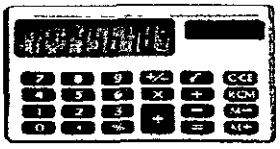
UNIVERSITY EXAMINATIONS



UNIVERSITEITSEKSAMENS

UNISA university of south africa

COS3751

October/November 2016

TECHNIQUES OF ARTIFICIAL INTELLIGENCE

Duration 2 Hours

100 Marks

EXAMINATION PANEL AS APPOINTED BY THE DEPARTMENT

Use of a non-programmable pocket calculator is permissible.

Closed book examination

Examiners :	
First	Dr W van Staden
Second	Prof. E van der Poel
External	Dr S Kroon (Stellenbosch)

Instructions

1 Answer all questions.

2 Write neatly and legibly

3 Read each question carefully before answering always make sure you provide an answer to what is being asked

4 This paper consists of 7 pages.

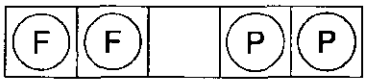
[TURN PAGE]

Question 1	State Spaces	[12]

(a) Differentiate between an *agent function* and an *agent program* (2)

(b) An agent equipped with a GPS unit, as well as actuators which allow it to move in any direction on a 2-dimensional plane, and proximity sensors, is attempting to find a path to some destination The agent determines that its next move should be 1 meter directly to the north, and proceeds to perform the action At the end of the action, the agent polls its location using the GPS unit, and discovers that it has only moved 0 75 meters, it executes another north-bound move (this time only 0 25 meters, to attempt to reach its original goal of moving 1 meter), and discovers that it moved 0.45 meters – thus a total displacement of 1 2 meters when it intended to move only 1 meter in total It also discovers that the actions did not take it directly north (it moved 10 degrees off course in total). What does this information tell us about the possible nature of the agent's environment and its sensors? Justify your answer (3)

(c) In the Francs and Pounds puzzle there is a container with five cells. In the initial state of the container the two leftmost cells are occupied by a Franc coin each, while two Pound coins occupy the two rightmost cells. The middle cell is empty It can be illustrated as follows:



The puzzle involves moving the coins one at a time to reach the goal state In the goal state the Pound and Franc coins are interchanged, as follows.

There are only four permissible moves

1 A Pound Slide - a Pound coin slides one position to the left into an empty cell
2 A Pound Hop - a Pound coin jumps left across one cell containing a coin into an empty cell.
3 A Franc Slide - a Franc coin slides one position to the right into an empty cell
4. A Franc Hop - a Franc coin jumps right across one cell containing a coin into an empty cell.

A cell may never contain more than one coin and all coins must be in the container after every move

i Define a state representation for the game (Provide the representation using formal mathematical notation.) (2)
ii Using your representation, show the start and goal states (2)
iii Define the applicable actions for the start state (state S_0); be sure to indicate that the action returns a resulting state (3)

Question 2	Searching	[25]

(a) Explain how a uniform cost search differs from a breadth first search Pay attention to the data structure that is used in each (4)

(b) Consider Figure 1 In the four queens problem, we try to place four queens on a 4×4 chess board, so that no queen can capture another queen (i.e there is only one queen on any diagonal, row, or column of the board) The placement of a queen is called *legal* if the queen is unable to capture any other queens on the board The start state is the empty board, and goal states are those boards that have four legally placed queens on them (In the figure, children nodes are generated by attempting to place queens in columns from left to right)

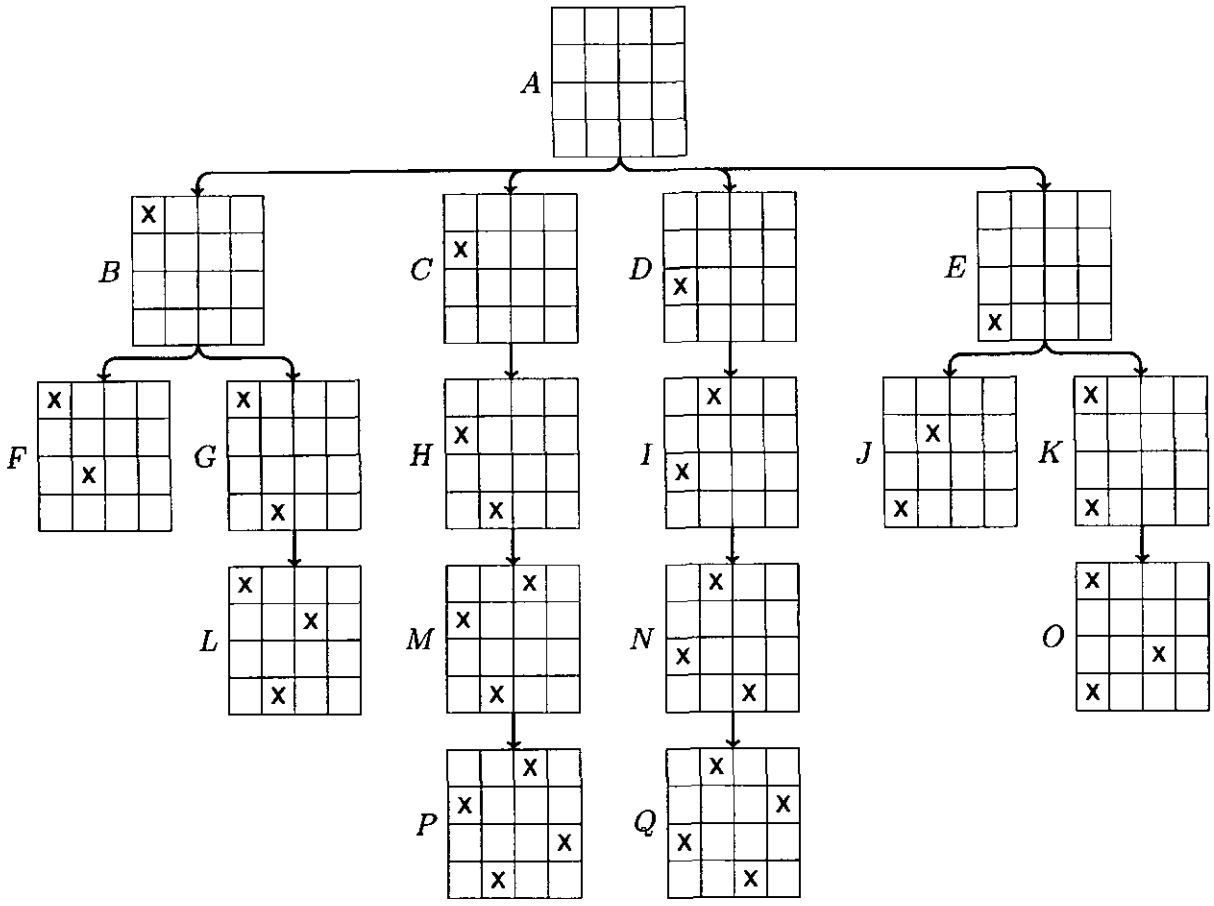


Figure 1 State Space for the Four Queens Problem

Perform an A^* search (on the state space provided in Figure 1) to find a solution path from the start state to a goal state. Keep the following in mind when answering this question:

1 You only need to show the first 4 steps (that is, steps 2 to 5).
2 In your answer, show the contents of the frontier after each step, as well as the $\hat{g}, \hat{h}$ and $\hat{f}$ values for every expanded node. The name of each node appears next to it in Figure 1
3. You only need to show the new nodes added to the frontier after each step. don't rewrite the entire frontier at each step.

4 Let $\hat{h}(S)$ be the number of squares on the board (for state S) where another queen may be placed legally.

5 Let $\hat{g}(m)$ be the depth of node m

6 $\hat{g}(A) = 0$

7 When two $\hat{f}$ values are the same, always choose the node with the name that is first alphabetically for expansion

The following table provides the structure you should use in your answer (the first step has been provided) (13)

Step	Expanded	Frontier $(n(\hat{h}, \hat{g}, \hat{f}))$
1		A(16, 0, 16)
2		.

(c) Consider the state-space graph in Figure 2

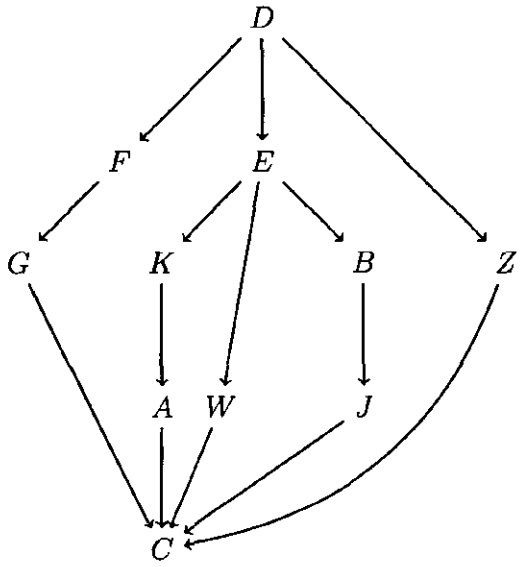


Figure 2 State-space graph

Assume that a breadth first search is employed, and that the start node is D and the goal node is J Write down the order in which the nodes are expanded (expansion proceeds in a left to right fashion) Continue until the goal test is successful. (8)

Question 3	Adversarial Search	**[15]**

(a) Consider the game tree in Figure 3 and then answer the questions that follow (the static utility values for the leaf nodes are provided below each leaf node) Circles represent MAX level nodes, and squares represent MIN level nodes:

i. Suppose a Minimax search is performed on the tree. Provide the min-max values for nodes $A, B, C,$ and G (4)

ii Suppose a Minimax search with Alpha/Beta pruning is done in a left-to-right fashion on the tree Provide the α and β values for nodes A $B, C,$ and E which would have been recorded during the search (the values when the search terminates). (8)

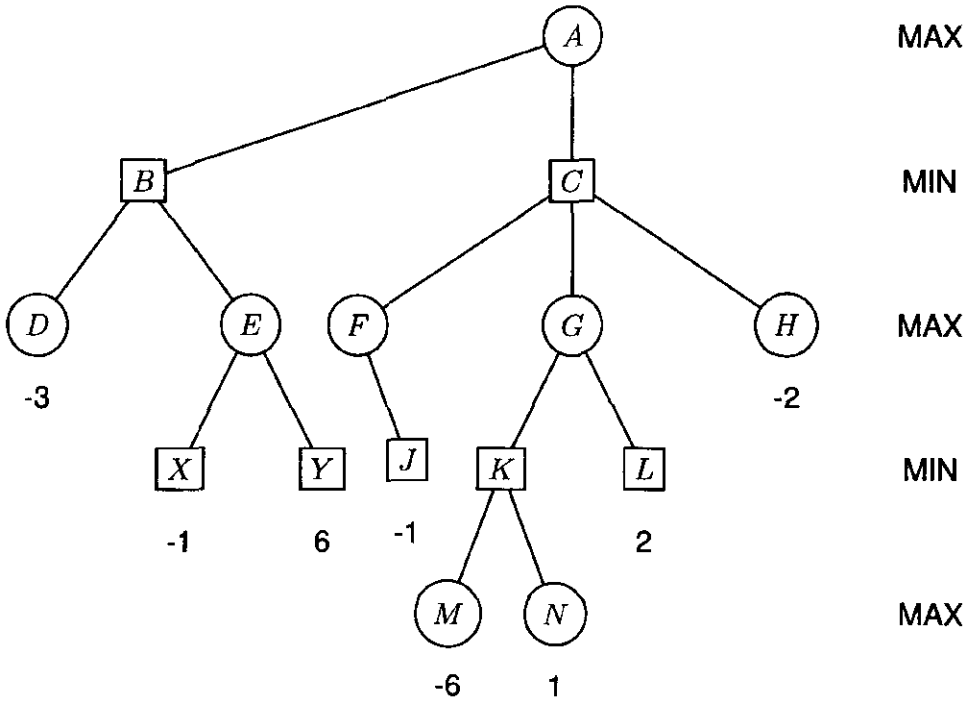


Figure 3 Adversarial Search Tree

(b) Analysis of chess games in which white has a King, a Queen, and a Knight, and black has a King, and two Rooks (for example a board position such as provided in Figure 4) revealed that 17% of such games end in a draw, 78% end in a win for white, and 5% end in a win for black.

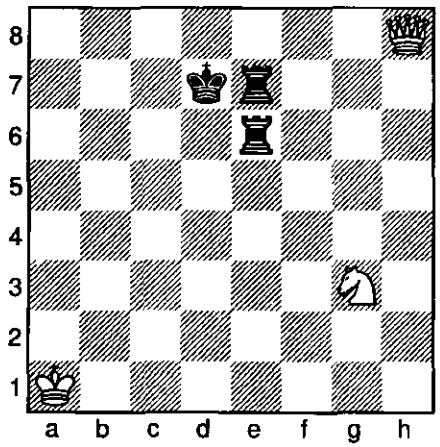


Figure 4. KQN/KRR Combination (white to move)

Calculate the expected utility value for boards as described above for white. Provide any detail you feel is necessary in order to calculate the value. (Show your calculations) (3)

Question 4 Constraint Satisfaction Problems **[15]**

Consider a slightly relaxed version of the Magic Square (Figure 5).

M_{11}	M_{12}	M_{13}
M_{21}	M_{22}	M_{23}
M_{31}	M_{32}	M_{33}

Figure 5: Magic Square for $n = 3$

For this magic square, each cell can be assigned the value 1, 2, or 3. The values should be assigned to the cells in such a way that the values for each row adds up to 6, the values for each column adds up to 6, and at least one of the diagonals should add up to 6

This problem can be presented as a Constraint Satisfaction Problem

(a) Define the variables for this problem. Provide appropriate notation for your answer (2)

(b) Define the domains for the variables of this puzzle. (2)

(c) Provide the constraints for this problem (7)

(d) If the value 2 is assigned to entry M_{11} (i.e $M_{11} = 2$), make the remaining variables domain consistent (**don't solve the square!**) (4)

Question 5 Resolution Refutation **[22]**

The following English statements are given:

1 Anything that anyone eats and becomes sick from eating, is poisonous

2 If something is poisonous, John won't eat it

3 Jack-o-lantern mushrooms are poisonous.

4. Death cap mushrooms are poisonous

5. Bill eats toadstools, and becomes sick from eating them

6 Sue eats everything that Bill eats.

(a) Convert the statements to First Order Logic (FOL) statements The first statement has been provided already, convert the rest Remember to standardise your variables (6)

1 $\forall y, z[eats(y, z) \wedge sickfromeating(y, z) \Rightarrow poisonous(z)]$

(b) Convert all of the FOL statements from question (a) to Conjunctive Normal Form (including the statement that was provided). **Hint:** First think carefully what it means for a statement to be in conjunctive normal form. (7)

(c) Use resolution refutation to prove that John does not eat toadstools, using the assumptions from question (b) (9)

Question 6	Machine Learning	[11]

(a) Many machine learning techniques suffer from the problem of overfitting. Briefly discuss two techniques that have been developed to reduce the problem of overfitting during decision tree learning. (5)

(b) Convert the following boolean function into a decision tree (4)

x_1	x_2	x_3	$f(x_1, x_2, x_3)$
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

Table 1: Boolean function

(c) Explain why the choice of the sequence in which we choose the variables for constructing a decision tree is important. (2)

Total: 100