MODULE-3

1. Examine Wumpus World game problem and explain the steps involved by the agent in the Wumpus World.

Answer:
The Wumpus World is a classic AI problem where an agent navigates a cave represented by a grid, seeking gold while avoiding pits and the Wumpus monster.
Steps involved by the agent:

1. **Perception:** The agent senses the environment (e.g., breeze, stench, glitter).
2. **Knowledge Update:** Based on perceptions, it updates its knowledge base about safe and dangerous locations.
3. **Reasoning:** Uses logic to infer new information (e.g., if breeze is felt, a pit is nearby).
4. **Decision:** Decides the next action (move, grab, shoot, climb) using inference.
5. **Action Execution:** Performs the action and loops the process.

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2. List all the basic symbols used in proposition logic and represent below sentences using proposition symbols.

Answer:
Basic symbols:

- Propositional variables (P, Q, R, etc.)
- Logical connectives:
  - Conjunction (AND): ∧
  - Disjunction (OR): ∨
  - Negation (NOT): ¬
  - Implication: →
  - Biconditional: ↔
- Parentheses: ( )

Sentence representations:

a. It is cold and dark

Let C = "It is cold", D = "It is dark"

Representation: $C \land D$

b. If I study hard then I get rich

Let S = "I study hard", R = "I get rich"

Representation: $S \rightarrow R$

c. Logic is not easy

Let E = "Logic is easy"

Representation: $\neg E$

d. I am breathing if and only if I am alive

Let B = "I am breathing", A = "I am alive"

Representation: $B \leftrightarrow A$

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3. Describe the forward-chaining and backward-chaining algorithms for propositional logic with suitable examples.

Answer:

- **Forward-chaining:** Starts with known facts and applies inference rules to extract more facts until the goal is reached.
  Example:
  - Rules:
    1. If $P \rightarrow Q$, and P is true, then Q is true.
    2. P is true.
  - Forward-chaining deduces Q.
- **Backward-chaining:** Starts with the goal and works backwards, looking for rules that could conclude the goal, and recursively tries to prove their premises.
  Example:
  - Goal: Q
  - Rule: If $P \rightarrow Q$
  - So, try to prove P.

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4. Show the following arguments is valid or not using Truth Table approach

Answer:
i) If it is humid then it will rain and since it is humid today it will rain
Let H = "It is humid", R = "It will rain"
Premises: $H \rightarrow R$, H
Conclusion: R

H	R	H→R	Premises True?	Conclusion
T	T	T	Both True	T
T	F	F	1st False	F

Only when both premises are true (H=T, H→R=T), R is also true. Thus, the argument is **valid**.

ii) If it is hot and humid then it is not raining
Let T = "It is hot", H = "It is humid", R = "It is raining"
Premise: $(T \wedge H) \rightarrow \neg R$

T	H	R	T∧H	¬R	(T∧H)→¬R
T	T	T	T	F	F
T	T	F	T	T	T
T	F	T	F	F	T
T	F	F	F	T	T
F	T	T	F	F	T
F	T	F	F	T	T
F	F	T	F	F	T
F	F	F	F	T	T

The implication only fails if it is hot, humid, and raining, but otherwise holds. The argument is **not valid in all cases**.

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5. Explain Wumpus world game problem with diagram and PEAS representation.

Answer:
PEAS Representation:

- **Performance measure:** Grab gold, avoid pits & Wumpus, exit safely.
- **Environment:** Grid world of rooms, some with pits/Wumpus/gold.
- **Actuators:** Move forward, turn left/right, grab, shoot, climb.
- **Sensors:** Stench, breeze, glitter, bump, scream.

Diagram:

```
+----+----+----+----+
|    |    |    |    |
+----+----+----+----+
|    |Pit |Wump|Gold|
+----+----+----+----+
|Pit |    |    |    |
+----+----+----+----+
|Agt |    |Pit |    |
+----+----+----+----+
```

(Agent starts at bottom left)

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6. Why proposition logic is required? List all the basic facts about proposition logic with an example.

Answer:
Propositional logic is required for representing and reasoning about facts that can be true or false.

Basic facts:

- Consists of propositions (atomic or compound).
- Uses logical connectives.
- Truth values: True/False.
- Supports inference rules (e.g., Modus Ponens).
- Example:
  - P: "It is raining", Q: "The ground is wet"
  - If $P \rightarrow Q$ and P is true, then Q is true.

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7. Write the Pseudocode for Knowledge Based agent. Describe the components of Knowledge Based System with an example.

Answer:
Pseudocode:

```
function KnowledgeBasedAgent(percept):
    t ← current time
    KB ← Tell(KB, MakePerceptSentence(percept, t))
    action ← Ask(KB, "What action should I do now?")
    KB ← Tell(KB, MakeActionSentence(action, t))
    return action
```

Components:

- **Knowledge Base (KB):** Stores facts/rules.
- **Inference Engine:** Applies logic to deduce new info.
- **Interface:** Receives percepts, outputs actions.

Example:
In Wumpus World, KB contains rules about breezes and pits, the inference engine deduces safe moves.

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8. Define the role of Propositional Logic in AI. Translate the following into propositional logic:

Answer:
Propositional Logic enables AI to represent facts, reason, and infer new knowledge.

a) If it rains, then the ground is wet.
P = "It rains", Q = "Ground is wet"
Representation: $P \rightarrow Q$

b) It is not raining or it is cloudy.
R = "It is raining", C = "It is cloudy"
Representation: $\neg R \vee C$

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9. Define the resolution principle in FOL. Provide a step-by-step example using resolution refutation to prove a conclusion.

Answer:
Resolution Principle:
A rule of inference for FOL; resolves two clauses containing complementary literals to produce a new clause.

Example:
Given:

1. P ∨ Q
2. ¬Q ∨ R
3. ¬R
   Prove: P

Steps:

- From (2) and (3): ¬Q ∨ R, ¬R ⇒ ¬Q (resolving R and ¬R)
- From (1) and above: P ∨ Q, ¬Q ⇒ P

Thus, P is proved.

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10. Given the following facts...prove by resolution that John likes peanuts.

Answer:
Facts:

1. ∀x Food(x) ⟶ Likes(John, x)
2. Food(Apples), Food(Vegetables)
3. ∀x∀y Eats(x, y) ∧ ¬Killed(x, y) ⟶ Food(y)
4. Eats(Anil, Peanuts), ¬Killed(Anil, Peanuts)
5. ∀x Eats(Harry, x) ⟵ Eats(Anil, x)

Goal: Likes(John, Peanuts)

Resolution Steps:

- From (4): Eats(Anil, Peanuts) and ¬Killed(Anil, Peanuts) ⇒ Food(Peanuts) (by 3)
- From (1): Food(Peanuts) ⇒ Likes(John, Peanuts)

Hence, John likes peanuts.

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11. Explain the syntax and semantics of First Order Logic. Provide suitable examples.

Answer:

- **Syntax:**
  - **Constants:** objects (e.g., John)
  - **Predicates:** relations (e.g., Loves(John, Mary))
  - **Variables:** x, y
  - **Quantifiers:** ∀ (universal), ∃ (existential)
  - **Connectives:** ∧, ∨, ¬, →, ↔
- **Semantics:**
  - Assigns meaning to symbols: objects, relations, truth values.

Example:
∀x Human(x) → Mortal(x): "All humans are mortal."

---

12. Define Universal and Existential Instantiation and give examples for both. Prove the following using Backward and Forward chaining...

Answer:

- **Universal Instantiation:**
  From ∀x P(x), infer P(c) for any constant c.
  Example: ∀x Human(x) → Mortal(x), so Human(Socrates) → Mortal(Socrates)
- **Existential Instantiation:**
  From ∃x P(x), infer P(c) for some new constant c.
  Example: ∃x Cat(x), so Cat(a) for some a.

Prove "Solan is criminal":

Given:

- Law: $\forall x, y, z\,[\text{American}(x) \land \text{Weapon}(y) \land \text{Sells}(x, y, z) \land \text{Hostile}(z)] \rightarrow \text{Criminal}(x)$
- Country E is hostile, has missiles sold by Solan (an American).
- Missiles are weapons.

Forward Chaining:

1. American(Solan), Weapon(Missiles), Sells(Solan, Missiles, E), Hostile(E)
2. Apply law: Solan is criminal.

Backward Chaining:

Goal: Criminal(Solan)

Try to satisfy all premises in the law; each is directly supported by facts.

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13. Explain First order Logic that converts FOL to propositional logic through Instantiation methods

Answer:

FOL can be converted to propositional logic by replacing variables with all possible constants (grounding the formula), turning quantified statements into propositional ones.

Example:

$\forall x\, P(x)$ with domain $\{a, b\}$ becomes $P(a) \land P(b)$.

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14. Explain in detail Modus Ponens and how it impact inference rules.

Answer:

Modus Ponens:

If $P \rightarrow Q$ and P is true, then Q is true.

Impact:

- Fundamental inference rule for deductive reasoning in logic systems.
- Enables automated proof systems to derive new facts.

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15. Write the algorithm for Unification process

Answer:
Algorithm:

1. Input two predicates.
2. If both are identical, return empty substitution.
3. If one is a variable, substitute it.
4. If both are compound, unify their arguments recursively.
5. If fails at any step, return "failure".
6. Output: Most General Unifier (MGU).

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16. Explain in detail resolution principle with suitable examples

Answer:
The resolution principle is a rule of inference for both propositional and first-order logic that produces new clauses by eliminating complementary literals.

Example:

1. A ∨ B
2. ¬B ∨ C
   Resolution on B and ¬B gives: A ∨ C

This process is repeated until the empty clause is derived, indicating the original set is unsatisfiable (proof by contradiction).

MODULE-4

1. Discuss about the language of propositions in probability assertions.

Answer:
The language of propositions in probability assertions refers to the formal way we express statements whose truth values affect probabilistic reasoning. In probability theory, propositions are logical statements that can be true or false, such as "It is raining" or "The patient has a cavity." Probability assertions assign a numerical likelihood to these propositions, enabling reasoning under uncertainty.

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2. Find a model for Probability of any Proposition.

Answer:
A probability model for any proposition is a mathematical framework that assigns a probability value (between 0 and 1) to each proposition. One common model is the probability space, comprising a sample space (Ω), a set of propositions (events), and a probability function P that satisfies Kolmogorov's axioms. For example, P(A) assigns a probability to proposition A.

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3. Discuss Basic Probability Notations and define the product rule in basic probability notation.

Answer:
Basic probability notations:

- P(A): Probability of event A.
- $P(A \cap B)$ or P(A, B): Probability that both A and B occur (joint probability).
- P(A | B): Probability of A given B occurs (conditional probability).
- $P(A \cup B)$: Probability of A or B occurring.

Product Rule:
$P(A, B) = P(A \mid B) \times P(B)$
This expresses the joint probability as the product of the conditional probability and the probability of the given event.

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4. Distinguish conditional and unconditional probabilities with examples.

Answer:

- **Unconditional probability (marginal):** Probability of an event regardless of other events.
  Example: P(Rain) = 0.3.
- **Conditional probability:** Probability of an event given that another event has occurred.
  Example: P(Rain | Clouds) = 0.7 (probability of rain given that it's cloudy).

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5. Define & prove the Bayes' rule.

Answer:
Bayes' Rule relates conditional probabilities:
$P(A \mid B) = [P(B \mid A) \times P(A)] / P(B)$

Proof:
From the product rule:
$P(A, B) = P(A \mid B) \times P(B) = P(B \mid A) \times P(A)$
Rearranging:
$P(A \mid B) = [P(B \mid A) \times P(A)] / P(B)$

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6. Discuss the cause of uncertainty.

Answer:
Uncertainty arises from incomplete, imprecise, or noisy information about the environment or system. Causes include randomness in natural phenomena, lack of knowledge, measurement errors, and inherent unpredictability in complex systems.

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7. Given the Join the Probability Distribution Calculate

- 1. P(Cavity)
- 2. P(Toothache)
- 3. P(Cavity ∨ Toothache)
- 4. P(Cavity | Toothache)

Answer:
Assume a joint probability table:

	Toothache=T	Toothache=F	Total (Cavity)
Cavity=T	0.08	0.02	0.10
Cavity=F	0.01	0.89	0.90
Total	0.09	0.91	1.00

1. **P(Cavity) = 0.10**
2. **P(Toothache) = 0.09**
3. **P(Cavity ∨ Toothache) = 0.10 + 0.09 - 0.08 = 0.11**
4. **P(Cavity | Toothache) = P(Cavity=T, Toothache=T) / P(Toothache=T) = 0.08 / 0.09 ≈ 0.89**

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8. List and explain basic probability notations used in AI, such as joint, marginal, and conditional probabilities.

Answer:

- **Joint Probability (P(A, B)):** Probability that both A and B occur.
- **Marginal Probability (P(A)):** Probability of A, regardless of other variables.
- **Conditional Probability (P(A | B)):** Probability of A given that B has occurred.

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9. Discuss the problem of Uncertainty and how agents act under uncertainty with one example.

Answer:
Uncertainty in AI comes from partial observability, noisy sensors, or unknown environments. Agents handle uncertainty by reasoning with probabilities, maximizing expected utility, or using belief states.
Example: A medical diagnosis agent uses patient symptoms and test results (which may be noisy or incomplete) to infer the most probable disease.

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10. Explain the concept of Full joint Probability distribution.

Answer:
A Full Joint Probability Distribution (FJPD) specifies the probability for every possible combination of variable values in a domain. It enables answering any probabilistic query about those variables.

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11. Define Bayes' rule and explain independence in conditional probability with one example

Answer:
Bayes' Rule:
$P(A | B) = [P(B | A) \times P(A)] / P(B)$

Independence:
Two events A and B are independent if $P(A | B) = P(A)$.
Example: Tossing two fair coins: P(Heads on first | Heads on second) = P(Heads on first) = 0.5.

---

12. Explain the concept of independence with suitable AI-based examples.

Answer:
Variables are independent if knowing the value of one does not affect the probability of the other.
AI Example: In spam detection, the probability that an email contains "free" may be independent of whether it is sent on a Monday.

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13. Define Bayes' Theorem. Derive the formula and explain each term using a real-world AI use case.

Answer:
Bayes' Theorem:
$P(H | E) = [P(E | H) \times P(H)] / P(E)$

- H: Hypothesis (e.g., email is spam)
- E: Evidence (e.g., contains "win money")
- P(H): Prior probability (belief before seeing evidence)
- P(E | H): Likelihood (probability of evidence given hypothesis)
- P(E): Marginal probability of evidence

Use case: In spam filtering, Bayes' theorem updates the probability that an email is spam given certain keywords.

14. What is a full joint probability distribution (FJPD)? Represent the FJPD of two binary variables A and B and discuss how it can be used for inference.

Answer:
A FJPD lists the probability of every combination of values for variables A and B.

	B=true	B=false
A=true	0.3	0.2
A=false	0.1	0.4

Total = 1.

Usage:

- Marginalize: P(A=true) = 0.3 + 0.2 = 0.5
- Conditional: P(A=true | B=true) = 0.3 / (0.3 + 0.1) = 0.75

MODULE-5

1. List & explain the types of learning.

Answer:
There are mainly three types of learning in machine learning:

- **Supervised Learning**: Learns a function from labeled training data.
- **Unsupervised Learning**: Finds hidden patterns in unlabeled data.
- **Reinforcement Learning**: Learns optimal actions through trial and error, receiving rewards or penalties.

2. Explain supervised learning and unsupervised learning with examples.

Answer:

- **Supervised Learning**: Input-output pairs are used. The model learns a function to map inputs to outputs.
  - *Example*: Email spam detection using labeled emails (spam or not).
- **Unsupervised Learning**: Only input data is available. The model finds patterns or structures.

- *Example*: Customer segmentation using purchasing behavior data.

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3. Define Machine Learning. Explain the various components of a learning system. How do they interact to form a complete machine learning pipeline?

Answer:
Machine Learning is the field of study that gives computers the ability to learn without being explicitly programmed.

Components:

1. **Learning Element**: Makes improvements.
2. **Performance Element**: Chooses actions.
3. **Critic**: Gives feedback based on performance.
4. **Problem Generator**: Suggests exploratory actions.

These components work together to form a learning agent. The agent performs actions, receives feedback, improves through learning, and explores new strategies.

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4. Discuss the different types of learning in machine learning systems with suitable examples.

Answer:

- **Supervised Learning**: Predict house prices (input: features, output: price).
- **Unsupervised Learning**: Cluster documents by topic.
- **Reinforcement Learning**: Self-driving car learns to navigate roads.

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5. Differentiate between supervised, unsupervised, and reinforcement learning with appropriate use cases and algorithms.

Answer:

Type	Data	Example Use Case	Algorithms
Supervised	Labeled	Spam detection	Decision Trees, SVM
Unsupervised	Unlabeled	Market segmentation	K-means, PCA

Type	Data	Example Use Case	Algorithms
Reinforcement	Feedback	Game playing agents	Q-learning, DQN

---

6. Discuss the Inductive Learning Framework. Explain its components and workflow with an example.

Answer:
Inductive Learning aims to generalize from specific training examples to unseen data.

Components:

- **Hypothesis Space**: Set of all possible hypotheses.
- **Training Examples**: Input-output pairs.
- **Target Function**: True mapping to approximate.

Example: Learning whether to play tennis based on weather conditions.

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7. Explain the working of Support Vector Machines (SVM). How does Support Vector Regression differ from classification SVMs?

Answer:
SVM Classification finds a hyperplane that maximizes the margin between two classes.

Support Vectors are the data points closest to the hyperplane.

Support Vector Regression (SVR) finds a function within a margin of tolerance, aiming to minimize error within this range.

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8. Explain K-means and Fuzzy C-means clustering algorithms with examples.

Answer:

- **K-means**: Partitions data into k clusters by minimizing intra-cluster distance.
  - *Example*: Grouping customers into k spending profiles.
- **Fuzzy C-means**: Assigns membership probabilities to each cluster.
  - *Example*: A product belonging to multiple categories (e.g., electronics and gadgets).

---

9. Discuss the Deductive Learning Framework. Explain its components and workflow with an example.

Answer:
Deductive Learning derives conclusions from a set of rules and facts.

Components:

- **Knowledge Base**: Contains rules.
- **Inference Engine**: Applies rules to derive conclusions.

Example: Given "All men are mortal" and "Socrates is a man," deduce "Socrates is mortal."

---

10. Demonstrate with real world examples for clustering techniques

Answer:

- **Customer Segmentation**: Retail chains use K-means to cluster customer buying patterns.
- **Document Clustering**: News websites cluster articles based on topics.
- **Image Segmentation**: Grouping similar pixels using clustering for object detection.