Birla Institute of Technology & Science, Pilani
Work-Integrated Learning Programmes Division
First Semester 2024-2025
Comprehensive Examination
EC-3 Regular

Course No.	: SE ZG557	
Course Title	: Artificial and Computational Intelligence	
Nature of Exam	: Open Book	No. of Pages = 3
Weightage	: 40%	No. of Questions = 5
Duration	: 2.5 Hours	
Date of Exam	: 25/05/2025 (AN)	

Note:
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.

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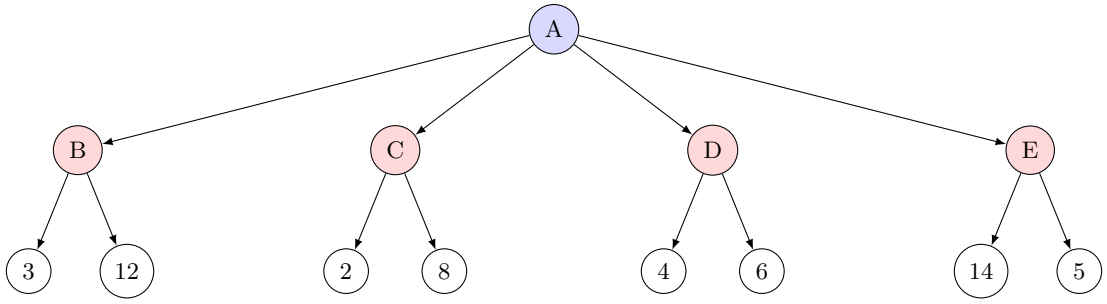
1. Recall from class that if h_1 and h_2 are admissible heuristics, then $\max\{h_1, h_2\}$ are also admissible. Assume that $h_1, h_2 > 0$. Which of the following other possibilities are <u>always</u> admissible?

   (a) $h_1 + h_2$
   (b) $h_1 \times h_2$
   (c) h_1/h_2, assuming $h_2 > 0$
   (d) $\|h_1 - h_2\|$

   [$2 \times 4 = 8$ Marks]

2. Consider the following 2 level adversarial zero-sum game where Player 1 starts and player 2 responds. Finally in the leaf nodes, we show the utilities of Player 1.



   Answer the following questions based on the above game:

   (a) Assuming minimax, what is the utility of Players 1 and 2. Fill the table below.

Node	A	B	C	D	E
Player 1					
Player 2					

   (b) Assuming $\alpha - \beta$ pruing, and left$\rightarrow$ right traversal, which leaf node would <u>not</u> be visited. (Note: identify the node using the value).

(c) Suppose the traversal order of the second level nodes are changed from B, C, D, E to E, B, C, D, then how many leaf nodes would be pruned.

[8 Marks]

3. Let P, Q, R denote the atoms in propositional logic. Let the knowledge base consist of the statements -

$$\begin{aligned} \phi_1 &:= (P \Rightarrow Q) \wedge (R \Rightarrow Q) \\ \phi_2 &:= P \vee R \\ \phi_3 &:= \neg(P \wedge R) \end{aligned}$$

(a) Complete the following Truth Table (T stands for TRUE, F stands for FALSE)

P	Q	R	ϕ_1	ϕ_2	ϕ_3
T	T	T			
T	T	F			
T	F	T			
T	F	F			
F	T	T			
F	T	F			
F	F	T			
F	F	F			

(b) Does the knowledge base entail Q??

(c) Does the knowledge base entail R??

[8 Marks]

4. Consider the following Bayesian network with 5 binary random variables - X_1, X_2, X_3, X_4, X_5 with the edges given by $X_1 \to X_3$, $X_2 \to X_3$, $X_3 \to X_4$, $X_3 \to X_5$. The conditional probability tables are given below

Node	Parents	$P(\text{node} = 1)$
X_1	—	0.001
X_2	—	0.002

X_3	X_1, X_2	X_1	X_2	$P(X_3 = 1)$
		0	0	0.001
		0	1	0.29
		1	0	0.94
		1	1	0.95

X_4	X_3	X_3	$P(X_4 = 1)$
		0	0.05
		1	0.90

X_5	X_3	X_3	$P(X_5 = 1)$
		0	0.01
		1	0.70

The aim is to compute $P(X_3 = 1 \mid X_4 = 1, X_5 = 0)$. We wish to draw <u>one</u> sample using importance sampling.

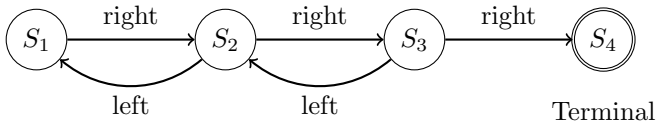
(a) What is the value of the initial weight w

(b) Complete the procedure in the table below for this. Assumed that in the sample drawn we have $X_1 = 1$, $X_2 = 0$, and $X_3 = 1$

Step	Variable processed	Assigned value	Weight multiplier	Cumulative weight
1	X_1	1		
2	X_2	0		
3	X_3	1		
4	X_4			
5	X_5			

[8 Marks]

5. Consider an MDP as shown below with 4 states. For simplicity, assume the discounting factor $\gamma = 1$. The transition $S_3 \to S_4$ receives a reward of $+1$, and all other steps taken will get a reward of -1.



Recall the Bellman optimality equations-

$$U^*(s) = \max_a \sum_{s'} P(s' \mid s, a)[R(s, a, s') + \gamma U^*(s')]$$

Note: Assume that all actions from all states are deterministic, i.e. $P(s' \mid (s, a)) = 1$.

Answer the following questions:

(a) What should be the value of $U^*(S_4)$?

(b) Write the Bellman optimality equation for $U^*(S_3)$.

(c) Write the Bellman optimality equation for $U^*(S_2)$.

(d) Write the Bellman optimality equation for $U^*(S_1)$.

(e) Give the values for $U^*(S_i)$ for all i which satisfy the above equations.

[8 Marks]