Birla Institute of Technology & Science, Pilani
Work Integrated Learning Programmes Division
First / 2023-2024

Comprehensive Test
(EC-3 Regular)

Course No.	:	AIMLCZG557
Course Title	:	Artificial and Computational Intelligence
Nature of Exam	:	Open Book
Weightage	:	40%
Duration	:	
Date of Exam	:	14-4-2024 (AN)

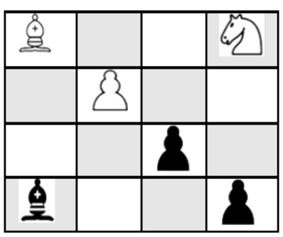
No. of Pages = 4
No. of Questions = 5

Note to Students:

1. Please follow all the *Instructions to Candidates* given on the cover page of the answer book.
2. All parts of a question should be answered consecutively. Each answer should start from a fresh page.
3. Assumptions made if any, should be stated clearly at the beginning of your answer.

Q1 Consider the below chess game problem and answer the following questions: (10 Marks)

[3+5+2 = 10 Marks]



- Bishops can only move diagonally in chess board. Every non attack move adds a penalty of 5 and every successful attack gains a reward of 4.
- The knight moves ‘two steps forward and one step sideways in any direction. Every non attack move adds a penalty of 4 and every successful attack gains a reward of 3
- A Soldier moves only one square forward on each move. Only if opponent coins are available, it can move in diagonally one step forward to attack the opponent coin. Every non attack move adds a penalty of 3 and every successful attack gains a reward of 5.

a) Assume that player with White colored pieces moves first. Construct the game tree (with neat diagram) from the given current state (0th level) as Start Node up to exactly 2 levels only (1^{st} & 2nd Level - ie., one round for each of the player.)

b) Calculate the utility of the leaves of the tree with below static evaluation function.

Board value = Utility of MAX player – Utility of MIN player

Utility of a player = (Sum of Reward w.r.t all pieces – Sum of Penalty w.r.t all Pieces) + Number of possible Moves w.r.t all pieces.

Note: eg., Board Value is calculated for the given Initial configuration,

White Pieces	Possible Moves	Reward	Penalty
Bishop	0	-	-
Knight	1 (Attack)	3	-
Soldier	2 (1 Attack & 1 Non Attack)	5	3
Total	***3***	***8***	***3***

Utility of a MAX (White) player = (Sum of Reward w.r.t all pieces – Sum of Penalty w.r.t all pieces) + Number of possible Moves w.r.t all pieces.

= (8-3) + 3 = 5+3 ➔ 8

Black Pieces	Possible Moves	Reward	Penalty
Bishop	1 (Attack)	4	-
Soldier	1 (Non Attack)	-	3
Soldier	2 (1 Attack & 1 Non Attack)	5	3
Total	***4***	***9***	***6***

Utility of a MIN (Black) player = Sum of Reward w.r.t all pieces – Sum of Penalty w.r.t all pieces) + Number of possible Moves w.r.t all pieces.

= (9-6) + 4 = 3+4 ➔ *7*

Board value = Utility of MAX player – Utility of MIN player

= 8 – 7 ➔ ***1***

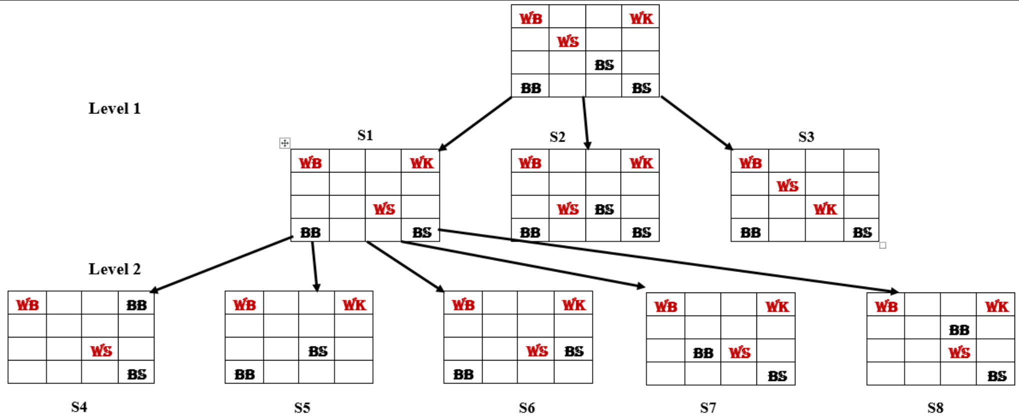
c) Apply the MIN MAX algorithm on the game tree constructed in part a) using static evaluation values calculated in the part b) and highlight the best path chosen by players in the game given.

Marking Scheme :

a) Game tree construction (for level 1 – 1 mark, for level 2 – 2 marks) – 3 marks

b) Utility calculation for the leaves – 5 marks

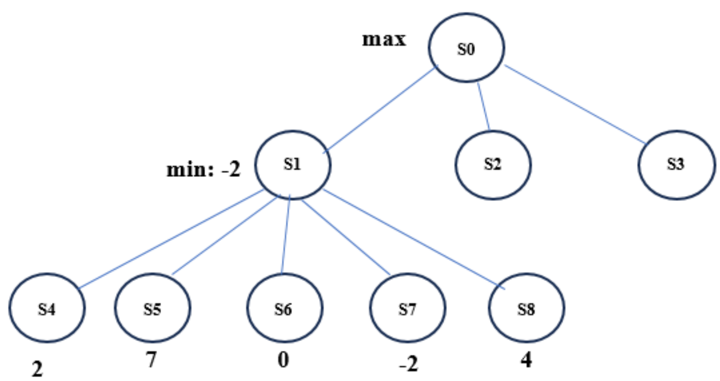
c) MIN MAX algorithm – 2 marks



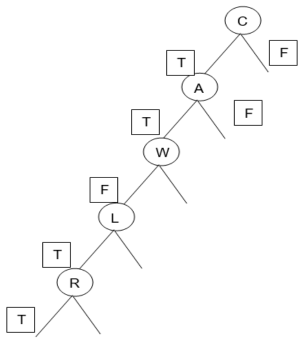
Similarly black moves must be constructed for S2 and S3

State	White Pieces	Possible Moves	Reward	Penalty	Black Pieces	Possible Moves	Reward	Penalty	MAX	MIN	Board Value
S4	Bishop	1		5	Bishop	3		15	-6	-8	2
	Knight	0			Soldier	2	5	3			
	Soldier	1		3	Soldier	0					
	Total	2	0	8	Total	5	5	18			
S5	Bishop	2	4	5	Bishop	3	4	10	2	-5	7
	Knight	2	3	4	Soldier	1		3			
	Soldier	0			Soldier	0					
	Total	4	7	9	Total	4	4	13			
S6	Bishop	1		5	Bishop	3	4	10	-5	-5	0
	Knight	2	3	4	Soldier	1		3			
	Soldier	1		3	Soldier						
	Total	4	3	12	Total	4	4	13			
S7	Bishop	1		5	Bishop	5	4	20	-9	-7	-2
	Knight	1		4	Soldier	2	5	3			
	Soldier	1		3	Soldier	0					
	Total	3	0	12	Total	7	9	23			
S8	Bishop	1		5	Bishop	5	4	20	-3	-7	4
	Knight	1		4	Soldier	2	5	3			
	Soldier	2	5	3	Soldier	0					
	Total	4	5	12	Total	7	9	23			

Similarly, BOARD VALUES can be calculated for other states



Q2	In the realm of fitness enthusiasts and their workout preferences, individuals who regularly engage in cardio exercises are classified as "aerobic enthusiasts." Not all aerobic enthusiasts practice weightlifting, but all weightlifting enthusiasts are aerobic enthusiasts. Aerobic enthusiasts typically favor the latest workout trends. Those who keep up with the latest workout trends will receive recommendations for upcoming fitness routines. ***[2+4 =6 Marks]*** a) Use propositional logic (without quantifiers) to efficiently represent the knowledge base given above. (Represent any 4 premises) b) W.r.t the knowledge base from part (a), convert it into Conjunctive Normal Form (CNF) and find one sample complete Binary Satisfiability (BSAT) solution to the variables using the DPLL algorithm. Marking Scheme : a. Propositional Logics (1Mark) C: Regular cardio exercise A: Aerobic enthusiast W: Weightlifting enthusiast L: Keeps up with the latest workout trends R: Receives recommendations for upcoming fitness routines Knowledge Base (1Mark) 1. C →A (Regularly engage in cardio exercises are aerobic enthusiasts) 2. W→A (All weightlifting enthusiasts are aerobic enthusiasts) 3. ¬W→¬A (Not all aerobic enthusiasts practice weightlifting) 4. A→L (Aerobic enthusiasts typically favor the latest workout trends) 5. L→R (Those who keep up with the latest workout trends will receive recommendations for upcoming fitness routines) b) CNF representation: Using implication remaining property (1 Mark) R1 C →A (¬C∨A) R2 W→A (¬W∨A) R3 ¬W→¬A (W∨¬A) R4 A→L (¬A∨L) R5 L→R (¬L∨R) DPLL algorithm (2 Marks) Final answer (1 Marks)	6 Marks



All rules satisfied

C	A	W	L	R
T	T	T	T	T
T	T	F	T	T

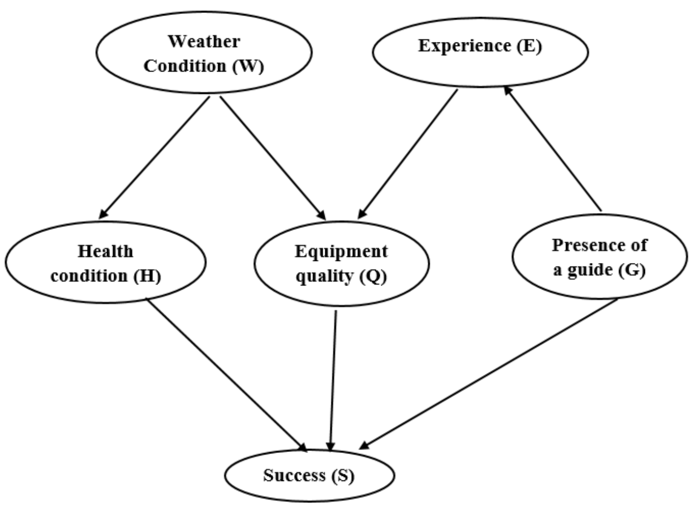
One sample which satisfies all rules.

Q3 ***Consider the below Bayesian Network and answer the following questions:***

9 Marks

Climbing Mount Everest is a physically and mentally demanding endeavor. The success (S) of climbers in reaching the summit is influenced by a combination of factors, including their health condition (H), experience (E), equipment quality (Q), weather conditions (W), and the presence of a guide (G). Assume all the events (conditional or unconditional) are equally likely to occur.

[3+ 6 = 9 Marks]



a) What is the likelihood that a climber, in good health but with unfavorable weather conditions, Low-quality equipment, and with neither guide support nor experience, achieves a successful ascent to the summit of Mount Everest? Use exact inference by enumeration to answer with clear steps.

b) Apply a more appropriate approximate inference method for the given query and justify your selection of the sampling method.

"***What is the likelihood of a climber achieves a successful ascent to the summit of Mount Everest given the evidence that, if he/she is having good health condition but low quality Equipment?***"

Generate only 5 samples using the below random numbers.

“0.7, 0.3, 0.5, 0.9, 0.45, 0.8, 0.12, 0.6, 0.4, 0.75, 0.25, 0.5, 0.36, 0.3, 0.8, 0.1, 0.6, 0.4, 0.7, 0.2, 0.8, 0.12, 0.6, 0.4,

Marking Scheme:

a) Proper query extraction - 1M, chain rule implementation - 1M. final result - 1M.

b) Correct query extraction - 1M, linear order and reverse - 1M, Sample table - 2M, Justification - 1M, Final result - 1M.

a) $P(S\ H\ \neg Q\ \neg W\ \neg E\ \neg G)$ proper Linearization – 1M

Applying chain rule – 1M

$\Rightarrow P(S|H \neg Q \neg G) * P(H|\neg W) * P(\neg Q|\neg W \neg E) * P(\neg W) * P(\neg E) * P(\neg G).$

$\Rightarrow 0.5 * 0.5 * 0.5 * 0.5 * 0.5 * 0.5$

$= (0.5)^6 = 0.015625$ final result – 1M

Query $\rightarrow P(S|H \neg Q)$

appropriate approximate inference method :
Likelyhood weighing Sampling :

Linearization : S H Q W E G – 1M
After reverse : G E W Q H S. – 1M

G	E	W	Q	H	S	wt
F	T	T	F	T	F	0.25 = 1*1*1*0.5*0.5*1
T	F	T	F	T	F	0.25
T	F	T	F	T	T	0.25
T	T	F	F	T	T	0.25
F	T	F	F	T	T	0.25

Query : $P(S|H \neg Q) = \dfrac{0.25 + 0.25}{5 * 0.25}$

$= \dfrac{2}{5} = 0.4$

Q4	In an online music streaming platform, users' music genre preferences are influenced not only by their inherent tastes but also by their current mood or emotional state. Understanding the interplay between users' moods and music genre preferences is crucial for delivering personalized recommendations and enhancing user satisfaction. Leveraging Hidden Markov Models (HMMs), we aim to predict users' genre preferences while taking into account their underlying mood transitions across listening sessions. Users' music genre preferences remain categorized into three states: Pop (P), Rock (R), and Classical (C). These genres represent distinct musical styles and atmospheres available on the platform. Users' moods are categorized into Happy (H) Relaxed (Rl) and Energetic (E) that influence their music genre preferences.	9 Marks

[3+6 =9 Marks]

Transition Probability Matrix:

Happy (H)	Relaxed (Rl)	Energetic (E)	
0.7	0.1	??	Happy (H)
0.1	??	0.3	Relaxed (Rl)
??	0.6	0.5	Energetic (E)

Emission Probability Matrix:

Happy (H)	Relaxed (Rl)	Energetic (E)	
0.5	??	0.2	Pop (P)
0.4	0.2	0.7	Rock (R)
??	0.6	??	Classical (c)

a. Construct the Markov Model with neat diagrams and compute the missing probability values.

b. What is the most likely explanation of the user’s mood or emotion state, if the music genre preferences sequence pattern observed as [Pop(P) - Classical(C)] Strictly follow the approach as discussed in class only. Assume equal likelihood for initial state.

Given Transition Probability Matrix is

Happy (H)	Relaxed (Rl)	Energetic (E)	
0.7	0.1	??(x)	Happy (H)
0.1	??(y)	0.3	Relaxed (Rl)
?? (x)	0.6	0.5	Energetic (E)

As total probability of each mood is 1,

x = 1 - 0.7 - 0.1 = 0.2

y = 1 - 0.6 - 0.1 = 0.3

z = 1 - 0.3 - 0.5 = 0.2 .... 1 Mark

Given Emission Probability Matrix is

Happy (H)	Relaxed (Rl)	Energetic (E)	
0.5	??(b)	0.2	Pop(P)
0.4	0.2	0.7	Rock(R)
??(a)	0.6	??(c)	Classical(c)

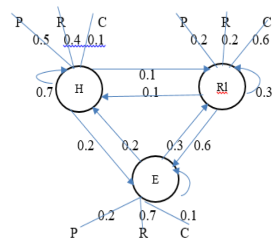
As total probability of each mood is 1 with respect to music,

a = 1 - 0.5 - 0.4 = 0.1

b = 1 - 0.6 - 0.2 = 0.2

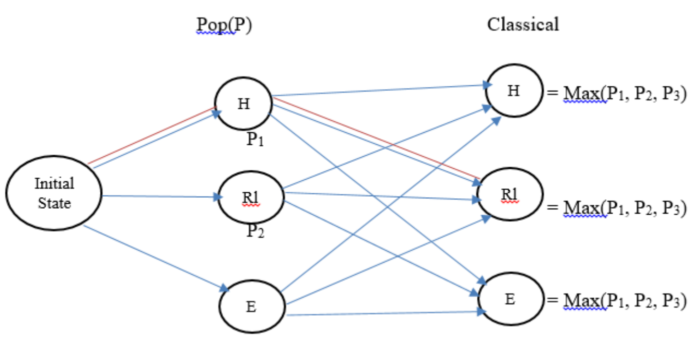
c = 1 - 0.2 - 0.7 = 0.1 .... 1 Mark

Transition diagram:



.... 1 Mark

Extend the model to the nest sequence i.e. Classical



$P_1 = P(H) \text{ X } P(P/H) = (1/3) \text{ X } 0.5 = 0.16667$

$P_2 = P(Rl) \text{ X } P(P/Rl) = (1/3) \text{ X } 0.2 = 0.06667$

$P_3 = P(E) \text{ X } P(P/E) = (1/3) \text{ X } 0.2 = 0.06667$

.... 1 Mark

The normalized probabilities of Pop(P) state are

For node H:
$P_1 = P(H) \text{ X } P(P/H) = (0.16667/(0.16667+0.06667+0.06667)) = 0.55556$
For node Rl:
$P_2 = P(Rl) \text{ X } P(P/Rl) = (0.06667/(0.16667+0.06667+0.06667)) = 0.22222$
For nodeE:
$P_3 = P(E) \text{ X } P(P/E) = (0.06667/(0.16667+0.06667+0.06667)) = 0.22222$

.... 0.5 Mark

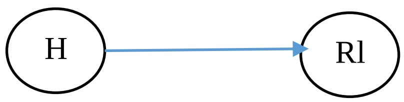
Hidden Markov Model for the initial state to Classic state via Pop state is

For node H:
P(H) X P(H/H) X P(C/H) = 0.55556 X 0.7 X 0.1 = 0.03889 ....Max Value

For node Rl:
P(Rl) X P(Rl/Rl) X P(C/Rl) = 0.22222 X 0.3 X 0.6 = 0.039996 ....Max Value

For node E:
P(Rl) X P(E/Rl) X P(C/Rl) = 0.22222 X 0.6 X 0.1 = 0.013333 ....Max Value

.... 1 Mark



Based on above Hidden Markov Model the most likely change of user's mood for the given sequence Pop to Classic (P→C) is from Happy state to Relaxed state (H →Rl).

.... 1 Mark

Q5 Answer the following questions: ***[3+3 = 6 Marks]*** — 6 Marks

a) Consider a two-player board game that involves both strategic moves and elements of chance, such as rolling dice. In this game, players need to make decisions based on incomplete information and random events. How this type of game can be designed to handle imperfect decision in real time? Provide a step-by-step explanation with numerical example, including the construction of a game tree

Algorithm used: Expecti Mini Max algorithm & its explanation – 1 Mark

Game Tree Construction with Chance Node: 2Marks

Chance node Holds the expected values that are computed as the sum of all outcomes weighted by their probability (of dice roll) -1 + 1

b) Explain the evaluation process of the Breadth-First Search (BFS) algorithm using an example.

Defn: 0.5

Example – 1

Evaluation of algorithm: -1.5

Completeness: If the shallowest goal is at depth d, BFS will eventually find it by generating all shallower nodes.

Optimality: Not necessarily. Optimal if path cost is non-decreasing function of depth of node. – Eg. All actions have same cost.

Time complexity- G(bd), b- branching factor and d-depth

Space complexity: G(bd -1) – in explored set, G(bd)- Infrontier set