|  |  |  |  |  |  |  |  |  |  |  |  |
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| Roll No |  |  |  |  |  |  |  |  |  |  |  |

PRESIDENCY UNIVERSITY BENGALURU

SCHOOL OF ENGINEERING

**MAKEUP EXAMINATION -JULY 2024**

**Course Code :** CSE3005

**Course Name :** Applied Artificial Intelligence

**Program :** B.Tech. Computer Science and Engineering

**Date :** 19-07-2024

**Time :** 1:30 PM - 4:30 PM

# Max Marks : 100

**Weightage :** 50%

# Instructions:

1. *Read all questions carefully and answer accordingly.*
2. *Question paper consists of 3 parts.*
3. *Scientific and non-programmable calculator are permitted.*
4. *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 cells). Mention the number of variables needed for solving the N-Queens problem.
2. Mention the sample space for a 6 sided dice.
3. Consider the following Bayesian network:



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

(CO2) [Knowledge] (CO4) [Knowledge]

(CO4) [Knowledge]

1. 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.
2. Mention any two backtracking heuristics.

(CO4) [Knowledge] (CO2) [Knowledge]

**PART B**

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

1. 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 **GREATER 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]

1. 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 “Earth has exactly 1 moon” can be quantified as follows: **U**x moon(x) ^ has(Earth, x)
	1. **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.
	2. **Use that description** to convert the statement “Earth has exactly 1 moon” into first order logic

**without using the unique quantifier**.

(CO3) [Comprehension]

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

(CO4) [Comprehension]

1. Consider the following situation, where we have a set of 5 variables - , such that the domains are:



And the constraints are:

,

,

, and

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

(CO2) [Comprehension]

1. *On the Beautiful Blue Danube* is a famous waltz by Johann Strauss, which was named after the Danube River - a river which flows through Central and South-Eastern Europe, through 10 countries. While at ACL 2016, which was held in Berlin in Germany, researchers from the CFILT Lab at IIT Bombay decided to go visit all 10 countries that the Danube flows through, namely Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Romania, Bulgaria, Moldova and Ukraine. The following table lists all the countries which border each of them.

**Country Neighbouring Countries**

Germany Austria

Austria Germany, Slovakia, Hungary Slovakia Austria, Ukraine, Hungary

Hungary Austria, Slovakia, Romania, Croatia, Serbia, Ukraine Croatia Hungary, Serbia

Serbia Croatia, Bulgaria, Romania, Hungary Romania Ukraine, Hungary, Serbia, Bulgaria, Moldova Bulgaria Romania, Serbia

Moldova Ukraine, Romania

Ukraine Romania, Moldova, Hungary, Slovakia

Consider each of the variables as the **first two letters** of the country's name (Eg. Germany = GE). 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.

(CO2) [Comprehension]

**PART C**

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

1. Consider the following axioms:
2. Every child loves anyone who gives the child any present.
3. Every child will be given some present by Santa if Santa can travel on Christmas eve.
4. It is foggy on Christmas eve.
5. Anytime it is foggy, anyone can travel if he has some source of light.
6. 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]

1. NPTEL gives a special award called a **DOMAIN Specialization**. In Computer Science, there are **FIVE DOMAINS**, namely:
2. Artificial Intelligence
3. Data Science
4. Foundations of Computing
5. Programming
6. Systems

In order to clear each of the domains, a candidate has to claim a total of **15 credits**, 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:

Methods for Problem Solving

|  |
| --- |
| **Artificial Intelligence Core Courses (All are mandatory - 1 under each number)****Number Course Name Short Code Instructor Credits Days Offered** |
|  | Artificial Intelligence: Search AI:SMPS | Deepak Khemani | 3 | Day 12 |
|  | An Introduction to Artificial AI | Mausam | 3 | Day 3 |
| 2 | Artificial Intelligence:Knowledge Representation and AI:KRR Reasoning | Deepak Khemani | 3 | Day 5 |
| 3 | Programming, Data Structures PDSaAiP | Mukund Madhav | 2 | Day 2, Day 8 |
| Python for Data Science PfDS Raghunathan Rengasamy 1 Day 2, Day 8 |
|  | Introduction to Machine IML-IITM | Balaraman Ravindran | 3 | Day 4, Day 10 |
|  | Introduction to Machine IML-IITKgp | Sudeshna Sarkar | 2 | Day 8 |
| **Artificial Intelligence Electives (At least 2, 1 under each number)****Number Course Name Short Code Instructor Credits Days Offered** |
|  | Deep Learning | DL-IITM | Mitesh Khapra | 3 | Day 6, Day 12 |
| 1 | Deep Learning | DL-IITKgp | Prabir Biswas | 3 | Day 5, Day 11 |
| Deep Learning for Computer Vision | DLfCV | Vineeth Balasubramaniam | 3 | Day 10 |
| 2 Reinforcement Learning | RL | Balaraman Ravindran | 3 | Day 4, Day 10 |
| 3 AI: Constraint Satisfaction | AI:CS | Deepak Khemani | 2 | Day 1 |

1

Intelligence

and Algorithms in Python

Learning

4

Learning

4 Natural Language Processing

NLP Pawan Goyal 3 Day 6, Day 12

and Algorithms in Python

|  |  |  |  |
| --- | --- | --- | --- |
| 5 Affective Computing | AC | Jainendra Shukla, Abhinav Dhal 3 | Day 3 |
| 6 Games and Information | GaI | Ankur Kulkarni 3 | Day 4 |
| **Data Science Core Courses (All are mandatory, 1 under each number)****Number Course Name Short Code Instructor Credits Days Offered** |
|  | Programming, Data Structures PDSaAiP | Mukund Madhav | 2 | Day 2, Day 8 |
|  | Python for Data Science PfDS | Raghunathan Rengasamy | 1 | Day 2, Day 8 |
|  | Introduction to Machine IML-IITM | Balaraman Ravindran | 3 | Day 4, Day 10 |
|  | Introduction to Machine IML-IITKgp | Sudeshna Sarkar | 2 | Day 8 |
|  |  | Raghunathan |  |  |
|  | Data Science for Engineers DSfE | Rengasamy, Shankar | 2 | Day 2, Day 8 |
| 3 |  | Narasimhan |  |  |
|  | Data Analytics with Python DAwP | A Ramesh | 3 | Day 5 |
| **Data Science Electives (At least 3, 1 under each number)****Number Course Name Short Code Instructor Credits Days Offered** |
|  | Deep Learning | DL-IITM | Mitesh Khapra | 3 | Day 6, Day 12 |
| 1 | Deep Learning | DL-IITKgp | Prabir Biswas | 3 | Day 5, Day 11 |
| Deep Learning for Computer DLfCV Vineeth 3 Day 10 |
|  | Vision |  | Balasubramaniam |  |  |
| 2 | Reinforcement Learning | RL | Balaraman Ravindran | 3 | Day 4, Day 10 |

1

Learning

2

Learning

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 3 AI: Constraint Satisfaction | AI:CS | Deepak Khemani | 2 | Day 1 |
| 4 Natural Language Processing | NLP | Pawan Goyal | 3 | Day 6, Day 12 |

Methods for Problem Solving

|  |  |  |  |
| --- | --- | --- | --- |
| Artificial Intelligence: Search AI:SMPS | Deepak Khemani | 3 | Day 12 |
| An Introduction to Artificial AI |  |  |  |
| Intelligence |  |  |  |  |
| Artificial Intelligence: |  |  |  |  |
| 6 Knowledge Representation and | AI:KRR | Deepak Khemani | 3 | Day 5 |
| Reasoning |  |  |  |  |
| 7 Learning Analytics Tools | LAT | Ramkumar Rajendran | 3 | Day 12 |
| 8 | Probability for Computer Science | PfCS | Nitin Saxena | 2 | Day 3 |
| 9 | Games and Information | GaI | Ankur Kulkarni | 3 | Day 4 |
| **Foundations of Computing Core Courses (All are mandatory, 1 under each number)** |
| **Number** | **Course Name** | **Short Code** | **Instructor** | **Credits Days Offered** |
| 1 | Discrete Mathematics | DM | Sudarshan Iyengar | 3 Day 6, Day 12 |
| 2 Design and Analysis of DaAoA | Mukund Madhav | 2 | Day 2, Day 8 |
| 3 | Programming, Data Structures and Algorithms in Python | PDSaAiP | Mukund Madhav | 2 | Day 2, Day 8 |
| 4 | Theory of Computation | ToC | Raghunath Tewari | 2 | Day 7 |
| **Foundations of Computing Electives (At least 2, 1 under each number)** |
| **Number** | **Course Name** | **Short Code** | **Instructor** | **Credits** | **Days Offered** |
| 1 | Graph Theory | GT | Soumen Maity | 2 | Day 2 |
| 2 | Foundations of Cryptography | FoC | Ashish Choudhary | 3 | Day 3 |
| 3 | Computer Graphics | CG | Samit Bhattacharyya | 2 | Day 7 |
| 4 Probability for Computer PfCS | Nitin Saxena | 2 | Day 3 |

5

Mausam 3 Day 3

Algorithms

Science

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

**Number Course Name Short Code Instructor Credits Days Offered**

1. Programming in Java PiJ Deepak Khemani 3 Day 5, Day 11
2. Programming in Modern C++ PiMC Partha Pratim Das 3 Day 6, Day 12

Programming, Data Structures

1. and Algorithms in Python

PDSaAiP Mukund Madhav 2 Day 2, Day 8

Data Structures Using Java DSUJ Debasis Samanta 3 Day 12

Database Management DMS Partha Pratim Das 2 Day 2, Day 8 Systems

4

Introduction to Database IDS Sreenivasa Kumar 3 Day 4 Systems

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

**Number Course Name Short Code Instructor Credits Days Offered**

1 Cloud Computing CC Soumya Kanti Ghosh 3 Day 3, Day 9

Introduction to Machine IML-IITM Balaraman Ravindran 3 Day 4, Day 10 Learning

2

Introduction to Machine

Learning

IML-IITKgp Sudeshna Sarkar 2 Day 8 Raghunathan

3 Data Science for Engineers DSfE

Rengasamy, Shankar Narasimhan

2 Day 2, Day 8

4 Introduction to Internet of Things

ItIoT Sudip Misra 3 Day 4, Day 10

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

**Number Course Name Short Code Instructor Credits Days Offered**

1 Compiler Design CD Santanu Chattopadhyay 3 Day 5

Fundamentals

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Operating System OSF | Santanu Chattopadhyay | 3 | Day 12 |
| Introduction to Operating ItOS | Chester Ribeiro | 2 | Day 8 |
| 3 Computer Networks and CNaIP Internet Protocol | Soumya Kanti Ghosh, 3 Day 3 Sandip Chakraborty |

2

Systems

4 Introduction to Database Systems

ItDS Sreenivasa Kumar 3 Day 4

**Systems Electives (At least 2, 1 under each number)**

**Number Course Name Short Code Instructor Credits Days Offered**

1. Cloud Computing CC Soumya Kanti Ghosh 3 Day 3, Day 9
2. Secure Systems Engineering SSE Chester Ribeiro 2 Day 1 Things

|  |  |  |  |
| --- | --- | --- | --- |
| 3 Introduction to Internet of ItIoT | Sudip Misra | 3 | Day 4, Day 10 |
| 4 Advanced Computer ACA | Smruti Sarangi | 3 | Day 6 |

Architecture

Considering that NPTEL conducts exams across 12 days and in each day, there are 2 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 3 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 2026.

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 2 exams**, 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** |
| 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

(CO2) [Application]