

# NAMIBIA UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF COMPUTING AND INFORMATICS

DEPARTMENT OF COMPUTER SCIENCE

QUALIFICATION: Bachelor of Computer Science	
QUALIFICATION CODE: 07BACS	LEVEL: 7
COURSE: Artificial Intelligence (and Computer Graphics)	COURSE CODE: ARI711S/AIG710S
SESSION: July 2022	PAPER: Theory
DURATION: 3 Hours	MARKS: 90

THIRD OPPORTUNITY EXAMINATION QUESTION PAPER	
EXAMINER:	Prof. José G. Quenum
MODERATOR:	Mr Stantin Siebritz

This paper consists of 2 pages  
(excluding this front page)

## INSTRUCTIONS

1. This paper contains 4 questions.
2. Answer all questions on the exam paper.
3. Marks/scores are provided at the right end of each question
4. Do not use or bring into the examination venue books, mobile devices and other materials that may provide you with unfair advantage. Should you be in possession of one right now, draw the attention of the examination officer or the invigilator.
5. NUST examination rules and regulations apply.

## PERMISSIBLE MATERIALS

Calculator

## Question 1 ..... [25 points]

- (a) Consider an air cargo transport problem involving loading and unloading cargo and flying it from place to place. We use three actions in this problem: `load`, `unload` and `fly`. We use two predicates to define the actions: `in(x, y)`, which means that cargo  $x$  is inside plane  $y$ ; `at(z, x)`, which means that object  $z$  (either cargo or plane) is at airport  $x$ . Note that once inside a plane, a cargo is not considered at an airport any longer. Additionally, the predicate `cargo(x)` means that  $x$  is a cargo; the predicate `airport(y)` means that  $y$  is an airport and the predicate `plane(z)` means that  $z$  is a plane. [15]
- Initially we have three planes:  $P_1$ ,  $P_2$  and  $P_3$ . We also have two cargos:  $C_3$  and  $C_4$  and three airports:  $Loc_1$  and  $Loc_4$  and  $Loc_5$ .  $C_3$  is at  $Loc_1$  and  $C_4$  is at  $Loc_4$ . As well,  $P_1$  is at  $Loc_1$ ,  $P_2$  is at  $Loc_4$  and  $P_3$  is at  $Loc_5$ .
- Using the STRIPS notation and first-order logic, define the actions and the initial knowledge base.
- (b) Consider the goal of moving  $C_3$  to  $Loc_4$  and  $C_4$  to  $Loc_1$ , update the partial plan  $\{\text{unload}(C_3, P_1, Loc_4)\}$  to satisfy the goal. Each step during the update must be discussed and justified. [10]

## Question 2 ..... [20 points]

- (a) The Millionaire is your favourite TV show. It is a ten-round game. Except for the first round, the player can choose to play or quit at each round. When the player quits, the game ends, and s/he can collect the rewards that s/he has earned so far. When the player plays, s/he can succeed and move to the next round or fail, leading to the end of the game. Note that if s/he loses, all the rewards s/he has accumulated so far are lost. Note also that when the player reaches the last round, whether s/he plays or not the game ends with the appropriate reward. [7]

Table 1: Millionaire – Rewards and success probability

Round	Success Probability	Reward
1	0.99	10
2	0.9	50
3	0.8	100
4	0.7	500
5	0.6	1000
6	0.5	5000
7	0.4	10000
8	0.3	50000
9	0.2	100000
10	0.1	500000

Model this problem as a Markov Decision process and evaluate the following policy:  $\pi = \{\text{round}_1 \mapsto \text{play}, \text{round}_2 \mapsto \text{play}, \text{round}_3 \mapsto \text{quit}\}$ . You will use a discount factor of 0.95.

- (b) Applying the policy iteration algorithm, find the optimal policy for the problem starting from the policy  $\pi$ . [13]

Question 3 ..... [25 points]

- (a) A Sudoku puzzle of order 3 is a  $9 \times 9$  grid filled with digits between 1 and 9. The following rules apply. The same digit should not appear more than once in a column or a row. As well, there should be no repetition of a digit in a  $3 \times 3$  block. [8]

Table 2: Incomplete Sudoku puzzle

	2	6			8	1	
3			7		8		6
4				5			7
	5		1		7		9
		3	9		5	1	
	4		3		2		5
1				3			2
5			2		4		9
	3	8				4	6

Table represents an incomplete puzzle. Define the puzzle in Table as a constraint satisfaction problem.

- (b) Use forward checking and propagation to complete the puzzle. You will show all the domain reductions. [17]

Question 4 ..... [20 points]

The diagram in Figure represents an adversarial game. Using the  $\alpha - \beta$  pruning, solve the game. You will indicate the values of  $\alpha$  and  $\beta$  at each node and where pruning occurs.

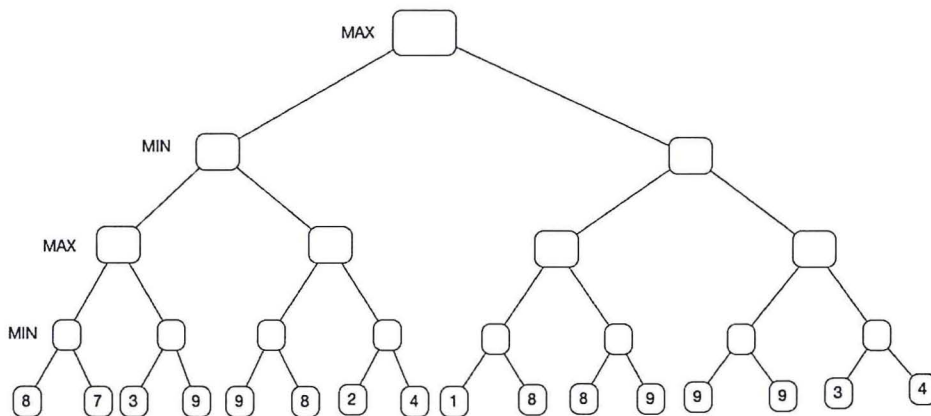


Figure 1: Adversarial Search Problem