

| Reg. Number: |  |
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**Continuous Assessment Test (CAT-2) - OCTOBER 2024**

| Programme | : | B.Tech  **(**CSE with Specialization) | Semester | : | FALL 2024-25 |
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| Course Code &  Course Title | : | BCSE306L  Artificial Intelligence | Slot | : | C2+TC2 |
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| Duration | : | 1 ½ hours | Max. Mark |  | 50 |
| **General Instructions:**   * Write only your registration number on the question paper in the box provided and do not write other information. | | | | | |
| **Answer all questions** | | | | | |

| Q. No | Sub Sec. | Description | Marks |
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| 1 |  |  |  |
| 92 |  | (i) (a) Conversion to Propositional Logic: Let's define the following propositional symbols for the statements:   * **R**: It rains. * **W**: The ground is wet. * **M**: The ground is marshy. * **P**: The match is postponed. * **C**: The match is cancelled. * **H**: The players are unhappy. * **S**: The ball is slippery. * **G**: The ball is greasy. * **U**: The players are upset.   Now, we translate each sentence into propositional logic:   * R → (W∧M) * W → (P∨C) * P → H * M → (S∧G) * C→ U * ¬H ∧ ¬U * R  (i) (b) Conversion to Conjunctive Normal Form (CNF): Now, let’s convert each statement to **CNF** by applying the following transformations:  1. **R→(W∧M)**  This is equivalent to ¬R∨(W∧M).  Applying distributivity: (¬R∨W)∧(¬R∨M).  2. **W→(P∨C)**  This is equivalent to ¬W∨(P∨C). No further changes needed.  3. **P→H**  This is equivalent to ¬P∨H. No further changes needed.  4. **M→(S∧G)**  This is equivalent to ¬M∨(S∧G).  Applying distributivity: (¬M∨S)∧(¬M∨G).  5. **C→U**  This is equivalent to ¬C∨U . No further changes needed.  6. **¬H ∧ ¬U** : This is already in CNF form.  7. **R :** This is already in CNF form. Listing the Individual Clauses: Each clause represents a disjunction of literals. We now list out the individual clauses obtained from the CNF conversions:  1. **From R→(W∧M)**   * ¬R ∨ W (Clause 1) * ¬R ∨ M (Clause 2)   2. **From W→(P∨C)**   * ¬W ∨ P ∨ C (Clause 3)   3. **From P→H**   * ¬P ∨ H (Clause 4)   4. **From M→(S∧G)**   * ¬M ∨ S (Clause 5) * ¬M ∨ G (Clause 6)   5. **From C→U**   * ¬C ∨ U (Clause 7)   6. **From ¬H ∧ ¬U**   * ¬H (Clause 8) * ¬U (Clause 9)   7. **From R**   * R (Clause 10)   (ii) FOL Representation of Premises:   * E(x) → B(x) * B(x) * ¬S(x) → Y(x) * S(x) → ¬ B(x) * Y(x) → F(x)   (ii) (a) Premises Involved:  1. B(x) (She has breakfast in the hostel mess).  2. S(x) → ¬ B(x) (If she sleeps till 9 am, she will not have breakfast in the hostel mess).  **Modus Tollens** says that if P→Q is true, and ¬Q is true, then we can conclude ¬P.  **Therefore, we conclude that she does not sleep till 9 am : ¬ S(x).**  (ii) (b) Additional Premise: ¬ B(x) ∨ ¬ F(x)  We also know from 5th premise that Y(x) → F(x). Hence, F(x) is true and ¬ F(x) is false.  So, from the additional premise, ¬ B(x) is true. This is **disjunctive syllogism**.  But, we also know from 2nd premise that B(x) is true, which is a **contradiction**.  OR  Additional Premise: ¬ B(x) ∨ ¬ F(x)  We also know from 1st and 5th premises that E(x) → B(x) and Y(x) → F(x).  **Destructive Dilemma** says P → Q , R → S, ¬ Q ∨ ¬ S , therefore, we can conclude ¬ P ∨ ¬ R.  So, ¬ E(x) ∨ ¬ Y(x) is concluded. i.e., “Either she does not get up early in the morning or she does not do yoga before her breakfast”. | 10 |
| 3 |  | Step 1: Convert statements to FOL logic: Predicates:  * Mother(x,y): x is the mother of y. * Child(x,y): x is the child of y. * Parent(x,y): x is the parent of y.  FOL Representation:  1. Mother(Devasena,Bahubali) : Devasena is the mother of Bahubali. 2. ∀x ∀y (Child(y,x)→Parent(x,y)) : Everyone who has a child is a parent. 3. ∃x ∃y Mother(x,y) : Someone is the mother of a child. 4. ∃x (Mother(x,Bahubali) ∧ Parent(x,Bahubali)) : The mother of Bahubali is a parent. 5. Mother(Sivagami,Bhallaldeva) : Sivagami is the mother of Bhallaldeva.  Successful Unification Case: Consider sentences 1 and 4. We will attempt to unify Mother(Devasena,Bahubali) with Mother(x,Bahubali).  The substitution needed for unification is: x=Devasena  Thus, the unification is successful with the substitution:  Θ = {x/Devasena}  Because of this substitution in Mother(x,Bahubali) ∧ Parent(x,Bahubali), we get: Mother(Devasena,Bahubali) ∧ Parent(Devasena,Bahubali)  Hence, after unification, we infer: Parent(Devasena,Bahubali)  indicating that the mother of Bahubali (Devasena) is a parent. Failed Unification Case: Now, consider sentences 1 and 5. We will attempt to unify Mother(Devasena,Bahubali) with Mother(Sivagami,Bhallaldeva).  The unification would require these matches:   * Devasena = Sivagami * Bahubali = Bhallaldeva   However, these constants represent different individuals, and we cannot unify Devasena with Sivagami or Bahubali with Bhallaldeva. Since constants cannot be unified unless they are identical, unification fails due to a constant mismatch.  Conditions for Unification:   1. Predicate symbol should be same i.e. atoms or expressions with different predicate symbols can’t be unified. 2. Number of arguments in both expressions must be identical. 3. Two similar variables shouldn’t be present in the same expression. | 2  3  3  2 |
| 4 |  | **(i) Build a Bayesian Network modeling the diagnosis of a car’s electrical system**  A Bayesian Network (BN) is a probabilistic graphical model that represents a set of variables and their conditional dependencies via a directed acyclic graph (DAG). Let's identify the key variables in the car's electrical system:   1. **Battery (B)**: Powers the video display system, lights, and ignition. 2. **Video Display (V)**: Powered by the battery (depends on Battery). 3. **Lights (L)**: Powered by the battery (depends on Battery). 4. **Ignition (I)**: Controls engine start (depends on Battery). 5. **Fuel System (F)**: Can start the engine and controls air conditioning. 6. **Engine (E)**: Can start via ignition or fuel system (depends on Ignition and Fuel System). 7. **Car Moves (M)**: The car moves if the engine starts (depends on Engine). 8. **Air Conditioning (C)**: Controlled by the fuel system (depends on Fuel System).   Now, we can construct a Bayesian Network using the above variables and their dependencies.  **Bayesian Network Structure:**   * **B → I** * **B → V** * **B → L** * **I → E** * **F → E** * **E → M** * **F → A**     **(ii) Formulate the Conditional Probability Table (CPT) for the Bayesian Network**  **To build a CPT for each node, we need to express the probability distribution of each node given its parents:**   1. **Battery (B): We assume prior probabilities for the battery, say:**    * **P(B=On)=0.9**    * **P(B=Off)=0.1**  | **P(B)** | **0.9** | | --- | --- | | **P(¬B)** | **0.1** |      1. **Ignition (I): Depends on the battery being on.**    * **P(I=On∣B=On)=0.95**    * **P(I=Off∣B=On)=0.05**    * **P(I=On∣B=Off)=0.1**    * **P(I=Off∣B=Off)=0.9**  | **Given B** | **P(I=T)** | **P(I=F)** | | --- | --- | --- | | **P(B)** | **0.95** | **0.05** | | **P(¬B)** | **0.1** | **0.9** |     **Video Display (V): Depends on the battery.**   * **P(V=On∣B=On)=0.9** * **P(V=Off∣B=On)=0.1** * **P(V=On∣B=Off)=0.05** * **P(V=Off∣B=Off)=0.95**  | **Given B** | **P(V=T)** | **P(V=F)** | | --- | --- | --- | | **P(B)** | **0.9** | **0.1** | | **P(¬B)** | **0.05** | **0.95** |     **Lights (L): Depend on the battery.**   * **P(L=On∣B=On)=0.95** * **P(L=Off∣B=On)=0.05** * **P(L=On∣B=Off)=0.2** * **P(L=Off∣B=Off)=0.8**  | **Given B** | **P(L=T)** | **P(L=F)** | | --- | --- | --- | | **P(B)** | **0.95** | **0.05** | | **P(¬B)** | **0.2** | **0.8** |     **Fuel System (F): Independent variable (with some prior assumption):**   * **P(F=On)=0.8** * **P(F=Off)=0.2**  | **P(F)** | **0.8** | | --- | --- | | **P(¬F)** | **0.2** |     **Engine (E): Depends on both ignition and fuel system.**   * **P(E=Start∣I=On,F=On)=0.99** * **P(E=Start∣I=On,F=Off)=0.8** * **P(E=Start∣I=Off,F=On)=0.7** * **P(E=Start∣I=Off,F=Off)=0.05**  | **Given I** | **Given F** | **P(E=T)** | **P(E=F)** | | --- | --- | --- | --- | | **P(I)** | **P(F)** | **0.99** | **0.01** | | **P(I)** | **P(¬F)** | **0.8** | **0.2** | | **P(¬I)** | **P(F)** | **0.7** | **0.3** | | **P(¬I)** | **P(¬F)** | **0.05** | **0.95** |     **Car Moves (M): Depends on the engine.**   * **P(M=Moves∣E=Start)=1.0** * **P(M=NotMoves∣E=Start)=0** * **P(M=Moves∣E=NotStart)=0.0** * **P(M=NotMoves∣E=NotStart)=1.0**  | **Given E** | **P(M=T)** | **P(M=F)** | | --- | --- | --- | | **P(E)** | **1** | **0** | | **P(¬E)** | **0** | **1** |     **Air Conditioning (A): Depends on the fuel system.**   * **P(A=On∣F=On)=0.9** * **P(A=Off∣F=On)=0.1** * **P(A=On∣F=Off)=0.9** * **P(A=Off∣F=Off)=0.1**  | **Given E** | **P(A=T)** | **P(A=F)** | | --- | --- | --- | | **P(F)** | **0.9** | **0.1** | | **P(¬F)** | **0.9** | **0.1** |     **(iii) Calculate the probability of “Car Moves” when the engine starts with ignition and without the fuel system, video display off, and lights on through battery.**  **Given:**   * **Ignition (I) is On** * **Fuel System (F) is Off** * **Video Display (V) is Off** * **Lights (L) are On** * **Battery is On**   **We need to compute**  **P(Car Moves = Yes | I=On, F=Off, V=Off, L = On, B = On)**  **We can break it down using the chain rule and the CPTs we formulated:**   1. **Step 1: Compute the probability of the engine starting given the ignition is on and the fuel system is off:**   **P(E=Start | I=On, FS=Off, B = On) = P(E=Start | I=On, FS=Off) \* P(I=On | B = On) =0.8\*0.95=0.76**   1. **Step 2: Given that the engine starts, the probability that the car moves is 1 (deterministic):**   **P(C=Moves | E=Start) = 1.0**  **Thus, the total probability:**  **P(CarMoves=Yes ∣ I=On, F=Off ,V=Off, L=On) = P(E=Start ∣ I=On, F=Off, B=On) × P(C=Moves ∣ E=Start)**  **P(CarMoves=Yes ∣ I=On, F=Off, V=Off, L=On) = 0.76 × 1.0 = 0.76**  **So, the probability that the car moves under the given conditions is 0.76 or 76%.** | 15 |