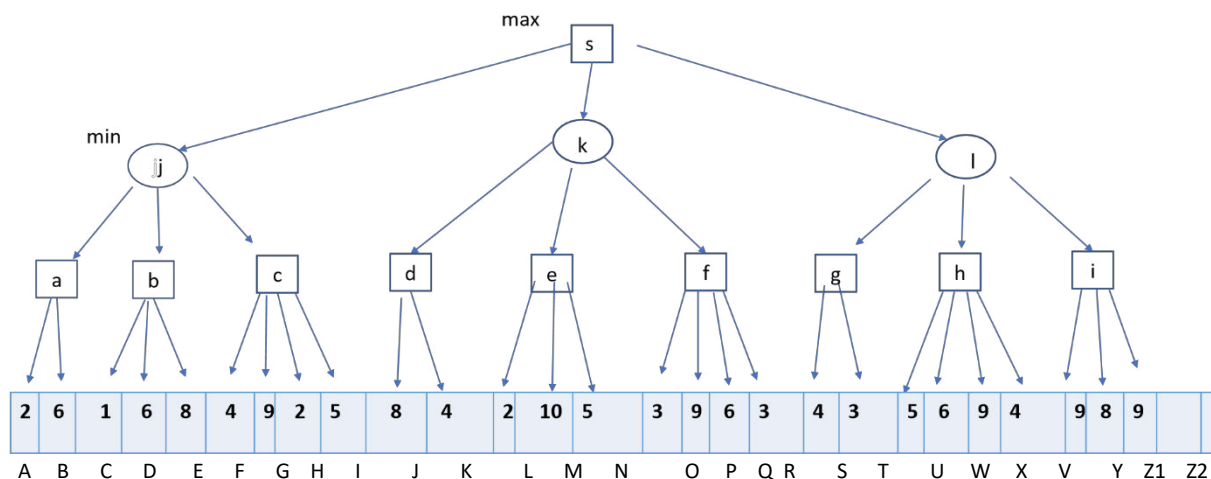
The 4. assigned variable is ....., and its value is .....

The 5. assigned variable is ....., and its value is .....

In this question you should calculate the Least Constraining Value by counting how many values in the domains of the neighboring variables in the constraint graph no longer satisfy the constraint between themselves and the variable being assigned to. You should also count no longer valid answers in the domains of already assigned variables.

## Problem 2: Adversarial Search (10 POINTS)

- 1) Write the minimax values in the nodes (s, j, k, l, ..., h, i) at different layers of the search tree above the leaf nodes.



- 2) Apply alpha-beta pruning algorithm to prune the parts of the tree that don't need to be examined.

For each pruned part (i.e., one or more leaf nodes) of the tree write down which nodes are pruned and why, referring to V and Alpha/Beta values, in the following format:

PRUNE <The letter(s) that represent the pruned leaf nodes> BECAUSE : <Reason>

The "reason" is either

$V = \langle \text{value} \rangle \leq \text{Alpha} = \langle \text{value} \rangle$  or

$V = \langle \text{value} \rangle \geq \text{Beta} = \langle \text{value} \rangle$

Example (not necessarily correct, just to show the requested format):

Prune A,B,C because:  $v=4 < \text{Alpha}=7$

So, if there are more than one leaf nodes next to each other write them at once and together as in the example above.

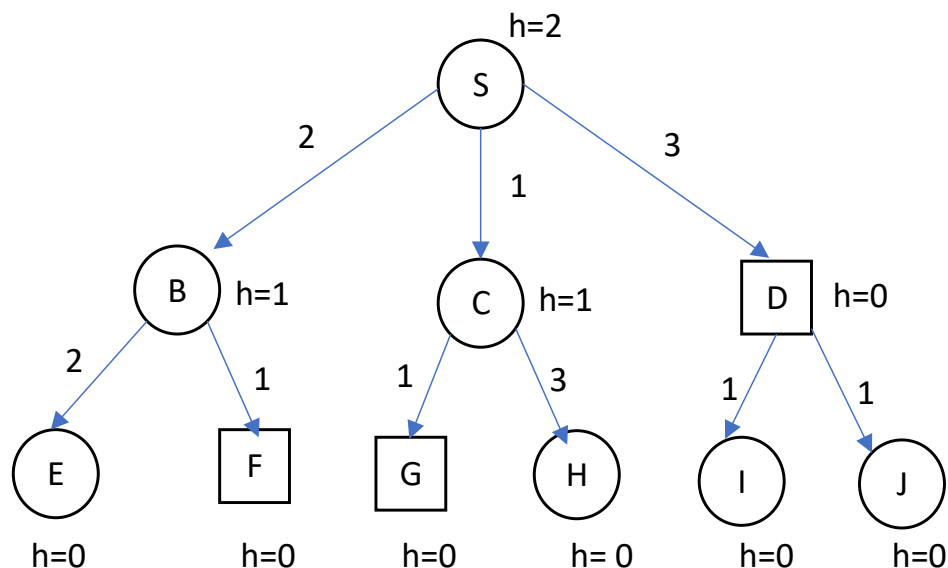
**PROBLEM 3 True/False Questions (2 points for each correct answer, -1 point for each wrong answer, 0 for each unanswered question. Total score between 0-20 points)**

1. Reactive agents typically use partial planning.
2. This is procedural knowledge about two cities in Norway: bigger (Oslo, Trondheim)
3. Expectimax is better suited for a deterministic environment than minimax.
4. In simulating annealing search the states represent a complete solution.
5. Principal of rationality (due to Allen Newell) maintains that the agent chooses actions in order to achieve its goal using the knowledge it has the knowledge it might gather.
6. Shortcoming of hill climbing algorithms are local maximas and plateaus.
7. Consider a block world problem where  $\text{On}(A,B)$ ,  $\text{On}(B,C)$  is the goal, and the KB Consists of these sentences:  $\text{On}(C,A)$ ,  $\text{On}(B,\text{Table})$ ,  $\text{On}(A,\text{Table})$ ,  $\text{Clear}(C)$ ,  $\text{Clear}(B)$ ,  $\text{Block}(A)$ ,  $\text{Block}(B)$ ,  $\text{Block}(C)$ . Suppose a planner that, given subgoals  $G_1, \dots, G_n$ , solves each subgoal consecutively (i.e., first one goal, and then the next one,...). If we use such a planner to solve the planning problem above and solve the goals in the given order (i.e.,  $\text{On}(A,B)$ ,  $\text{On}(B,C)$ ) the planning will obtain an optimal plan.
8. "Frames" as knowledge representation language combines declarative and procedural knowledge through their resolution mechanism.

9. Semantic networks allow multiple inheritance on the basis of specificity in the hierarchy.
10. Precision measures an NLP system's ability not to exclude a relevant document from the list of retrieved documents

#### PROBLEM 4 (Search Algorithms) (10 POINT)

In the following tree, the goals are shown by squares - there are three goals. Heuristic values and the step costs are as shown in the figure.



For each of the following algorithms, write the list of expanded nodes, and the path found. Ties are broken alphabetically.

1. Depth-first search

Expanded nodes:

The final path:

2. Breadth first search

Expanded nodes:

The final path:

3. Uniform Cost search

Expanded nodes:

The final path:

4. Greedy Best First search

Expanded nodes:

The final path:

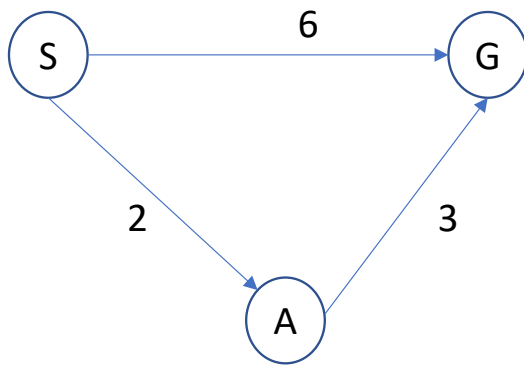
5. A\* search

Expanded nodes:

The final path:

## PROBLEM 5 (A\* heuristics) (10 POINTS)

Consider A\* search for the following search graph where S is the starting and G is the goal node. There are 4 different heuristic functions (H1-H4) of which values for the S, G, A nodes are shown in the table on the right of the graph.



Heuristic	$h(S)$	$h(A)$	$h(G)$
H1	4	1	0
H2	5	4	0
H3	4	3	0
H4	5	2	0

- 1) For each heuristic function fill in the following table with Y/N for admissibility and consistency for the search graph above. Explain your answer for each Yes or No.

Heuristic	Admissible (Yes/No)	Consistency (Yes/No)
H1		
H2		
H3		
H4		

- 2) Dominance of Heuristics. Remember that domination has a special meaning in the context of heuristic functions. What does it mean that a heuristic function dominates another one? Write the definition of dominance of heuristics.

Now your task is to investigate the dominance relationship between H1 – H4.

- 3) Do heuristic functions H3 and H4 have a dominance relationship?  
 4) Is there a dominance relationship between Heuristic function H4 and H1?

## PROBLEM 6 (Propositional Logic) 10 POINTS

Four bunny rabbits played together in the forest. Each bunny is either brown or white.

However, none of them could see each other very clearly, and their views were obscured by bushes.

Bunny 1 says, "One of bunnies 2 & 3 is brown and one is white, but I can't tell which."

Bunny 2 says, "One of bunnies 3 & 4 is brown and one is white, but I can't tell which."

Bunny 3 says, "Bunny 4 is brown."

Bunny 4 says, "It is not the case that both Bunny 1 and Bunny 4 are brown."

Bunny 1 asks, "Is it true that I am a white bunny rabbit?"

Converting these statements into propositional logic and using resolution refutation, can we answer the question of Bunny 1? Use  $B_i$  for "Bunny  $i$  is brown", e.g.,  $B_2$ : Bunny 2 is brown.

Show all the steps you have taken to prove/answer this question.

## PROBLEM 7 (GAME THEORY) (10 POINTS)

This problem is about watering rice farms in Sumatra. Two farms are located in the riverside, upstream and downstream farms. Water is not sufficient---meaning if both farmers water their rice crops at the same time the upward one gets enough water but the downstream one is not watered sufficiently. However, if they don't water their crops at the same time, both farms will suffer from a pest problem.

The game is about the timing of watering. Assume two possible times for watering, A and B.

Let  $x$  represent the utility loss for the farmer who gets reduced water and let  $y$  represent the loss in utility due to pests. Assume that when there is no crop loss due to lack of water or a pest problem, then the payoff is equal to 1.

1. Draw the payoff matrix using A and B as actions. Use  $x$  and  $y$  to define the payoffs for the upward and downward farms.
2. Under which conditions does a strongly dominant strategy equilibrium arise?

## PROBLEM 8 SHORT QUESTIONS

1. In some environments randomized behaviour can be rational. Describe what type of environments and give an example.



2. Entailment for first-order logic is semidecidable. What does this mean? Explain very briefly.

3. Convert this sentence into Conjunctive normal form and show all the steps in this process:

$$\forall Y (\forall X \text{ taller}(Y,X) \vee \text{wise}(X)) \Rightarrow \text{wise}(Y)$$

5 Fill in the blank so that the sentence becomes correct.

A entails B if and only if ( . . . . . ) is unsatisfiable.

## PROBLEM 9 (LOGIC) (10 points, 2 point each)

Translation from English to Logic.

- 1) There is a mouse that every cat chases.
- 2) For every flavor, there is some person who likes that flavor.
- 3) "There was no student who scored 100 on every quiz."
- 4) There is a barber who shaves all men in town who do not shave themselves.
- 5) There exists a lawyer all of whose clients are doctors