EXAM TDT4136 HØST-2018 ORDINARY.
QUESTIONS and ANSWERS (at the very end)

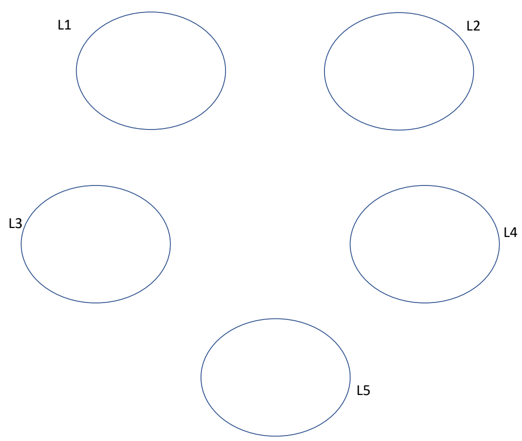
Problem 1: CSP (10 POINTS)

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: Day(L1) < Day(L2), i.e., Lecture 1 must be taught the day before the day of Lecture 2, and Day(L3) < 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: {   }

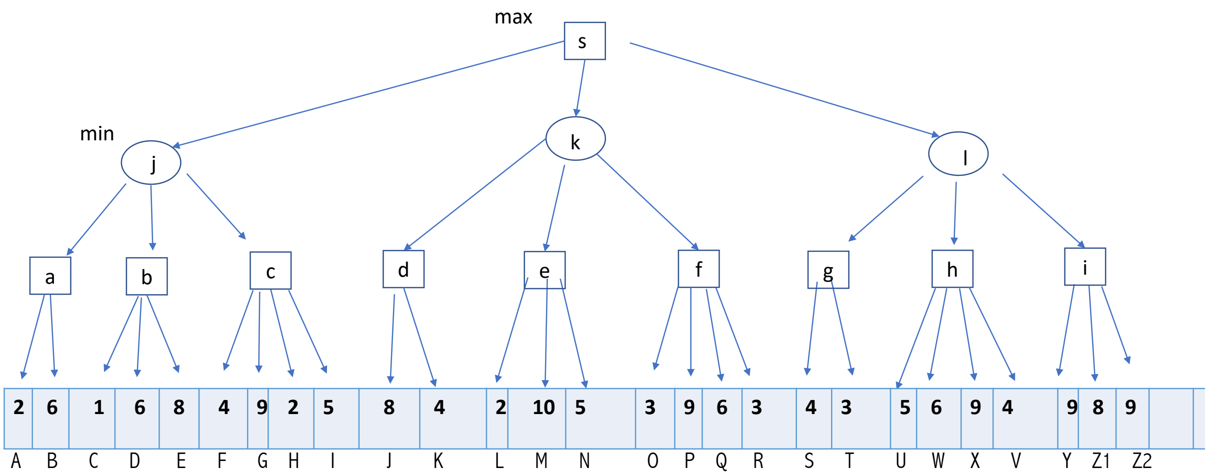
L5: {   }

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 ……………......

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= <value> **<** Alpha = <value> or

V= <value> **>** Beta = <value>

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

Prune A,B,C because: v=4 < 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 On(A,B), On(B,C) is the goal, and the KB Consists of these sentences: On(C,A), On(B,Table), On(A,Table), Clear(C), Clear(B), Block(A), Block(B), Block(C). Suppose a planner that, given subgoals G1,...,Gn, 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., On(A,B), On(B,C)) the planning will obtain an optimal plan.

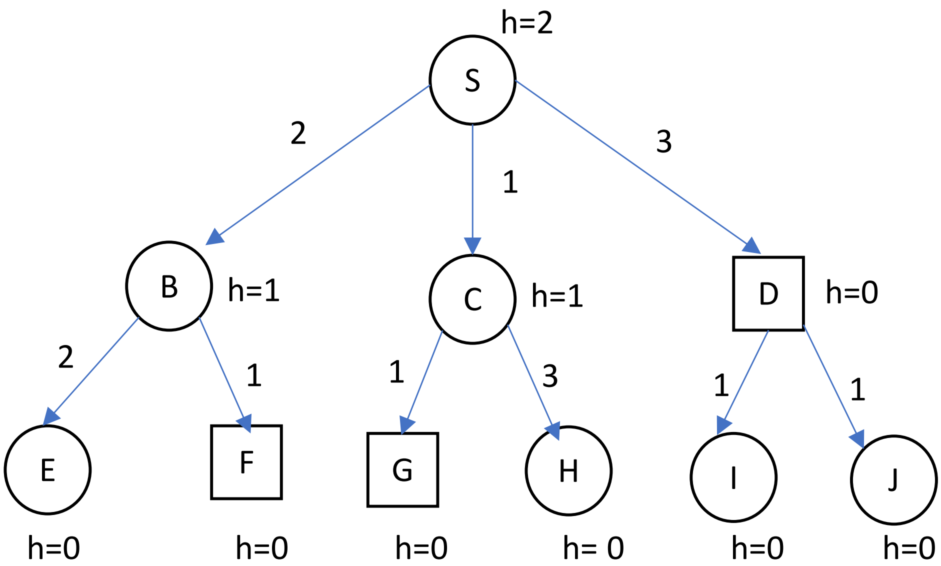
8. "Frames" as knowledge representation language combines declarative and procedural knowledge through their resolution mechanism.

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:

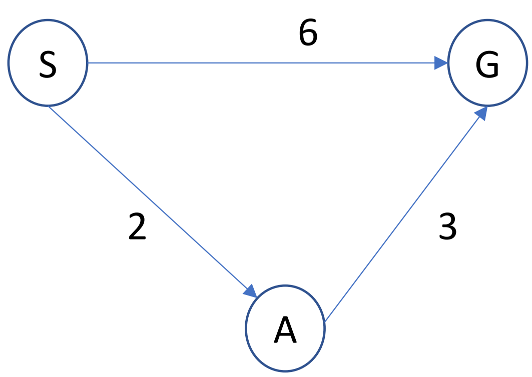
5. A* search

   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 Bi for "Bunny *i* is brown", e.g., B2: 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 Conjunctional normal form and show all the steps in this process:
   $\forall Y\ (\forall X\ (taller(Y,X) \lor wise(X)) \Rightarrow wise(Y))$

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

ANSWERS

PROBLEM 1 (CSP): (points: 2-2-1-2-3)

1) Fully connected graph. Alldiff (L1, L2, L3, L4,L5). A lecture is represented in terms of 2 attributes, the prof and the day/time, combination of these two. In map colouring problem there was 1 attrib, i.e, the color. Here each leture is different from all others because no lecture has same prof-day combination. 2 points are given only if each lecture node has an edge with each of the rest of the lectures, otherwise zero points.

2)
L1: {A1, A2, B1, B2 }

L2: { A1, A2, B1,B2, C1,C2 }

L3: { A1, A2 }

L4: { C1, C2 }

L5: { B1, B2, C1, C2 }

3) Constraints:

   Alldiff(L1, L2, L3, L4, L5)
   Day(L1) < Day (L2)
   Day(L3)< Day(L5)

4) Not arc-consistent.

L1: { B1 }

L2: { A2,B2, C2 }

L3: { A1 }

L4: { C1, C2 }

L5: { B2, C2 }

5) Bactracking:

The 1. assigned variable is L1, and its value is B1

The 2. assigned variable is L3, and its value is A1

The 3. assigned variable is L4, and its value is C1

The 4. assigned variable is L5, and its value is B2

The 5. assigned variable is L2, and its value is A2

PROBLEM 2 (Adversarial Search): (points 3-7)

1) 8 ; 6,8,4 ; 6,8,9 ; 8,10,9 ; 4,9,9

2) Here full point both for strictly larger/smaller and larger&equal/smaller&equal versions where the former was the version the exam question. If the answer is correct for either of these cases, ful point for this question is given

Prune H and I because: V=9 > Beta=6

Prune E Because V=6 >= beta=6. (counted as correct both if E is pruned and not pruned)

Prune N because: V= 10 > Beta=8

Prune Q and R because: V=9 > Beta=8

Prune h (i.e., U, W, X, V) and i (i.e., Y, Z1,Z2) because: V=4 < Alpha=8

PROBLEM 3 (True/False): (total 20 pts, 2 points each correct answer, -1 each wrong answer. 0 for no answer)

F **F** **F** **T** **F** **T** **F** **F**(Frame does not have resolution mechanism) **T** **F**

PROBLEM 4 (Search Algorithms) (points 2-2-2-2-2)

1 Depth-first search

Expanded nodes: SBEF

The final path: SBF

2 Breadth first search

Expanded nodes: S
Children(S): B,C,D where goal test immediately, D is goal

The final path: SD

3 Uniform Cost search

Expanded nodes: SCBG

The final path: SCG

4 Greedy Best search

Expanded nodes: SD

The final path: SD

5 A* search

Expanded nodes: SCG

The final path: SCG

Problem 5 (Heuristics) (points: 6-2-1-1)

1)

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

H2 is not inadmissible heuristic, because it overestimates the cost from A. The actual cost of A to G is 3 while its heuristic value is 4.
Heuristic H1 is not consistent: h(S) - h(A) = 4 - 1 = 3 NOT <= path(S →A) = 2.
Heuristic H3 is consistent: h(S) - h(A) = 4 - 3 = 1 <= 2
Heuristic H4 is not consistent: h(S) - h(A) = 5 - 2 = 3 NOT <=2

2) A heuristic dominates another if all of its values are greater than or equal to the corresponding values of the other heuristic
3) Heuristic functions H3 and H4 have no dominance relationship.
4) Heuristic function H4 dominates H1.

PROBLEM 6 Propositional Logic (Bunny)

You translate these facts into Propositional Logic as:
"One of bunnies 2 & 3 is brown and one is white, but I can't tell which." : (B2 and ¬ B3) or (¬ B2 and B3) **! Note that the propospositional sentence should represent that one of 2 and 3 is white and one is brown, i.e., only one is brown - and they don't have the same colour. You lose point if you represent this sentence for example as (B2 or B3).**

[B3 and (¬ B4) or [(¬ B3) and B4)]
B4
¬(B1 and B4)

Bunny 1 asks, "Is it true that I am a white bunny rabbit?"
You translate this query into Propositional Logic as "(¬ B1)" and form the negated goal as "B1." Your
knowledge base (KB) in CNF plus negated goal (in clausal form) is:
(B2 or B3)
[(¬ B2) or (¬ B3)]
(B3 or B4)
[(¬ B3) or (¬ B4)]
B4
[(¬ B1) or (¬ B4)]
B1 (negation of ¬B1 (= white Bunny)

You have B4 and B1 and [(¬ B1) or (¬ B4)]. So you reach a contradiction immediately.

From B4 and [(¬ B1) or (¬ B4)] derive (¬ B1)
Contradiction with B1.

PROBLEM 7 (GAME THEORY, 10 points) (points: 5-5)

1) The payoff matrix:

	A	B
A	1, 1 − x	1 − y, 1 − y
B	1 − y, 1 − y	1, 1 − x

2. There is no strongly dominant strategy equilibrium in this problem. Assume x,y are positive numbers. Then (B,A) cannot be a dominant strategy equilibrium (DSE) as both agents could get a positive payoff by choosing another action. the same holds for (A,B). For (A,A) to be a DSE, it would have to be the case that $x < y$ (so that A-for the column player- is a strict best response to to A-for the row player). However, for A-column player to be a dominant strategy, it must also do better if row player plays B, which can only be the case when $y < x$. Thus (A,A) cannot be a DSE. The same reasoning holds for (B,B) meaning there is no DSE for any value of x or y.

The question goes like this:

This problem is about….

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

Let x represent….

1……..
2…….
It is obvious that both 1 and 2 is about "This problem/game" and you are expected to answer for the matrix you created.

If you wrote as the answer what strongly dominance means (with formula etc), but didn't apply it to this problem, 1 point will still be given.

If the matrix is not correct but still have the same utility structure and you answer correctly the second part, you get full point (5 pts) for the 2. Part (i.e., no strongly dominant str.)

PROBLEM 8 SHORT QUESTIONS

1) In competitive multiagent environments it can avoid the pitfalls of predictability.
2) Algorithms exist that say yes to every entailed sentence but no alg. Exists that also say no to every nonentailed sentence (Textbook, p 325)

3)

$$\forall y\ (\forall x\ (taller(y,x) \lor wise(x)) \Rightarrow wise(y))$$

$$\forall y\ (\forall x\ \neg(taller(y,x) \lor wise(x)) \lor wise(y))$$

$$\forall y\ \forall x\ (\neg taller(y,x) \land \neg wise(x)) \lor wise(y))$$

$$\forall y\ \forall x\ (\neg taller(y,x) \lor wise(y)) \land (\neg wise(x) \lor wise(y))$$

$$(\neg taller(y,x) \lor wise(y)) \land$$

$$(\neg wise(x) \lor wise(y))$$

4) $A \wedge \neg B$

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

Translation from English to Logic.

1) There is a mouse that every cat chases.

$\exists y\ \forall x\quad Mouse(y) \wedge [Cat(x) \Rightarrow Chases(x, y)]$

2) For every flavor, there is some person who likes that flavor.

$\forall f\ \exists p\ Flavor(f) \Rightarrow [\ Person(p) \wedge Likes(p, f)\ ]$

3) "There was no student who scored 100 on every quiz."

$\forall s\ \exists q\ Student(s) \rightarrow [\ Quiz(q) \wedge \neg Scored100(s, q)\ ]$

4) There is a barber who shaves all men in town who do not shave themselves.

$\exists x\ \forall y\ Barber(x) \wedge Man(y) \wedge \neg Shaves(y, y) \Rightarrow Shaves(x, y)$

5) There exists a lawyer all of whose clients are doctors

$\exists\ p1\ \forall\ p2\ Occupation(p1, Lawyer) \wedge [Customer(p2, p1) \Rightarrow \_Occupation(p2, Doctor)]$

or

$\exists\ p1\ Occupation(p1, Lawyer) \wedge [\forall\ \_p2\ Customer(p2, p1) \Rightarrow \_Occupation(p2, Doctor)]$