NAMIBIA UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF COMPUTING AND INFORMATICS
DEPARTMENT OF SOFTWARE ENGINEERING

QUALIFICATION: BACHELOR OF COMPUTER SCIENCE (SOFTWARE DEVELOPMENT)	
QUALIFICATION CODE: 07BACS	LEVEL: 7
COURSE: ARTIFICIAL INTELLIGENCE	COURSE CODE: ARI711S
DATE: JULY 2024	SESSION: THEORY
DURATION: 3 HOURS	MARKS: 100

SECOND OPPORTUNITY \ SUPPLEMENTARY EXAMINATION QUESTION PAPER	
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THIS QUESTION PAPER CONSISTS OF 7 PAGES
(Including this front page)

INSTRUCTIONS TO STUDENTS:

1. Read all the questions, passages, scenarios, etc., carefully before answering.
2. All questions must be answered in the Answer Booklet. Clearly indicate the question number for each answer.
3. Please, ensure that your writing is legible, neat and presentable.
4. There are no books, notes or any other additional aids allowed in the examination.
5. Use the allocated marks as a guideline when answering questions.
6. Looking at other students' work is strictly prohibited.

PERMISSIBLE MATERIALS

1. Calculator
2. Ruler

Question 1 -True or false **(16 marks)**

Select whether the following statements are either **TRUE** or **FALSE.** (2 marks each)

1.1. Depth-First Search (DFS) is always the best choice for finding all possible solutions in a search problem.

1.2. MDPs are a powerful tool for modelling and solving decision-making problems in various domains like robotics, game playing, and resource allocation.

1.3. In an MDP, the agent has complete knowledge of the entire state of the environment at any given time.

1.4. A CSP involves assigning values to variables such that all the constraints between them are satisfied.

1.5. Breadth-First Search (BFS) is guaranteed to find the shortest path between two points in a graph.

1.6. CSPs are only applicable to problems with numerical variables.

1.7. Heuristic functions are used to evaluate the potential cost of reaching the goal state in a search problem.

1.8. Alpha-Beta Pruning can be used to improve the efficiency of minimax search in two-player zero-sum games.

Question 2 **(2 marks)**

How does using additional knowledge make informed search algorithms more efficient than uninformed search algorithms?

Question 3 **(4 marks)**

Discuss the trade-offs between using a simple reflex agent and a model-based agent in an intelligent vacuum cleaner. Consider factors like efficiency, adaptability, and robustness in your answer.

Question 4 **(6 marks)**

In your own words, explain what a search problem entails. What are the key components involved?

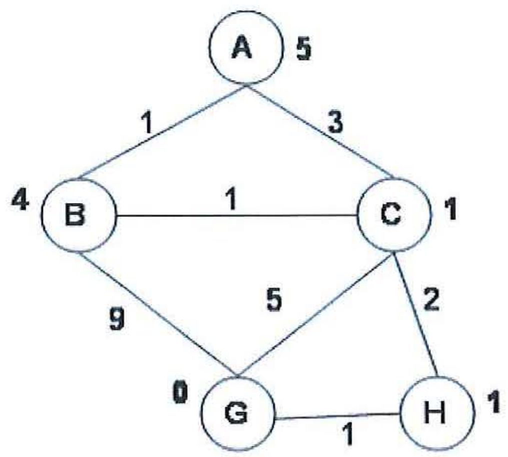
Question 5 **(4 marks)**

Considering the properties of search algorithms, which property would be most relevant to add to the following description:

Property	**Description**
	A measure of how much memory the algorithm needs to run.
	A measure of how long it takes the algorithm to find a solution (typically based on the number of steps involved).
	A guarantee that the algorithm will find the solution with the lowest cost among all possible solutions.
	A guarantee that the algorithm will find a solution if one exists.

Question 6 - Graph Search **(18 marks)**

6.1. Consider the graph shown below where the numbers on the links are link costs and the numbers next to the states are heuristic estimates. Note that the arcs are undirected. Let A be the start state and G be the goal state.



Simulate A* search with a strict expanded list on this graph. At each step, show the path to the state of the node that's being expanded, the length of that path, the total estimated cost of the path (actual + heuristic), and the current value of the expanded list (as a list of states). You are welcome to use scratch paper or the back of the exam pages to simulate the search. However, please transcribe (only) the information requested into the table given below.

Expanded List - is a collection of nodes in a graph that have been fully explored during the search process.

Path to State Expanded	Length of Path	Total Estimated Cost	Expanded List (Closed list)
A	0	5	(A)

(10 marks)

6.2.1. Is the heuristic given in **6.1** admissible? Explain. **(2 marks)**

6.2.2. Is the heuristic given in **6.1** consistent? Explain. **(2 marks)**

6.2.3. Did the A* algorithm with a strictly expanded list finds the optimal path in the previous example (6.1)? If it did find the optimal path, explain why you would expect that. If it didn't find the optimal path, explain why you would expect that and give a simple (specific) change of state values of the heuristic that would be sufficient to get the correct behaviour. **(4 marks**

Question 7 - Constraint Satisfaction Problems (CSPs) **(40 marks)**

You need to schedule guest lectures for 7 historical figures within 4 time slots (1pm-4pm). Certain attendee groups want to see specific speakers concurrently (e.g., physics students want both Bohr and Newton).

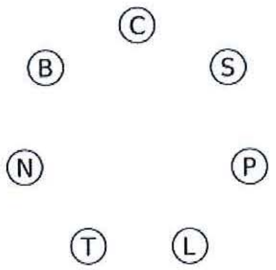
Your task is to create a schedule that satisfies these attendance preferences.

The list of guest lecturers consists of Alan **T**uring, Ada **L**ovelace, Niels **B**ohr, Marie **C**urie, **S**ocrates, **P**ythagoas, and Isaac **N**ewton.

- **T**uring has a scheduling constraint. He can only be assigned the 1pm time slot.
- The Course VIII students want to see the physicists: **B**ohr, **C**urie, and **N**ewton.
- The Course XVIII students want to see the mathematicians: **L**ovelace, **P**ythagoras, and **N**ewton.
- The members of the Ancient Greece Club want to see the ancient Greeks: **S**ocrates and **P**ythagoras.
- The visiting Wellesley students want to see the female speakers: **L**ovelace and **C**urie.
- The CME students want to see the British speakers: **T**uring, **L**ovelace, and **N**ewton.
- Finally, you decide that you will be happy if and only if you get to see both **C**urie and **P**ythagoras. (Yes, even if you belong to one or more of the groups above.)

7.1. Draw a constraint graph using the initials of each pair of lecturers who cannot share a time slot. **(6 marks)**

Constraint graph for this problem



Domains for this problem

T	1
L	1,2,3,4
B	1,2,3,4
C	1,2,3,4
S	1,2,3,4
P	1,2,3,4
N	1,2,3,4

7.2. Search for a solution using **backtracking only**—without any forward checking or propagation. The only check is to make sure that each new assignment violates no constraint with any previous assignment. As a tiebreaker, assign a lecturer to the earliest available time slot. ***Continue up to the first time you try and fail to assign any time to***

Newton and must backtrack, at which point you give up and move on to Part C to try a more sophisticated approach

Fill out the **worksheet** and **draw a search tree (indicating where you back track)**. There may be more rows than you need.

	Var assigned	List all values eliminated from neighbouring variables	Back track?
Ex	X	$Y \neq 3, 4$ $z \neq 3$ (example)	•
1			•
2			•
3			•
4			•
5			•

(8 marks)

Draw Search Tree (Follow the diagram below) **(7 marks)**

T

L

B

C

S

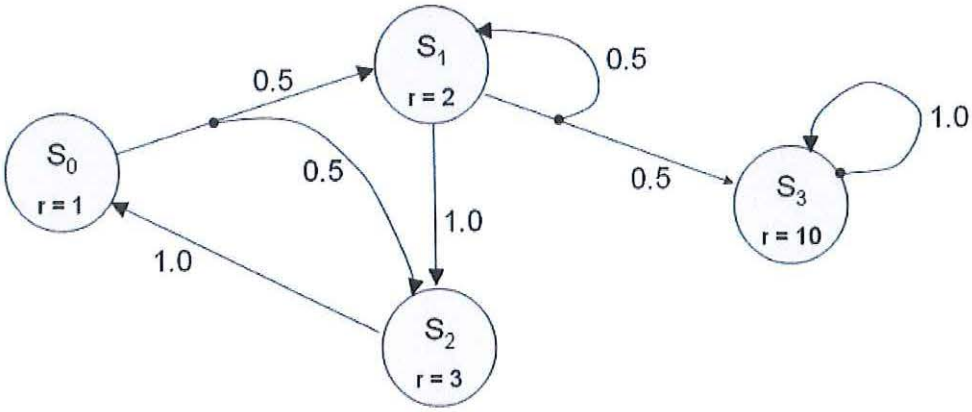
P

N

7.3. You're not fond of backtracking, so rather than wait and see how much backtracking you'll have to do, you decide to use **backtracking with forward checking and propagation through singletons (propagation through domains reduced to size 1)** to solve the problem. As before, show your work by filling out the domain worksheet and drawing the search tree. (like 6.2) **(19 marks)**

Question 8 - Markov Decision Processes (MDPs) **(10 marks)**

Consider the MDP given in the figure below. Assume the discount factor γ = 0.9. The r-values are rewards, while the numbers next to arrows are probabilities of outcomes. Note that only state S1 has two actions. The other states have only one action for each state.



8.1. Write down the numerical value of J(S1) after the first and the second iterations of Value Iteration? **(5 marks)**

Initial value function:

$J^0(S_0) = 0;\ J^0(S_1) = 0;\ J^0(S_2) = 0;\ J^0(S_3) = 0;$

$J^1(S_1) =$

$J^2(S_1) =$

8.2. Write down the optimal value of state S1. There are few ways to solve it, and for one of them you may find the following equality: P∞ i=0 α i = 1 1−α for any 0 ≤ α < 1. **(5 marks)**

$J^*(S_1) =$

— END OF QUESTION PAPER —