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: AIG710S
SESSION: July 2019	PAPER: Theory
DURATION: 3 Hours	MARKS: 100

SECOND OPPORTUNITY/SUPPLEMENTARY EXAMINATION QUESTION PAPER	
EXAMINER:	Prof. José G. Quenum
MODERATOR:	Mr Simbarashe Nyika

This paper consists of 4 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, programmable calculators, 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 examiner officer or the invigilator.
5. NUST examination rules and regulations apply.

PERMISSIBLE MATERIALS

None

Question 1 .... [40 points]

(a) Consider a problem $\mathcal{P}$ defined as follows: [12]

- initial state: S;
- actions: $\{a_0, a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9, a_{10}, a_{11}, a_{12}\}$;
- transition model: as depicted in Table 1;
- goal test: $\forall \mathsf{W} : State, \mathsf{W} = \mathsf{G}$;
- path cost and heuristic: as indicated in Table 1.

Table 1: Transition Model and Heuristic

State Name	State Heuristic	Transition Tuple	Transition Cost	-	State Name	State Heuristic	Transition Tuple	Transition Cost
S	6	$(\mathsf{S}, \mathsf{a}_0, \mathsf{A})$	6		C	5	$(\mathsf{C}, \mathsf{a}_7, \mathsf{B})$	3
		$(\mathsf{S}, \mathsf{a}_1, \mathsf{B})$	2				$(\mathsf{C}, \mathsf{a}_8, \mathsf{F})$	6
		$(\mathsf{S}, \mathsf{a}_2, \mathsf{C})$	1				$(\mathsf{C}, \mathsf{a}_9, \mathsf{E})$	6
A	8	$(\mathsf{A}, \mathsf{a}_3, \mathsf{G})$	20		B	6	$(\mathsf{B}, \mathsf{a}_5, \mathsf{D})$	2
		$(\mathsf{A}, \mathsf{a}_4, \mathsf{D})$	3				$(\mathsf{B}, \mathsf{a}_6, \mathsf{E})$	6
D	4	$(\mathsf{D}, \mathsf{a}_{10}, \mathsf{F})$	5		E	2	$(\mathsf{E}, \mathsf{a}_{11}, \mathsf{G})$	2
F	1	$(\mathsf{F}, \mathsf{a}_{12}, \mathsf{G})$	1		G	0		

Note that a tuple $(\mathsf{S}_i, \mathsf{a}_\ell, \mathsf{S}_j)$ in the transition column in Table 1 depicts a deterministic transition, where S_j and S_i are states and a_ℓ an action.

Using the A* search strategy, find a solution to $\mathcal{P}$.

(b) Consider the constraint network depicted in Figure 1. The domain of each variable is the set $\{\mathsf{R}, \mathsf{G}, \mathsf{B}\}$. [18]

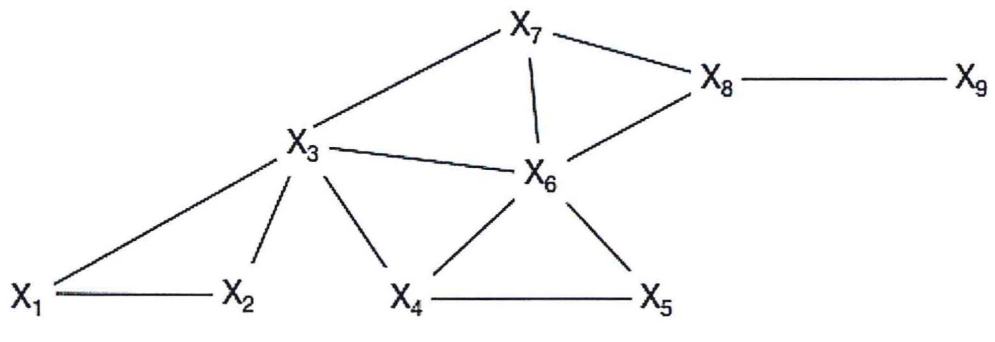

Figure 1: Constraint Network

Assuming that variable X_6 is assigned the value R, provide a complete solution to this constraint satisfaction problem using a combination of forward checking and propagation.

(c) Using the $\alpha - \beta$ pruning technique, solve the adversarial game depicted in Figure 2. [10]

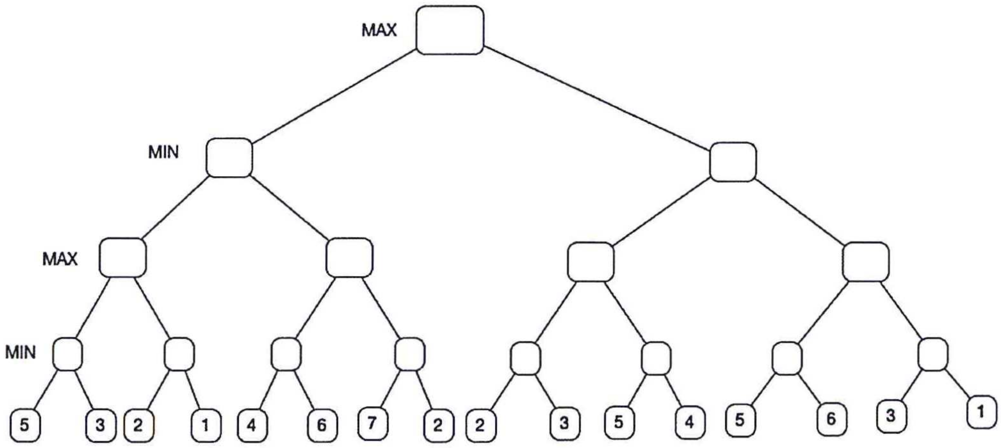

Figure 2: Adversarial Search Problem

Question 2 .... [20 points]

Consider the blocks world. Here we have seven (7) blocks: A, B, C, D, E, F and G. There is also a table with a capacity of three (3) blocks (i.e., three distinct blocks can lay on the table at any point in time simultaneously). It is assumed that a block can either be inside the box or outside. When outside the box, a block can either be on the table or on top of another block.

We have the following predicates:

$ontable(\mathtt{x})$: the block x is on the table;

$on(\mathtt{x}, \mathtt{y})$: the block x lays on top of the block y;

$clear(\mathtt{x})$: the block x is clear, i.e., there is nothing on top of it;

$inbox(\mathtt{x})$: the block x is inside the box.

Moreover, the following actions are introduced:

$pick(\mathtt{x})$: which picks a block from the box and drops it on the table;

$drop(\mathtt{x}, \mathtt{y})$: which drops the block on either the table or another block.

Consider a partial plan Q containing two actions: a_0 and $a_\imath$, with $a_0 \prec a_\imath$. The action a_0 has the following effect:

$ontable(\mathsf{B}); ontable(\mathsf{C}); ontable(\mathsf{E}); clear(\mathsf{B}); clear(\mathsf{C}); clear(\mathsf{E}); inbox(\mathsf{D}); inbox(\mathsf{F}); inbox(\mathsf{G});$

The action $a_\imath$ leads to a goal state and has the following pre conditions:

$$ontable(\mathsf{F}); ontable(\mathsf{A}); clear(\mathsf{Table}); on(\mathsf{B}, \mathsf{A}); on(\mathsf{C}, \mathsf{B}); on(\mathsf{D}, \mathsf{C}); on(\mathsf{E}, \mathsf{F});$$

Modify Q to generate a complete and correct plan.

Question 3 .... [30 points]

Table 2: Game Board

1	E					-	-	-
2				-				
3						-		-
4			-		-			
5					-			
6			-				-	
7		-						
8	-			-				
9	-							S
10	H	G	F	E	D	C	B	A

(a) The board in Table 2 represents a game played by two players, Player 1 and Player 2. The game focuses on the region from rows 1 to 9 and the columns $\mathtt{H}$ to $\mathtt{A}$. The game starts from the cell marked $\mathtt{S}$ and ends in the cell marked $\mathtt{E}$. From a given cell, a player moves a coin up, left or one cell up in the left diagonal. For example, from $(\mathsf{A}, 1)$, a player can move the coin to $(\mathsf{A}, 2)$, $(\mathsf{B}, 1)$ or $(\mathsf{B}, 2)$. The cells marked with a dash are not accessible. [12]

1. Suppose the coin is in cell $(\mathsf{G}, 4)$ and it is Player 1's turn to move. Is there a strategy that allows Player 1 to win the game from cell $(\mathsf{G}, 4)$?
2. Describe a play of the game from cell $(\mathsf{A}, 1)$ where Player 1 wins;
3. Describe a play of the game from cell $(\mathsf{A}, 1)$ where Player 2 wins;

(b) Find the mixed-strategy Nash equilibria of the game in Table 3: [10]

Table 3: Game Board

		Player 2	
		b_0	b_1
Player 1	a_0	$1, 4$	$4, 3$
	a_1	$2, 0$	$1, 2$
	a_2	$1, 5$	$0, 6$

(c) Consider the reduced game in Table 4. Calculate the payoff for each player using the following mixed strategy: $\begin{bmatrix} a_3 & a_4 & a_5 \\ \frac{1}{4} & \frac{3}{4} & 0 \end{bmatrix}, \begin{bmatrix} b_4 & b_5 \\ \frac{1}{2} & \frac{1}{2} \end{bmatrix}$. [8]

Is the mixed strategy a Nash equilibrium?

Table 4: Game Board

		Player 2	
		b_4	b_5
	a_3	$0, 1$	$6, 3$
Player 1	a_4	$4, 4$	$2, 0$
	a_5	$3, 0$	$4, 2$

Question 4 .... [10 points]

Consider the following vectors:

$$X_1 = \begin{bmatrix} 7 \\ 5 \\ 9 \end{bmatrix} X_2 = \begin{bmatrix} -1 \\ 2 \\ 5 \end{bmatrix} X_3 = \begin{bmatrix} 6 \\ -4 \\ 7 \end{bmatrix}$$

. Perform the following operations:

- X_1X_2
- $X_1 \times X_2$
- $(X_1 + X_2) \times X_3$
- the rotation of X_3 of $45°$