UNIVERSITY EXAMINATIONS

UNIVERSITEITSEKSAMENS

UNISA university of south africa

COS3751

May/June 2017

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.

This examination question paper remains the property of the University of South Africa and may not be removed from the examination venue.

Examiners :

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Second	:	Prof. E van der Poel
External	:	Dr WS Leung (University of Johannesburg)

Instructions:

1. Answer all questions.
2. Write neatly and legibly.
3. The table in the appendix is provided to help during your entropy and information gain calculations.
4. This paper consists of 6 pages including Appendix A (page 6).

Question 1	State Spaces	**[9]**

(a) Define the concept of a *Fully Observable* environment. (3)

(b) Consider a game of chess. Is this a deterministic or stochastic environment? Clearly explain why. (2)

(c) Differentiate between discrete and continuous environments. Provide an example of each. (4)

Question 2	Searching	**[23]**

(a) Consider the diagram shown in Figure 1 below and answer the questions that follow (the $\hat{h}$ value of each node is provided in brackets after the node name, and the $\hat{g}$ value is provided next to the edges between nodes):

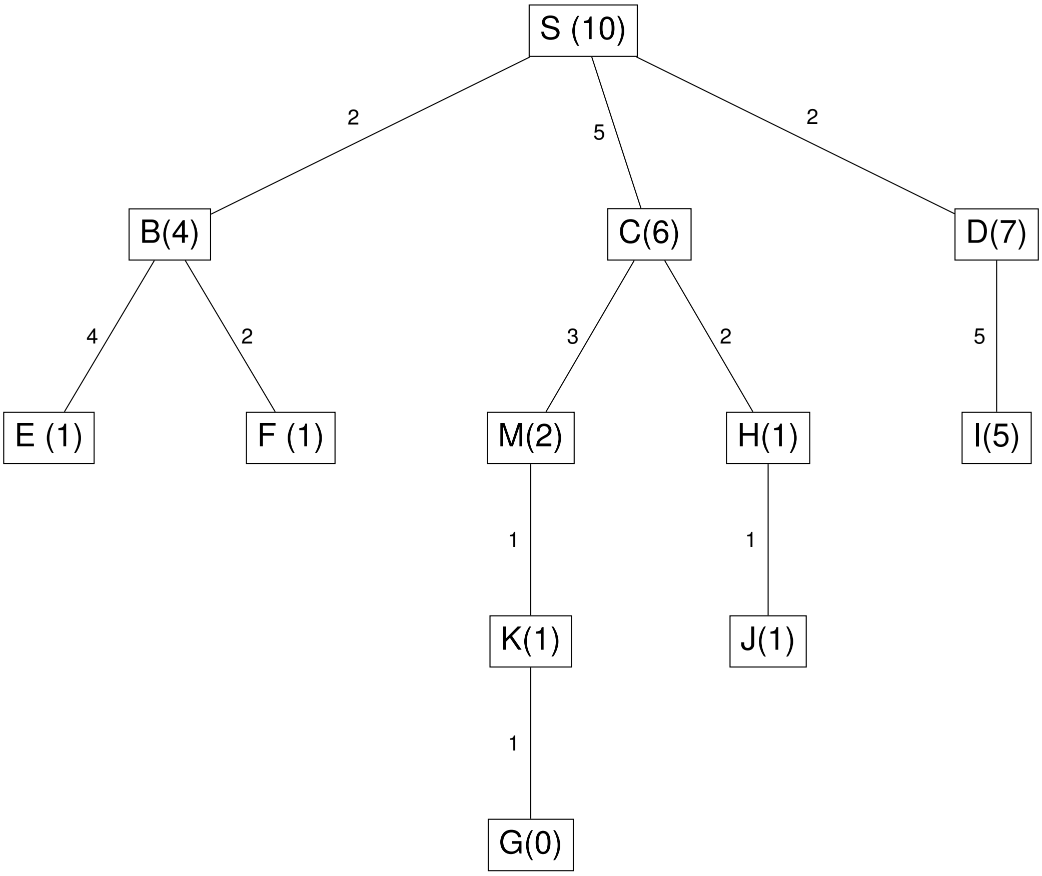

Figure 1: State Space

i. Explain what an *admissible heuristic* is. (2)

ii. Based on observation, is the heuristic employed in the figure admissible? Clearly explain your answer. (3)

iii. 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 5 steps (step 1 has already been completed for you; you don't have to find the solution).

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 inside the node (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. 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). (11)

Step	Expanded	Frontier $(n(\hat{h}, \hat{g}, \hat{f}))$
1		S(10, 0, 10)
2	...	...

(b) Consider the diagram provided in Figure 2 below.

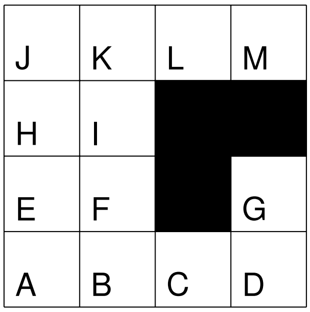

Figure 2: Depth First Search

Assume that loops are detected, that is, already expanded nodes will not be expanded again. Nodes are generated in the the order Down, Right, Up, and Left. For example, if node F is expanded, nodes are generated: B (Down), and I (Up), and E (Left). Take note that there are no nodes right of F. Diagonal moves are not permitted.

i. Suppose the start node is node M, and the goal node is node G. List the first 4 nodes (after M) in the order they are generated for a non-recursive based depth-first search. (4)

ii. Does the search above discover an optimal solution to the problem? Justify your answer. (3)

Question 3	Adversarial Search	**[12]**

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).

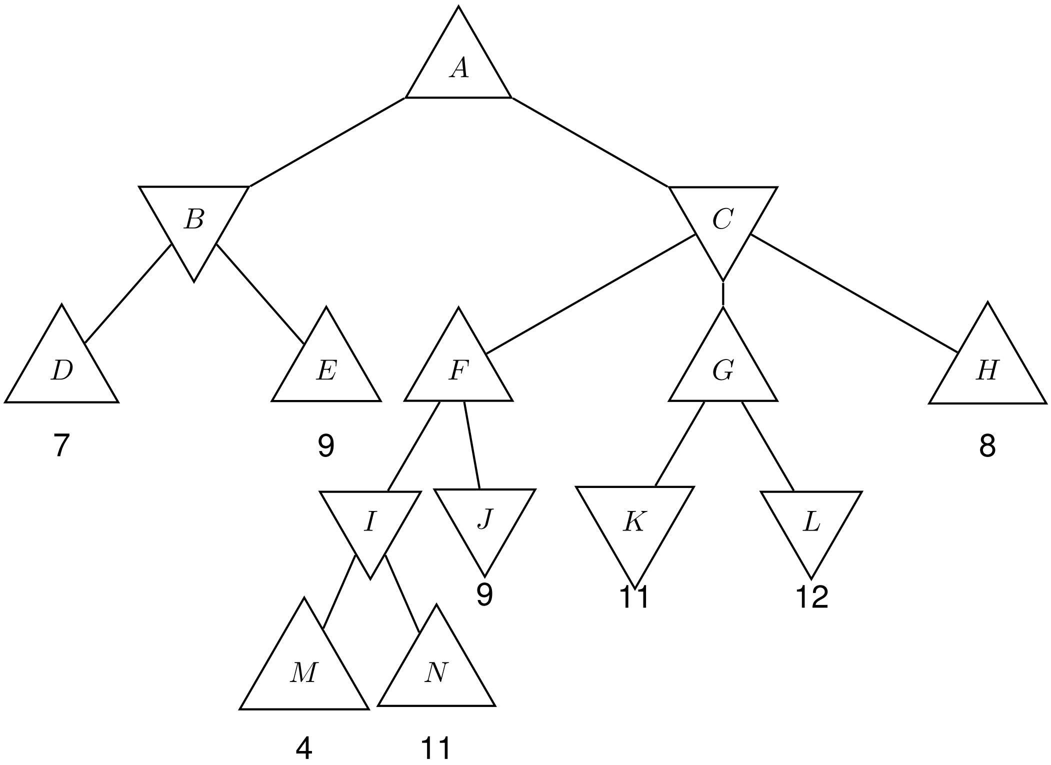

Figure 3: Adversarial Search Tree

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

(b) 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 F which would have been recorded during the search (the values when the search terminates). (8)

Question 4	Constraint Satisfaction Problems	**[16]**

Consider the following crypt-arithmetic puzzle:

```
      S E N D
 +    M O R E
 ------------
    M O N E Y
```

The puzzle can be rewritten as a CSP. Answer the questions below.

(a) Define the variables for this puzzle (include all possible variables that are used). (6)

(b) Define the domain for each variable. Be as specific as possible. (4)

(c) Provide the constraints for this problem. (6)

Question 5	Predicate Logic	**[20]**

(a) Convert the following propositional sentence to Conjunctive Normal Form:
$(P \Rightarrow Q) \Rightarrow (\neg R \Rightarrow (S \land T))$ (10)

(b) Closely examine the following propositional sentences in a knowledge base ρ.

1 $\neg A \lor \neg B \lor \neg C \lor D$

2 $\neg D \lor \neg F \lor G$

3 $\neg G \lor \neg H \lor I$

4 $\neg A \lor \neg H \lor C$

5 $\neg A \lor B$

6 A

7 H

8 F

Show that $\rho \models I$ using forward chaining. (10)

Question 6	Learning from Examples	**[20]**

Consider the following data in Table 1, comprised of three binary input attributes (A_1, A_2, and A_3), and one binary output y:

Example	A_1	A_2	A_3	y
x_1	1	0	0	0
x_2	1	0	1	0
x_3	0	1	0	0
x_4	1	1	1	1
x_5	1	1	0	1

Table 1: Data set

(a) Using the principles of Information Gain build a decision tree for the data. Show the computations made to determine the attribute to split at each node. Use the table on page 6 for the entropy calculations. Also show the decision tree: branch and leaf nodes, as well as edges and appropriate labels for the edges. (20)

Total: 100

A Entropy Table (Boolean valued variables)

p : Ratio of positive examples.
E : Corresponding entropy ($-(plog_2p + (1-p)log_2(1-p))$).

p	E
0.00	0.00
0.10	0.47
0.15	0.61
0.20	0.72
0.25	0.81
0.29	0.87
0.30	0.88
0.33	0.91
0.35	0.93
0.38	0.96
0.40	0.97
0.45	0.99
0.50	1.00
0.55	0.99
0.60	0.97
0.63	0.95
0.65	0.93
0.67	0.91
0.70	0.88
0.75	0.81
0.80	0.72
0.85	0.61
0.90	0.47
0.95	0.29
1.00	0.00

Example: For a set of 4 positive examples, and 1 negative example (written $E[4,1]$), the ratio is $p = \frac{4}{5}$, or 0.80. The corresponding entropy value is given by the table as 0.72.

Round to the closest value on the table above, and always round to the closest integer: for example $0.375 \simeq 0.38$, but $0.374 \simeq 0.37$.