🌟 MODULE 3 – Knowledge Representation, Reasoning & Knowledge-Based Agents

(VERY SIMPLE + DETAILED)

✅ 1. What is Knowledge Representation (KR)?

KR means **how a computer stores knowledge so it can think like humans**.

Humans store knowledge in:

- Brain
- Notes
- Photos
- Experience

Computers store knowledge in:

- Logic
- Rules
- Graphs
- Semantic networks
- Databases

Purpose of KR:

- To let AI understand the world
- To let AI make decisions

- To let AI reason (think)

✅ 2. Types of Knowledge Representation

A) Propositional Logic (Simple Statements)

- Used to represent simple TRUE/FALSE facts.
- Example:
  “It is raining” = True
  “2+2=5” = False

Uses symbols like P, Q, R.

B) First Order Logic (FOL)

More powerful than propositional logic.
It can represent:

- Objects
- Relations
- Functions

Example:
Father(Ram, Rohan)
Means: Ram is father of Rohan.

C) Semantic Networks

Knowledge is stored in a **graph**:

- Nodes = concepts
- Links = relationships

Example:
Animal
↓ (is-a)
Bird

↓ (is-a)
Sparrow

Useful for inheritance:
If Bird can fly → Sparrow can fly.

D) Rule-Based Knowledge (IF-THEN rules)

Example:
IF fever AND cough
THEN flu

Used in expert systems.

✅ 3. Knowledge-Based Agents (KBA)

A Knowledge-Based Agent works like a **thinking machine**.

It has:

✔ Knowledge Base (KB) → stores facts, rules
✔ Inference Engine → applies logic
✔ TELL–ASK–ACT cycle

Working:

1️⃣ **TELL** – Add new information to KB
2️⃣ **ASK** – Ask KB: "What should I do?"
3️⃣ **ACT** – Perform that action

Example:
A medical agent gets symptoms → finds disease → gives advice.

✅ 4. Inference – How AI thinks?

A) Forward Chaining (Fact → Goal)

- Starts from known facts
- Applies rules
- Reaches conclusion

Example:
Rule: If Bird → CanFly
Fact: Bird(Tweety)
Conclusion: Tweety can fly

Used in expert systems.

B) Backward Chaining (Goal → Facts)

- Starts from goal
- Checks which rules support goal
- Moves backward until facts match

Example:
Goal: Can Tweety fly?
Rule: Bird → Fly
Check: Is Tweety a bird?
Yes → proven

Used in PROLOG.

✅ 5. Inference Rules Explained Simple

Modus Ponens:

If P → Q
And P is true
Then Q is true

Modus Tollens:

If P → Q
And Q is false
Then P is false

Resolution:

Used for proving things by eliminating contradictions.
Very important for exams.

🎯 MODULE 3 – Final Summary

- KR = storing knowledge
- KBA = agent with knowledge + reasoning
- Forward chaining = facts → goal
- Backward chaining = goal → facts
- Semantic nets = graph of concepts
- Rules = IF-THEN
- Inference rules = ways of reasoning

🌟 MODULE 4 – Artificial Neural Networks (ANN)

(DETAILED + SIMPLE)

✅ 1. What is ANN?

ANN is a model inspired by the **human brain**.

Human brain → neurons
ANN → artificial neurons (perceptrons)

ANN learns from examples.

Example:
You show many cat images → ANN learns what a cat looks like.

✅ 2. Structure of ANN

1. Input Layer

Takes raw inputs.
Example: pixel values of image.

2. Hidden Layers

They do calculations and feature extraction.
More hidden layers = more learning power.

3. Output Layer

Gives final result.
Example:
“Cat” or “Dog”

✅ 3. Artificial Neuron (Perceptron)

A perceptron takes:

- Inputs
- Weights
- Bias
- Applies activation
- Gives output

Formula:
[
Y = f(w_1 x_1 + w_2 x_2 + … + b)
]

✅ 4. Types of Neural Networks

Single-Layer NN

- Only one layer
- Simple problems

- Uses Perceptron Rule
- Can only solve linear problems

Multi-Layer NN

- Has hidden layers
- Can learn complex patterns
- Uses Backpropagation
- Used everywhere today

✅ 5. Activation Functions (Why needed?)

They add **non-linearity** → helps ANN learn complex patterns.

a) Sigmoid

Smooth S-shaped
Output: 0 to 1
Used in binary classification.

b) Tanh

Output: –1 to 1
Better than sigmoid because it is zero-centered.

c) ReLU

If x < 0 → 0
If x > 0 → x
Fastest, most used.

d) Softmax

Used for multi-class classification.
Turns numbers into probabilities.

✅ 6. Perceptron Learning Rule

[
w = w + \eta (t - o) x
]
[
b = b + \eta (t - o)
]

Where:

- t = target output
- o = predicted output
- η = learning rate

Perceptron learns by fixing its mistakes.

🎯 MODULE 4 – Final Summary

- ANN = small artificial brain
- Neuron = weighted sum + activation
- Layers = input → hidden → output
- Activation = decides firing
- Perceptron = simplest ANN
- Softmax = multiclass
- ReLU = fastest

🌟 MODULE 5 – Uncertainty, Fuzzy, Bayesian Networks

(DETAILED + SIMPLE)

✅ 1. Why uncertainty occurs?

Because we don't always have perfect information.

Examples:

- Weather predictions
- Medical diagnosis
- Stock market
- Human behaviour

🟦 2. Non-Monotonic Reasoning (NMR)

Normal logic: once true → always true
NMR: truth can change with new info.

Example:
"Birds can fly"
But new fact: "Penguin is a bird" → cannot fly

Used for real-world reasoning.

NMR Types:

- Default Logic
- Circumscription
- Autoepistemic Logic

🟩 3. Fuzzy Logic (Simple)

Fuzzy logic deals with **partial truth**.

Example:
Is a person tall?
Height 150 cm → 0.2
Height 170 cm → 0.6
Height 190 cm → 0.9

Used in:

- AC
- Washing machine
- Fan speed controller

Uses **membership functions** (triangle, trapezoid, Gaussian etc.)

🟥 4. Probability & Bayes Theorem

Bayes helps us update our belief when new evidence comes.

Formula:
[
P(H|E)=\frac{P(E|H)P(H)}{P(E)}
]

Example:
Probability of disease increases when test is positive.

🟧 5. Bayesian Networks (BN)

BN is a **graph showing cause → effect**.

Example:

Smoking → Lung Cancer → Cough
Pollution → Lung Cancer

Components:

- Nodes = variables
- Arrows = dependencies
- CPT = Conditional Probability Table for each node

Used in:
✔ Medical diagnosis
✔ Fault detection

✔ Machine learning
✔ Decision making

🎯 MODULE 5 – Final Summary

- NMR = truth changes with new facts
- Fuzzy logic = partial truth (0 to 1)
- Probability = uncertain events
- Bayes theorem = update beliefs
- Bayesian networks = DAG of causes

Great Chandril!
Here are the FULL ANSWERS for the Expected CT-2 Question Paper I gave you.
The answers are written in simple language, exam-friendly, and exactly enough for full marks.

✅ SECTION – A (2 Marks Answers)

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1. What is Knowledge Representation?

Knowledge Representation (KR) is the method of storing knowledge inside a computer in a structured way so that the system can think, reason, and make decisions like humans.

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2. Define Knowledge-Based Agent.

A Knowledge-Based Agent is an AI agent that uses a Knowledge Base (facts + rules) and an Inference Engine to decide what action to take.
It works using TELL, ASK, ACT cycle.

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3. What is Forward Chaining?

Forward Chaining is a data-driven reasoning method where we start from facts and apply rules to reach the goal.
Example:
If A → B, and A is true → B becomes true.

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4. What is Backward Chaining?

Backward Chaining is a goal-driven reasoning method.
We start with the goal, and check what facts/rules can prove that goal.

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5. Define heuristic function in A* search.

A heuristic function h(n) is a guess of how close a node is to the goal.
It helps A* search choose the best path faster.

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6. What is Hill Climbing?

Hill Climbing is a local search method where the algorithm always moves to the next better (higher valued) state.
Problem: It may get stuck in local maxima.

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7. Define Perceptron.

A Perceptron is the simplest artificial neuron used for binary classification.
It takes inputs, multiplies with weights, applies activation, and gives output.

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8. What is an Activation Function?

Activation function decides whether a neuron should fire or not by converting the input into output.
Example: Sigmoid, ReLU, Tanh.

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9. Define Fuzzy Set.

A fuzzy set allows partial membership between 0 and 1.
Example:
Height 180 cm → Tall = 0.8 (not full true)

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10. What is Bayes Theorem?

Bayes Theorem updates probability when new evidence comes.
[
P(H|E)=\frac{P(E|H)P(H)}{P(E)}
]

✅ SECTION – B (3 Marks Answers)

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11. Explain Semantic Networks with an example.

A semantic network is a graph-based representation of knowledge.

- **Nodes = Concepts**
- **Edges = Relationships**

Example:
Animal → Bird → Sparrow
Here, Bird "is-a" Animal, Sparrow "is-a" Bird.

It supports inheritance:
If Birds can fly → Sparrow can fly.

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12. Difference between Propositional Logic & First Order Logic.

Propositional Logic	First Order Logic
Uses simple True/False statements	Represents objects & relationships
Less expressive	More expressive
Example: P = "It rains"	Example: Father(John, Alex)

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13. Explain TELL–ASK–ACT cycle.

A Knowledge-Based Agent works in this cycle:

1. **TELL: Add new percepts/information to Knowledge Base.**
2. **ASK: Agent queries KB for the best action.**
3. **ACT: Agent performs the chosen action.**

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14. Write a short note on Min–Max Algorithm.

Min-Max is used in two-player games.

- **MAX player tries to maximize score.**
- **MIN player tries to minimize score.**

It looks at all possible moves and chooses the best one.
Often used with Alpha–Beta Pruning to make it faster.

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15. Explain A* Search with formula.

A* search selects node with lowest f(n) value:
[
f(n) = g(n) + h(n)
]

- **g(n): cost so far**
- **h(n): estimated cost**

A* is both optimal and complete, if heuristic is admissible.

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16. Describe structure of an Artificial Neuron.

It has:

- **Inputs (x1, x2 …)**

- **Weights (w1, w2 …)**
- **Bias (b)**
- **Summation**
- **Activation function**
- **Output**

Formula:
[
y = f(w \cdot x + b)
]

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17. Types of activation functions.

- **Sigmoid: 0 to 1 output**
- **Tanh: –1 to +1 output**
- **ReLU: max(0, x)**
- **Softmax: used for multiclass**
- **Softplus: smooth version of ReLU**

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18. Explain Perceptron Learning Rule.

Perceptron updates its weights based on error:
[
w = w + \eta (t - o)x
]
[
b = b + \eta (t - o)
]
Where
t = target output,
o = predicted output,
η = learning rate.

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19. What is Non-Monotonic Reasoning?

Non-monotonic reasoning allows truth to change when new information comes.

Example:
Birds fly → Tweety is bird → Tweety flies
New info: Tweety is penguin → cannot fly

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20. Explain Bayesian Network.

A Bayesian Network is a graphical model (DAG) representing probabilistic relationships.

- **Nodes = Variables**
- **Edges = Causal links**
- **Each node has a CPT (Conditional Probability Table)**

Example:
Smoking → Lung Cancer → Cough

✅ SECTION – C (5 Marks Answers)

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21. Knowledge-Based Agent architecture with diagram.

A KBA has:

1. **Knowledge Base (KB): Stores facts & rules**
2. **Inference Engine: Applies logic rules**
3. **TELL–ASK–ACT system:**
    - **TELL: add percept**
    - **ASK: query best action**
    - **ACT: perform action**

Levels:

- **Knowledge Level → what agent knows**
- **Logical Level → how knowledge is represented**
- **Implementation Level → actual data structures**

Working Example:
Agent enters Wumpus World → gets percept → adds to KB → queries KB → decides safe path.

A diagram is typically:
Environment → Percept → TELL → KB ↔ Inference Engine → ASK → Action selection → ACT → Environment

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22. Forward & Backward Chaining with examples.

Forward Chaining:

- **Data-driven**
- **Starts with facts**
- **Applies rules to reach new facts**

Example:
Rule: If A → B
Fact: A
Conclusion: B

Used in Expert Systems.

Backward Chaining:

- **Goal-driven**
- **Starts with desired goal**
- **Checks rules that support goal**

Example:
Goal: B

Rule: If A → B
Check: Is A true? If yes → proven

Used in PROLOG.

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23. Single Layer vs Multi Layer Neural Network.

Single Layer NN:

- **Only input + output**
- **Can solve only linearly separable problems**
- **Uses perceptron rule**
- **Simple, fast**

Multi Layer NN:

- **Input + hidden + output**
- **Can solve complex, non-linear problems**
- **Uses backpropagation**
- **Basis of Deep Learning**

Advantages of MLNN:

- **Learns complex patterns**
- **High accuracy**
- **Used in vision, NLP, speech**

Disadvantages:

- **Slow**
- **Requires more data**
- **Hard to interpret**

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24. A* and AO* Search Algorithm.

A* Search:

- **Uses f(n) = g(n) + h(n)**
- **Optimal & complete**
- **Widely used (GPS, games)**

AO* Search:

- **Works on AND–OR graphs**
- **Used when tasks require multiple sub-tasks**
- **Finds best combination of AND & OR paths**
- **Used in expert systems and hierarchical planning**

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25. Fuzzy Logic, Membership Functions & Applications.

Fuzzy Logic:

Allows partial truth (0 to 1).
Real-world not always true/false.

Membership Functions:

- **Triangular**
- **Trapezoidal**
- **Gaussian**
- **Singleton**

Applications:

- **Air conditioners**

- **Washing machines**
- **Traffic control**
- **Robots**
- **Medical decision systems**

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26. Bayesian Networks (Structure + CPT + Example).

A Bayesian Network is:

- **A Directed Acyclic Graph (DAG)**
- **Nodes represent variables**
- **Edges show cause → effect**
- **Each node has a CPT showing probability of the node given its parents**

Example:

Smoking → Lung Cancer → Cough
Pollution → Lung Cancer

CPT Example:

Lung Cancer	Smoking	Pollution	P
Yes	Yes	High	0.8
Yes	No	Low	0.2
No	Yes	High	0.4

Used for diagnosis, prediction, risk analysis.