Roll No											

PRESIDENCY UNIVERSITY
BENGALURU

SET B

SCHOOL OF ENGINEERING
END TERM EXAMINATION - JAN 2024

Semester : Semester V - 2021
Course Code : CSE3005
Course Name : Applied Artificial Intelligence
Program : B.Tech.

Date : 05-JAN-2024
Time : 9:30AM - 12:30 PM
Max Marks : 100
Weightage : 50%

Instructions:
(i) Read all questions carefully and answer accordingly.
(ii) Question paper consists of 3 parts.
(iii) Scientific and non-programmable calculator are permitted.
(iv) Do not write any information on the question paper other than Roll Number.

PART A

ANSWER ALL THE QUESTIONS **5 X 2M = 10M**

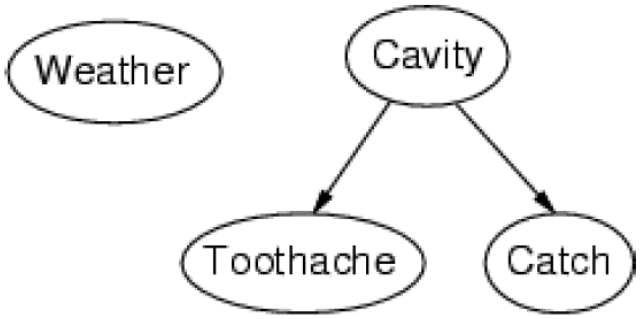
1. Recall the N-Queens problem where we have to place N queens on an NxN chessboard (which has N^2 cells). Mention the number of variables needed for solving the N-Queens problem.

(CO2) [Knowledge]

2. Mention the sample space for a 6 sided dice.

(CO4) [Knowledge]

3. Consider the following Bayesian network:



Mention the relationship between the variable **Weather** and **Cavity**.

(CO4) [Knowledge]

4. Recall the coloured balls problem for the Hidden Markov Model. To evaluate the probability of the sequence, we find the product of 3 probabilities, one of which is the initial probability and another is the emission probability. Name the 3rd probability.

(CO4) [Knowledge]

5. Mention any two backtracking heuristics.

(CO2) [Knowledge]

PART B

ANSWER ALL THE QUESTIONS **5 X 10M = 50M**

6. Mr. SAM had 2 research papers accepted at a workshop on Text Simplification in Portoroz (P), Slovenia, in 2016. However, there is no direct flight from Bengaluru to Portoroz. To help guests arrive, the organizers offer a pick-up from the following locations at the following rates:

- From Trieste Centrale Railway Station, 50 Euros
- From Trieste Ronchi dei Legionari Airport, 150 Euros
- From Ljubljana Joze Pucnik Airport, 260 Euros
- From Venice Marco Polo Airport, 350 Euros

To reach certain pick-up points, the costs are as follows:

- From Rome Leonardo da Vinci Airport to Roma Termini Railway Station, 10 Euros
- From Roma Termini to Trieste Centrale Railway Station, 38 Euros
- From Venice Marco Polo Airport to Venezia Santa Lucia Railway Station, 15 Euros
- From Venezia Santa Lucia Railway Station to Trieste Centrale Railway Station, 29 Euros

The cost of flights from Bengaluru to some of the airports are as follows:

- Bengaluru to Rome Leonardo da Vinci Airport, 459 Euros
- Bengaluru to Ljubljana Joze Pucnik Airport, 532 Euros
- Bengaluru to Venice Marco Polo Airport, 498 Euros
- Bengaluru to Trieste Ronchi dei Legionari Airport, 505 Euros

Draw the graph. While naming the nodes on the graph, use the abbreviations in the table:

Place	Abbreviation	H-Distance (in km)
Bengaluru Airport (BA) – Start	BA	7000
Rome Leonardo da Vinci Airport (RA)	RA	136
Roma Termini Railway Station (RT)	RT	117
Ljubljana Joze Pucnik Airport (LA)	LA	105
Venice Marco Polo Airport (VA)	VA	96
Venezia Santa Lucia Railway Station (VRS)	VRS	90
Trieste Ronchi dei Legionari Airport (TA)	TA	35
Trieste Centrale Railway Station (TC)	TC	20
Portoroz (P) – GOAL	P	0

Your main task is to now find out if the heuristic values for each of the nodes is **admissible** for an A* search algorithm. A node's value is admissible if and only if the H-Distance is **LESSER than or equal to** the **MINIMUM cost of reaching the destination** from the node. Find the minimum distances to reach the destination from **EACH of the nodes** and verify if the given heuristic values are admissible for each of them.

(CO2) [Comprehension]

7. Let us define a new type of quantifier called a **UNIQUE** quantifier. Let the symbol for the quantifier be a **U** (for unique). The unique quantifier is defined as follows: “There exists **EXACTLY ONE** x P(x)”. For example the statement “The Universal Question has only one answer that is correct” can be quantified as follows: **U**x answer(x) ^ has(Universal Question, x) ^ correct(x).

(A) **Write** the unique quantifier using already described terms in first order logic, such as universal quantifier, existential quantifier, equality (and other operations), variables, predicates, etc.

(B) **Use that description** to convert the statement “The Universal Question has only one answer that is correct” into first order logic **without using the unique quantifier**.

(CO3) [Comprehension]

8. Consider the following definitions for a deck of cards. A deck of cards has 52 cards which are split into **4 suits** - called **Spades (S), Diamonds (D), Clubs (C) and Hearts (H)**. Each suit has 13 cards which are divided as follows - **9 number cards** (from 2 to 10) and **4 letter cards** (the **ace (A), king (K), queen (Q) and jack (J)**). The letter cards are further classified into **face cards** (**king, queen, jack**) and the **ace**. With these definitions, calculate the probabilities (NOTE: you can leave the numbers as fractions) of the following events.

1. You select the **Queen of Spades** from a deck of cards
2. You select **either a Queen OR a Spade** from a deck of cards
3. You select **first a queen AND THEN a spade** from a deck of cards (with replacing the first card back in the deck).
4. You select an **Ace of Spades** , given that you have drawn an **Ace** from the deck of cards.
5. You draw an **Ace of Spades**, given that you have drawn a **Face** card from the deck of cards.

(CO4) [Comprehension]

9. Consider the following situation, where we have a set of 5 variables - $X_1, X_2, X_3, X_4, \& X_5$, such that the domains are:

- $D(X_1) = \{91, 92, 93, 94, 95\}$
- $D(X_2) = \{93, 94, 95, 96, 97\}$
- $D(X_3) = \{95, 96, 97, 98, 99\}$
- $D(X_4) = \{97, 98, 99\}$
- $D(X_5) = \{99\}$

And the constraints are:

- $X_1 < X_2$,
- $X_2 < X_3$,
- $X_3 < X_4$, and
- $X_4 < X_5$

Draw the constraint graph. Is the network arc-consistent? If not, remove values in the domain to make it arc-consistent.

(CO2) [Comprehension]

10. Colour the map of South India considering the following states to be a part of South India - Karnataka (KA), Goa (GA), Kerala (KL), Maharashtra (MH), Andhra Pradesh (AP), Tamil Nadu (TN) and Telangana (TL). The following table lists all the states and which ones border each of them.

State	Neighbouring States
KA	KL, MH, GA, AP, TN, KL
MH	GA, KA, TL
TL	KA, AP, MH
GA	MH, KA
KL	KA, TN
AP	TN, KA, TL
TN	KL, KA, AP

Use backtracking heuristics to colour the map with only **3 colours** (RED, GREEN, BLUE). Use the LRV Backtracking Heuristic. In case of ties, break them using the Maximum Degree Heuristic. If this is a ***nearly complete tree consistent graph***, list the minimum number of states, whose removal results in a tree-consistent graph.

(CO2) [Comprehension]

PART C

ANSWER ALL THE QUESTIONS **2 X 20M = 40M**

11. Consider the following axioms:

1. Every child loves anyone who gives the child any present.
2. Every child will be given some present by Santa if Santa can travel on Christmas eve.
3. It is foggy on Christmas eve.
4. Anytime it is foggy, anyone can travel if he has some source of light.
5. Any reindeer with a red nose is a source of light.

Based on the above axioms, **prove that:** If Santa has some reindeer with a red nose, then every child loves Santa.

Use the following predicates only:

- child(x) = x is a child
- present(x) = x is a present
- gives(x,y,z) = x gives y to z
- loves(x,y) = x loves y
- travel(x, t) = x travels at time t.
- foggy(t) = it is foggy at time t.
- light(x) = x is a source of light
- RNR(x) = x is a red-nosed reindeer
- has(x, y) = x has y.

(CO3) [Application]

12. NPTEL gives a special award called a **DOMAIN Specialization**. In Computer Science, there are **FIVE DOMAINS**, namely:

1. Artificial Intelligence
2. Data Science
3. Foundations of Computing
4. Programming
5. Systems

In order to clear each of the domains, a candidate has to claim a total of **60 weeks**, which are spread across a set of core courses and elective courses. The following tables detail the different core and elective courses for the student:

Artificial Intelligence Core Courses (All are mandatory - 1 under each number)					
Number	**Course Name**	**Short Code**	**Instructor**	**Weeks**	**Days Offered**
1	Artificial Intelligence: Search Methods for Problem Solving	AI:SMPS	Deepak Khemani	12	Day 12
	An Introduction to Artificial Intelligence	AI	Mausam	12	Day 3
2	Artificial Intelligence: Knowledge Representation and Reasoning	AI:KRR	Deepak Khemani	12	Day 5
3	Programming, Data Structures and Algorithms in Python	PDSaAiP	Mukund Madhav	8	Day 2, Day 8
	Python for Data Science	PfDS	Raghunathan Rengasamy	4	Day 2, Day 8
4	Introduction to Machine Learning	IML-IITM	Balaraman Ravindran	12	Day 4, Day 10
	Introduction to Machine Learning	IML-IITKgp	Sudeshna Sarkar	8	Day 8

Artificial Intelligence Electives (At least 2, 1 under each number)					
Number	**Course Name**	**Short Code**	**Instructor**	**Weeks**	**Days Offered**
1	Deep Learning	DL-IITM	Mitesh Khapra	12	Day 6, Day 12
	Deep Learning	DL-IITKgp	Prabir Biswas	12	Day 5, Day 11
	Deep Learning for Computer Vision	DLfCV	Vineeth Balasubramaniam	12	Day 10
2	Reinforcement Learning	RL	Balaraman Ravindran	12	Day 4, Day 10
3	AI: Constraint Satisfaction	AI:CS	Deepak Khemani	8	Day 1
4	Natural Language Processing	NLP	Pawan Goyal	12	Day 6, Day 12
5	Affective Computing	AC	Jainendra Shukla, Abhinav Dhal	12	Day 3
6	Games and Information	Gal	Ankur Kulkarni	12	Day 4

Data Science Core Courses (All are mandatory, 1 under each number)					
Number	**Course Name**	**Short Code**	**Instructor**	**Weeks**	**Days Offered**
1	Programming, Data Structures and Algorithms in Python	PDSaAiP	Mukund Madhav	8	Day 2, Day 8
	Python for Data Science	PfDS	Raghunathan Rengasamy	4	Day 2, Day 8
2	Introduction to Machine Learning	IML-IITM	Balaraman Ravindran	12	Day 4, Day 10
	Introduction to Machine Learning	IML-IITKgp	Sudeshna Sarkar	8	Day 8
3	Data Science for Engineers	DSfE	Raghunathan Rengasamy, Shankar Narasimhan	8	Day 2, Day 8
	Data Analytics with Python	DAwP	A Ramesh	12	Day 5

Data Science Electives (At least 3, 1 under each number)					
Number	**Course Name**	**Short Code**	**Instructor**	**Weeks**	**Days Offered**

1	Deep Learning	DL-IITM	Mitesh Khapra	12	Day 6, Day 12
	Deep Learning	DL-IITKgp	Prabir Biswas	12	Day 5, Day 11
	Deep Learning for Computer Vision	DLfCV	Vineeth Balasubramaniam	12	Day 10
2	Reinforcement Learning	RL	Balaraman Ravindran	12	Day 4, Day 10
3	AI: Constraint Satisfaction	AI:CS	Deepak Khemani	12	Day 1
4	Natural Language Processing	NLP	Pawan Goyal	12	Day 6, Day 12
5	Artificial Intelligence: Search Methods for Problem Solving	AI:SMPS	Deepak Khemani	12	Day 12
	An Introduction to Artificial Intelligence	AI	Mausam	12	Day 3
6	Artificial Intelligence: Knowledge Representation and Reasoning	AI:KRR	Deepak Khemani	12	Day 5
7	Learning Analytics Tools	LAT	Ramkumar Rajendran	12	Day 12
8	Probability for Computer Science	PfCS	Nitin Saxena	8	Day 3
9	Games and Information	GaI	Ankur Kulkarni	12	Day 4

Foundations of Computing Core Courses (All are mandatory, 1 under each number)

Number	Course Name	Short Code	Instructor	Weeks	Days Offered
1	Discrete Mathematics	DM	Sudarshan Iyengar	12	Day 6, Day 12
2	Design and Analysis of Algorithms	DaAoA	Mukund Madhav	8	Day 2, Day 8
3	Programming, Data Structures and Algorithms in Python	PDSaAiP	Mukund Madhav	8	Day 2, Day 8
4	Theory of Computation	ToC	Raghunath Tewari	8	Day 7

Foundations of Computing Electives (At least 2, 1 under each number)

Number	Course Name	Short Code	Instructor	Weeks	Days Offered
1	Graph Theory	GT	Soumen Maity	8	Day 2
2	Foundations of Cryptography	FoC	Ashish Choudhary	12	Day 3
3	Computer Graphics	CG	Samit Bhattacharyya	8	Day 7
4	Probability for Computer Science	PfCS	Nitin Saxena	8	Day 3

Programming Core Courses (All are mandatory, 1 under each number)

Number	Course Name	Short Code	Instructor	Weeks	Days Offered
1	Programming in Java	PiJ	Deepak Khemani	12	Day 5, Day 11
2	Programming in Modern C++	PiMC	Partha Pratim Das	12	Day 6, Day 12
3	Programming, Data Structures and Algorithms in Python	PDSaAiP	Mukund Madhav	8	Day 2, Day 8
	Data Structures Using Java	DSUJ	Debasis Samanta	12	Day 12
4	Database Management Systems	DMS	Partha Pratim Das	8	Day 2, Day 8
	Introduction to Database Systems	IDS	Sreenivasa Kumar	12	Day 4

Programming Electives (At least 2, 1 under each number)

Number	Course Name	Short Code	Instructor	Weeks	Days Offered
1	Cloud Computing	CC	Soumya Kanti Ghosh	12	Day 3, Day 9
2	Introduction to Machine Learning	IML-IITM	Balaraman Ravindran	12	Day 4, Day 10
	Introduction to Machine Learning	IML-IITKgp	Sudeshna Sarkar	8	Day 8
3	Data Science for Engineers	DSfE	Raghunathan Rengasamy, Shankar Narasimhan	8	Day 2, Day 8
4	Introduction to Internet of Things	ItIoT	Sudip Misra	12	Day 4, Day 10

Systems Core Courses (All are mandatory, 1 under each number)

Number	Course Name	Short Code	Instructor	Weeks	Days Offered

1	Compiler Design	CD	Santanu Chattopadhyay	12	Day 5
2	Operating System Fundamentals	OSF	Santanu Chattopadhyay	12	Day 12
	Introduction to Operating Systems	ItOS	Chester Ribeiro	8	Day 8
3	Computer Networks and Internet Protocol	CNaIP	Soumya Kanti Ghosh, Sandip Chakraborty	12	Day 3
4	Introduction to Database Systems	ItDS	Sreenivasa Kumar	12	Day 4

Systems Electives (At least 2, 1 under each number)					
Number	**Course Name**	**Short Code**	**Instructor**	**Weeks**	**Days Offered**
1	Cloud Computing	CC	Soumya Kanti Ghosh	12	Day 3, Day 9
2	Secure Systems Engineering	SSE	Chester Ribeiro	8	Day 1
3	Introduction to Internet of Things	ItIoT	Sudip Misra	12	Day 4, Day 10
4	Advanced Computer Architecture	ACA	Smruti Sarangi	12	Day 6

Considering that NPTEL conducts exams across 12 days and in each day, there are 3 exams that are conducted. Days 1 to 6 are in March and April, while Days 7 to 12 are in September and October. However, once a course is tagged to a domain for a given user, it cannot be used again. Hence, SAM will need **two user ids**, lets say "RED" and "BLUE".

List of constraints:

- A domain has to be completed **within 2 years** from the date of commencement. For example, if SAM starts his Programming domain in October 2023, he will have to finish it by **Day 6** in 2025.
- Once SAM finishes a domain, all the courses he did in that domain will be tagged with that domain. For example, if SAM completed his Data Science domain, using the course PDSaAiP with the RED user id, he cannot complete the Foundations of Computing domain with the RED user id (i.e. he will have to use the BLUE user id).
- On any given day, SAM can write **at most 3 exams. All 3 are** with **the same user ID**. For example, he cannot write SSE with RED and AI:CS with BLUE.

Given that SAM has started his quest with the **RED** user id in **October 2023** for the courses, PiJ and DSUJ, is planning to do PfCS on Day 3 in 2024, and that he is trying to complete his domain specializations as early as possible, try to come up with an assignment to help Dr. SAM. This can be done by completing the following table:

Year	**Day**	**User ID**	**Short Code 1**	**Short Code 2**	**Short Code 3**
2023	Day 11	RED	PiJ		
2023	Day 12	RED	DSUJ		
2024	Day 1	BLUE			
	Day 2	BLUE			
	Day 3	BLUE	PfCS		
	…	…	…	…	
2025	Day 1	…	…	…	
…	…	…	…	…	

In addition, you also need to complete the domain table as follows:

User ID	**Domain**	**Start Date**	**Courses**	**End Date**
	Artificial Intelligence			
	Data Science			
BLUE	Foundations of Computing	2024, Day 3	PfCS, ...	
RED	Programming	2023, Day 11	PiJ, DSUJ, ...	
	Systems			

You can assume that Dr. SAM will pass each course on their very first attempt. (CO2) [Application]