School of Computer Science and Engineering

Fall Semester 2024-25

CAT II

SLOT: E1+TE1

Programme Name & Branch: B.Tech BCB, BCE, BCT, BCI, BDS, BKT

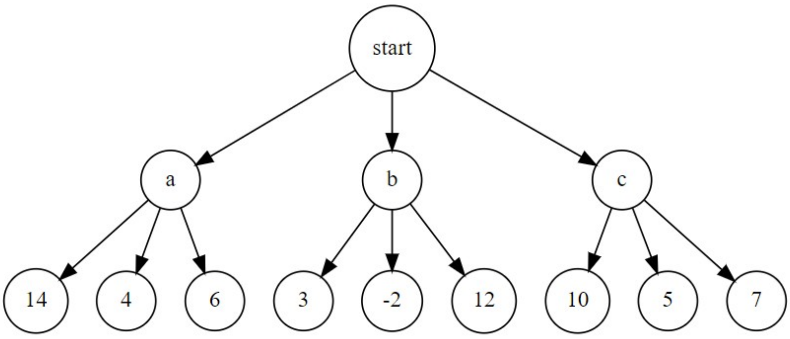
Course Name & Code: BCSE306L – Artificial Intelligence

Class Number (s):VL2024250101490

Faculty Name (s): Dr. Sunija. A. P

Exam Duration: 90 Min. **Maximum Marks: 50**

General instruction(s): ANSWER ALL THE QUESTIONS

Q. No.	Question	Max Marks	CO	BL
1.	Consider a two-player turn-based strategy game where each player tries to maximize or minimize the game score at the end of the game. The game tree is given below  a) Apply the Minimax Algorithm to determine the optimal move for the Maximizer at the start node. Show all calculations for each node. b) Apply Alpha-Beta Pruning to the same game tree and show how it reduces the number of node evaluations. Explain which nodes were pruned and why. **Solution:**	10	CO4	BL2

a) **Minimax Algorithm Solution:**

In the Minimax algorithm, we evaluate the values bottom-up, assuming one player (Maximizer) tries to maximize the score, and the other player (Minimizer) tries to minimize it.

Step 1: Evaluate Leaf Nodes

At the bottom level, the terminal nodes have the values:

From node a: [14, 4, 6]

From node b: [3, -2, 12]

From node c: [10, 5, 7]

Step 2: Minimizer's Turn

At the second level, nodes a, b, and c are controlled by the Minimizer. Therefore, the Minimizer will choose the minimum value from each child set:

Node a: Min(14, 4, 6) = 4

Node b: Min(3, -2, 12) = -2

Node c: Min(10, 5, 7) = 5

Step 3: Maximizer's Turn

At the root node (Start), the Maximizer will now choose the maximum value among 4, -2, and 5:

Max(4, -2, 5) = 5

Minimax Conclusion:

The optimal outcome for the Maximizer is to choose Node c, with a value of 5.

b) **Alpha-Beta Pruning Solution:**

Alpha-Beta Pruning improves the efficiency of the Minimax algorithm by eliminating branches that won't affect the final decision.

	Alpha (α): The best value the Maximizer can guarantee. Beta (β): The best value the Minimizer can guarantee. Step 1: Evaluate Node a Start with α = -∞ and β = +∞. Node a has children [14, 4, 6]: The Minimizer evaluates 14: β = 14. The Minimizer evaluates 4: β is updated to 4 (Min(14, 4)). The Minimizer evaluates 6: β remains 4 (Min(4, 6)). Node a = 4. Step 2: Evaluate Node b Now α = 4 (because of Maximizer's best choice so far) and β = +∞. Node b has children [3, -2, 12]: The Minimizer evaluates 3: β = 3. The Minimizer evaluates -2: β is updated to -2 (Min(3, -2)). Prune: No need to evaluate 12 since -2 is already less than α = 4. Node b = -2. Step 3: Evaluate Node c Now α = 4 (Maximizer's best choice so far) and β = +∞. Node c has children [10, 5, 7]: The Minimizer evaluates 10: β = 10. The Minimizer evaluates 5: β is updated to 5 (Min(10, 5)). Prune: No need to evaluate 7 since 5 is already greater than α = 4. Node c = 5. Step 4: Maximizer's Turn Now, the Maximizer will choose the maximum value from Node a, Node b, and Node c: Max(4, -2, 5) = 5.			
2.	Jake wants to be selected for a sports team. The selection criteria	10	CO2	BL4

and Jake's circumstances are as follows:

1. Anyone fast or strong gets selected.
2. Training makes you fast.
3. Exercise makes you strong.
4. Jake trains but does not exercise.

Convert the given scenario into propositional logic statements and use resolution to prove that "Jake gets selected."

SOLUTION:

Step 1: Define Propositional Variables

We will represent the various aspects of the scenario using propositional variables:

F: Jake is fast.

S: Jake is strong.

T: Jake trains.

E: Jake exercises.

G: Jake gets selected.

Step 2: Convert Statements into Propositional Logic

The given scenario translates into the following logical expressions:

1. **Anyone fast or strong gets selected**:
   F∨S ⟹ GF \lor S \implies GF∨S⟹G
   (If Jake is fast or strong, he gets selected.)
2. **Training makes you fast**:
   T ⟹ FT \implies FT⟹F
   (If Jake trains, he is fast.)
3. **Exercise makes you strong**:
   E ⟹ SE \implies SE⟹S
   (If Jake exercises, he is strong.)
4. **Jake trains but does not exercise**:
   T∧¬ET \land \neg ET∧¬E
   (Jake trains, but he does not exercise.)

Step 3: Convert Implications into Clauses for Resolution

Next, we need to convert the implications into Conjunctive Normal Form (CNF), which is required for resolution.

1. $F \vee S \implies G$ becomes $\neg(F \vee S) \vee G$, which is equivalent to $\neg F \wedge \neg S \vee G$.
   - Clause 1: $\neg F \vee G$
   - Clause 2: $\neg S \vee G$
2. $T \implies F$ becomes $\neg T \vee F$.
   - Clause 3: $\neg T \vee F$
3. $E \implies S$ becomes $\neg E \vee S$.
   - Clause 4: $\neg E \vee S$
4. $T \wedge \neg E$ can be split into two clauses:
   - Clause 5: T
   - Clause 6: $\neg E$

Step 4: Apply Resolution to Prove "Jake Gets Selected"

We want to prove G (Jake gets selected). To use resolution, we will negate the goal and attempt to derive a contradiction. So, assume $\neg G$ (Jake does not get selected).

- **Assume** $\neg G$ (negation of goal)

Now, we have:

- Clause 7: $\neg G$

Step 1: Resolve Clauses 1 and 7

- Clause 1: $\neg F \vee G$
- Clause 7: $\neg G$

Resolving these, we get:

- $\neg F$

Step 2: Resolve Clauses 2 and 7

- Clause 2: $\neg S \vee G$
- Clause 7: $\neg G$

Resolving these, we get:

- $\neg S$

	Step 3: Resolve Clauses 3 and 5 • Clause 3: $\neg T \lor F$ • Clause 5: T Resolving these, we get: • F **Step 4: Resolve F with $\neg F$** • From Step 1, we have $\neg F$. • From Step 3, we have F. This results in a contradiction, as both F and $\neg F$ cannot be true simultaneously. **Conclusion:** Since we have derived a contradiction, the assumption $\neg G$ (Jake does not get selected) must be false. Therefore, **Jake gets selected (G)** is true.			
3.	Consider the following set of rules for classifying transportation modes: Vehicles that have engines are motorized. Vehicles that run on tracks and carry passengers are trains. Vehicles that are motorized and have two wheels are motorcycles. Vehicles that have wings and fly are airplanes. Vehicles that are motorized, have four wheels, and carry passengers are cars. The working memory contains the following assertions: A1: Speedster has two wheels. A2: Zoomer runs on tracks. A3: Glider has wings. A4: Speedster has an engine. A5: Glider flies. i) Use forward chaining to derive all assertions that are derivable from this knowledge base (i.e., from the set of rules together with the assertions in the working memory). ii) Use backward chaining to determine whether Speedster is a motorcycle. Construct all trees showing the steps followed by forward and backward chaining, and show when and how the	10	CO2	BL5

	working memory is updated during the process. Solution: vehicle = x R1: Speedster has an engine ?x has an engine succeeds due to A4 WM := WM + {A6: Speedster is motorized} ?x is motorized R2: Zoomer runs on tracks ?x runs on tracks succeeds due to A2 Zoomer carries passengers ?x carries passengers fails (no information about passengers) hence Rule R2 is not triggered. R3: Speedster has two wheels ?x has two wheels succeeds due to A1 Speedster is motorized ?x is motorized succeeds due to A6 WM := WM + {A7: Speedster is a motorcycle} ?x is a motorcycle			

	R4: Glider has wings ?x has wings succeeds due to A3 Glider flies ?x flies succeeds due to A5 WM := WM + {A8: Glider is an airplane} ?x is an airplane b) **Backward Chaining** Goal: Is Speedster a motorcycle? Goal: Speedster is a motorcycle ?x is a motorcycle R1: Vehicles that are motorized and have two wheels are motorcycles | ├── Condition 1: Is Speedster motorized? | | | └── Rule: Vehicles with engines are motorized ?x has an engine | succeeds due to A4: Speedster has an engine | hence, Speedster is motorized (Rule 1) | └── Condition 2: Does Speedster have two wheels? ?x has two wheels succeeds due to A1: Speedster has two wheels **Conclusion:** Speedster satisfies both conditions. Therefore, **Speedster is a motorcycle**.			
4.	Consider the following statements 1. Any book in the library is more expensive than any magazine in the store. 2. Any electric car is more efficient and produces less pollution than a gasoline car. 3. There is exactly one student whose GPA is 4.0.	10	CO2	BL1

4. There is a restaurant in Paris that serves better food than any other restaurant in the city.
5. A person who helps others is respected by everyone.

a) Convert the following English statements into First-Order Logic (FOL)

b) Convert the above FOL expressions to Conjunctive Normal Form (CNF).

Solution:

English: Any book in the library is more expensive than any magazine in the store.

(a) FOL Representation:

Let:

- $B(x)$: x is a book.
- $L(x)$: x is in the library.
- $M(y)$: y is a magazine.
- $S(y)$: y is in the store.
- $E(x, y)$: x is more expensive than y.

The FOL sentence is:

$$\forall x \forall y \left((B(x) \land L(x) \land M(y) \land S(y)) \implies E(x, y) \right)$$

(For all x and y, if x is a book in the library and y is a magazine in the store, then x is more expensive than y).

Statement 2:

English: Any electric car is more efficient and produces less pollution than a gasoline car.

(a) FOL Representation:

Let:

- $EC(x)$: x is an electric car.
- $GC(y)$: y is a gasoline car.
- $Efficient(x, y)$: x is more efficient than y.
- $LessPollution(x, y)$: x produces less pollution than y.

The FOL sentence is:

$$\forall x \forall y \left((EC(x) \wedge GC(y)) \implies (Efficient(x, y) \wedge LessPollution(x, y)) \right)$$

(b) CNF Conversion:

1. Convert implication: $(EC(x) \wedge GC(y)) \implies (Efficient(x, y) \wedge LessPollution(x, y)) \equiv \neg(EC(x) \wedge GC(y)) \vee (Efficient(x, y) \wedge LessPollution(x, y))$
2. Apply De Morgan's Law: $\neg EC(x) \vee \neg GC(y) \vee (Efficient(x, y) \wedge LessPollution(x, y))$
3. Distribute conjunction in the consequent: $(\neg EC(x) \vee \neg GC(y) \vee Efficient(x, y)) \wedge (\neg EC(x) \vee \neg GC(y) \vee LessPollution(x, y))$

So, the CNF form is:

$$(\neg EC(x) \vee \neg GC(y) \vee Efficient(x, y)) \wedge (\neg EC(x) \vee \neg GC(y) \vee LessPollution(x, y))$$

3.There is exactly one student whose GPA is 4.0.

CNF is

$$S(c) \wedge GPA(c, 4.0) \wedge (\neg S(y) \vee \neg GPA(y, 4.0) \vee y = c)$$

5. There is a restaurant in Paris that serves better food than any other restaurant in the city.

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(a) FOL Representation:

Let:

- $R(x)$: x is a restaurant.
- $P(x)$: x is in Paris.
- $BetterFood(x, y)$: x serves better food than y.

The FOL sentence is:

$$\exists x\, (R(x) \land P(x) \land \forall y\, (R(y) \land P(y) \land y \neq x \implies BetterFood(x, y)))$$

(There exists a restaurant x in Paris, such that for all y, if y is another restaurant in Paris, then x serves better food than y).

(b) CNF Conversion:

1. Eliminate the existential quantifier (Skolemization):
   Let c be the restaurant in Paris that serves better food.

$$R(c) \land P(c) \land \forall y\, (R(y) \land P(y) \land y \neq c \implies BetterFood(c, y))$$

2. Convert the implication:
   $$\forall y\, (\neg(R(y) \land P(y) \land y \neq c) \lor BetterFood(c, y))$$
3. Apply De Morgan's Law:
   $$\forall y\, (\neg R(y) \lor \neg P(y) \lor y = c \lor BetterFood(c, y))$$

So, the CNF form is:

$R(c) \land P(c) \land (\neg R(y) \lor \neg$ [illegible] $) \lor y = c \lor BetterFood(c, y))$

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Consider the following dataset that includes demographic information and symptoms for disease diagnosis:

a) Using the dataset provided, apply Naive Bayes Classification to predict the diagnosis of a new individual based on the following features:

Age Group: 30-40, Gender: Female, Fever: Yes, Cough: Yes, Fatigue: Yes, Sore Throat: No

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Age Group	Gender	Fever	Cough	Fatigue	Sore Throat	Diagnosis
<30	Female	Yes	Yes	Yes	No	Flu
30-40	Male	Yes	Yes	No	Yes	COVID-19
>40	Female	No	Yes	Yes	Yes	Allergies
<30	Male	Yes	No	Yes	No	Flu
30-40	Female	Yes	Yes	Yes	Yes	COVID-19
>40	Male	No	No	No	No	Healthy
<30	Female	Yes	Yes	No	Yes	COVID-19
30-40	Male	Yes	No	Yes	Yes	Flu
>40	Female	Yes	Yes	Yes	Yes	COVID-19
30-40	Male	No	Yes	No	No	Allergies

b) Based on the data given, answer the following:

i)What is the probability that an individual has a COVID-19 diagnosis given that they are Male and have Fatigue and Cough?

ii) Given that an individual has No Fever and No Cough, what is the probability that their diagnosis is Healthy?

Solution a

Using Bayes' theorem:

$$P(\text{COVID-19}|\text{Male}, \text{Fatigue} = \text{Yes}, \text{Cough} = \text{Yes}) = \frac{P(\text{Male}, \text{Fatigue} = \text{Yes}, \text{Cough} = \text{Yes}|\text{COVID-19}) \cdot P(\text{COVID-19})}{P(\text{Male}, \text{Fatigue} = \text{Yes}, \text{Cough} = \text{Yes})}$$

Step 1: Calculate $P(\text{COVID-19})$

From the dataset, there are 3 COVID-19 cases out of 10 total records. Thus:

$$P(\text{COVID-19}) = \frac{3}{10} = 0.3$$

Step 2: Calculate $P(\text{Male}, \text{Fatigue} = \text{Yes}, \text{Cough} = \text{Yes}|\text{COVID-19})$

We need to check how often a male with fatigue and cough appears in COVID-19 cases. Looking at the data, there is **1 male COVID-19 patient**, but this patient has no fatigue. Therefore, the probability:

$$P(\text{Male}, \text{Fatigue} = \text{Yes}, \text{Cough} = \text{Yes}|\text{COVID-19}) = 0$$

Since the likelihood is zero, we can conclude that:

$$P(\text{COVID-19}|\text{Male}, \text{Fatigue} = \text{Yes}, \text{Cough} = \text{Yes}) = 0$$

Thus, there is **0 probability** that a male with fatigue and cough has COVID-19 based on this dataset.

b)

$$P(\text{Healthy} | \text{Fever} = \text{No}, \text{Cough} = \text{No})$$

Using Bayes' theorem:

$$P(\text{Healthy} | \text{Fever} = \text{No}, \text{Cough} = \text{No}) = \frac{P(\text{Fever} = \text{No}, \text{Cough} = \text{No} | \text{Healthy}) \cdot P(\text{Healthy})}{P(\text{Fever} = \text{No}, \text{Cough} = \text{No})}$$

Step 1: Calculate $P(\text{Healthy})$

From the dataset, there is **1 Healthy case** out of 10 total records. Thus:

$$P(\text{Healthy}) = \frac{1}{10} = 0.1$$

Step 2: Calculate $P(\text{Fever} = \text{No}, \text{Cough} = \text{No} | \text{Healthy})$

The only Healthy individual has no fever and no cough. Therefore:

$$P(\text{Fever} = \text{No}, \text{Cough} = \text{No} | \text{Healthy}) = 1$$

Step 3: Calculate $P(\text{Fever} = \text{No}, \text{Cough} = \text{No})$

Out of the 10 records, there are 2 individuals who have no fever and no cough (the Healthy individual and the Allergies individual). Therefore:

$$P(\text{Fever} = \text{No}, \text{Cough} = \text{No}) = \frac{2}{10} = 0.2$$

Step 4: Calculate the Final Probability

Now, applying Bayes' theorem:

$$P(\text{Healthy} | \text{Fever} = \text{No}, \text{Cough} = \text{No}) = \frac{1 \cdot 0.1}{0.2} = 0.5$$

Thus, the probability that an individual is **Healthy** given that they have **no fever and no cough** is **0.5**