SCHEME OF EVALUATION

III/IV B.Tech., **Sixth** -Sem. Regular Degree Examination
Electronics and Communication Engineering

Artificial Intelligence

[20ECJ22]

Prepared by

P. Sumanth Kumar
Assistant Professor
Department of ECE

Verified by

Dr. B. Chandra Mohan
Prof. & Head
Department of ECE

20ECJ22

Hall Ticket Number:

III/IV B.Tech (Regular) DEGREE EXAMINATION

July/August, 2023 — **Electronics & Communication Engineering**

Sixth Semester — **Artificial Intelligence**

Time: Three Hours — **Maximum:** 70 Marks

Answer question 1 compulsory. **(14X1 = 14Marks)**

Answer one question from each unit. **(4X14=56 Marks)**

			CO	BL	M
1	a)	List various applications of AI.	CO1	L1	1M
	b)	What are the different types of problem?	CO1	L1	1M
	c)	What are the components of state space search?	CO1	L1	1M
	d)	List different problem characteristics.	CO1	L1	1M
	e)	What do you mean of intelligent?	CO2	L1	1M
	f)	Define agent.	CO2	L1	1M
	g)	What is called informed search?	CO2	L1	1M
	h)	Differentiate blind search and heuristic search.	CO2	L4	1M
	i)	List various search strategies.	CO2	L1	1M
	j)	Why does uncertainty arise?	CO3	L1	1M
	k)	What is knowledge?	CO3	L1	1M
	l)	What is semantic network?	CO3	L1	1M
	m)	Write two real world applications of expert systems.	CO4	L3	1M
	n)	What is NLTK used for?	CO4	L1	1M
		Unit-I			
2	a)	Discuss the risks and benefits of artificial intelligence.	CO1	L2	7M
	b)	Write a short note on data acquisition and learning aspects in AI.	CO1	L3	7M
		(OR)			
3	a)	Define problem. Explain the state space representation method of a problem with an example.	CO1	L2	7M
	b)	Describe uninformed search strategies with example.	CO1	L2	7M
		Unit-II			
4	a)	Explain Hill Climbing algorithm with an example.	CO2	L2	7M
	b)	Derive the proof of optimality of A* searching algorithm.	CO2	L4	7M
		(OR)			
5	a)	Explain in detail about intelligent agents.	CO2	L2	4M
	b)	Write short note on Agent types and agent program.	CO2	L3	10M
		Unit-III			
6	a)	What are the properties of knowledge based system? Describe various knowledge representation techniques.	CO3	L2	7M
	b)	Explain semantic networks for knowledge representation.	CO3	L2	7M
		(OR)			
7	a)	What is predicate logic? Explain the predicate logic representation with reference to suitable example.	CO3	L2	7M
	b)	Explain the concept of frames as a knowledge representation technique in AI.	CO3	L5	7M
		Unit-IV			
8	a)	Explain the basic components of an expert system.	CO4	L2	7M
	b)	Compare and contrast expert system and traditional system.	CO4	L4	7M
		(OR)			
9	a)	Write the characteristic features of expert system.	CO4	L3	7M
	b)	Write a brief summary on expert system shell.	CO4	L6	7M

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			CO	BL	M
1	a)	List various applications of AI.	CO1	L1	1M

Ans:

Artificial Intelligence has various applications in today's society. It is becoming essential for today's time because it can solve complex problems with an efficient way in multiple industries, such **as Healthcare, entertainment, finance, education, etc. AI is making our daily life more comfortable and fast.**

b) What are the different types of problem? CO1 L1 1M

Ans:

There are basically four types of problem in artificial intelligence:

1. Deterministic or observable
2. Non observable
3. Non Deterministic or partially observable
4. Unknown state space

c) What are the components of state space search? CO1 L1 1M

Ans:

It takes four arguments:

1. A list of valid starting states
2. A predicate to decide if we have reached a goal state
3. A function to generate the successors of a state
4. A function that decides in what order to search.

d) List different problem characteristics. CO1 L1 1M

Ans:

To choose an appropriate method for a particular problem first we need to categorize the problem based on the following characteristics.

1. Is the problem decomposable into small sub-problems which are easy to solve?
2. Can solution steps be ignored or undone?
3. Is the universe of the problem is predictable?
4. Is a good solution to the problem is absolute or relative?
5. Is the solution to the problem a state or a path?
6. What is the role of knowledge in solving a problem using artificial intelligence?
7. Does the task of solving a problem require human interaction?

e) What do you mean of intelligent? CO2 L1 1M

Ans:

The ability of a system to calculate, reason, perceive relationships and analogies, learn from experience, store and retrieve information from memory, solve problems, comprehend complex ideas, use natural language fluently, classify, generalize, and adapt new situations.

f) Define agent. CO2 L1 1M

Ans:

An “agent” is an independent program or entity that interacts with its environment by perceiving its surroundings via sensors, then acting through actuators or effectors.

g) What is called informed search? CO2 L1 1M

Ans:

Informed Search

- A search using **domain-specific knowledge**.
- Suppose that we have a way to estimate how close a state is to the goal, with an **evaluation function**.
- General strategy: expand the best state in the open list first. It's called a **best-first search** or **ordered state-space search**.
- In general the evaluation function is imprecise, which makes the method a **heuristic** (works well in most cases).
- The evaluation is often based on **empirical observations**.

h) Differentiate blind search and heuristic search. CO2 L4 1M

Ans:

A blind such is usually uninformed. That is, it doesn’t have any specific knowledge about the problem whereas a heuristic search is that which has information about the problem and therefore uses logic in decision making.

i) List various search strategies. CO2 L1 1M

Ans:

Search algorithms in artificial intelligence are classified into two types: informed algorithms and uninformed algorithms.
Breadth-first, depth-first, and uniform-cost algorithms are examples of uninformed algorithms. Greedy, A* tree and AO* graph algorithms are examples of informed algorithms.

j) Why does uncertainty arise? CO3 L1 1M

Ans:

It arises due to incomplete or incorrect information or a lack of understanding of a system.
In AI, epistemic uncertainty is encountered when the system does not have complete knowledge of a situation, and the outcome is unknown.

k) What is knowledge? CO3 L1 1M

Ans:

Facts, information, and skills acquired through experience or education.

l) What is semantic network? CO3 L1 1M

Ans:

In artificial intelligence, a semantic network is a knowledge representation technique for organizing and storing knowledge. Semantic networks are a type of graphical model that shows the relationships between concepts, ideas, and objects in a way that is easy for humans to understand. The nodes in a semantic network are concepts, and the edges between nodes represent the relationships between those concepts. Semantic networks are used to represent both simple and complex knowledge structures.

m) Write two real world applications of expert systems. CO4 L3 1M

Ans:

Expert systems that are in use include the following examples:

1. CaDet (Cancer Decision Support Tool) is used to identify cancer in its earliest stages.
2. DENDRAL helps chemists identify unknown organic molecules. DXplain is a clinical support system that diagnoses various diseases.

n) What is NLTK used for? CO4 L1 1M

Ans:

The Natural Language Toolkit (NLTK) is a platform used for building Python programs that work with human language data for applying in statistical natural language processing (NLP). It contains text processing libraries for tokenization, parsing, classification, stemming, tagging and semantic reasoning.

Unit-I

2 a) Discuss the risks and benefits of artificial intelligence. CO1 L2 7M

Ans:

Benefits of Artificial Intelligence [3.5 marks]

AI machines use machine learning algorithms to mimic the cognitive abilities of human beings and solve simple or complex problems.

1. **Increase work efficiency**

AI-powered machines are great at doing a particular repetitive task with amazing efficiency. The simple reason is that they remove human errors from their tasks to achieve accurate results every time they do that specific task.

Moreover, such machines can work 24X7, unlike humans. Thus, they eliminate the need to deploy two sets of employees working in day and night shifts to work on important tasks. For example, AI-powered chat assistants can answer customer queries and provide support to visitors every minute of the day and boost the sales of a company.

2. **Work with high accuracy**

Scientists are working to teach artificial intelligence-powered machines to solve complex equations and perform critical tasks on their own so that the results obtained have higher accuracy as compared to their human counterparts.

Their high accuracy has made these machines indispensable to work in the medical field particularly, owing to the criticality of the tasks. Robots are getting better at diagnosing serious conditions in the human body and performing delicate surgeries to minimize the risk to human lives.

3. **Reduce the cost of training and operation**

AI uses machine learning algorithms like Deep Learning and neural networks to learn new things like humans do. This way they eliminate the need to write new code every time we need them to learn new things.

There is significant Research and Development going on in the world to develop AI machines that optimize their machine-learning abilities so that they learn much faster about new processes. This way the cost of training robots would become much lesser than that of humans. Moreover, machines already reduce the cost of operations with their high efficiency and accuracy of doing work. For example, machines don't take breaks and can perform the same mundane task again and again without any downtime or change in results.

4. **Improve Processes**

The best part about AI-powered machines being deployed for work is that they let us gather humongous amounts of data related to their work. Such data can be processed to gather deep insights into the processes with quantitative analysis so that we can optimize them even further.

Machine learning abilities of AI machines are increasing further and further to do even the analysis by themselves.

Risks of Artificial Intelligence [3.5 Marks]

Although hailed as a boon for humanity by tech pundits, artificial intelligence is feared by a lot of scientists and regular citizens alike. This fear has made it to the silver screen several times in the form of movies depicting dystopian futures created by AI machines that took over the planet. The most notable of these is The Matrix and The Terminator.

AI is Unsustainable

Intelligent machines have characteristically high computing powers contributed by an array of several processers. These computer chips have rare earth materials like **Selenium** as a major constituent. Besides, the batteries of such machines run on **Lithium**, again a rare element in Earth's crust. The increased mining of these materials is irreversibly **damaging our environment** at a rapid pace. Moreover, they consume huge amounts of power to function, that is putting severe pressure on our power plants and again harming the environment.

Lesser Jobs

There is no doubt that machines do routine and repeatable tasks much better than humans. Many businesses would prefer machines instead of humans to increase their profitability, thus reducing the jobs that are available for the human workforce.

A threat to Humanity(?)

Elon Musk is considered to be one of the smartest people working on AI in present times. He has also stated publicly that AI is the biggest threat to human civilization in the future. This means that the dystopian future that sci-fi movies show is not impossible. Also, **Stephen Hawking** has always shown his disagreement with the advancement in the field of AI.
The biggest risk associated with AI is that machines would gain sentience and turn against humans in case they go rogue.

b) Write a short note on data acquisition and learning aspects in AI. CO1 L3 7M

Ans:

Data acquisition and learning aspects in AI **[Theory 7 Marks]**

Data acquisition meaning is to collect data from relevant sources before it can be stored, cleaned, preprocessed, and used for further mechanisms. It is the process of retrieving relevant business information, transforming the data into the required business form, and loading it into the designated system.

- Knowledge discovery and learning aspects of AI
- Data is nothing but extraction of meaningful information that is previously unknown.
- Main concern of data mining is data analysis and use of suitable techniques and to identify and recognise the patterns to give good prediction.

(OR)

3 a) Define problem. Explain the state space representation method of a problem with an example. CO1 L2 7M

Ans:

Problem: [1 Mark]

It is the question which is to be solved. For solving the problem it needs to be precisely defined. The definition means, defining the start state, goal state, other valid states and transitions.

AI Problem Representation

Before the gathering of relevant information for the problem, we need to first define and represent the problem in a very precise manner. This is done using one of the commonly used approaches to represent a problem in AI. These are:

- State Space Representation
- Problem Reduction

Now, let us have a closer look at the approaches.

State Space Representation [6 marks]

The state space of a problem can be defined as the set of all possible states in which a problem can be

represented and solved.

The method of State Space Representation involves the process of defining the state space, defining the start and the goal states, and searching for a path from the start state to the goal state across this state space.

The state space hence forms a graph or tree, where states are represented as nodes and the arcs connecting the nodes represents the actions. The method of search for the goal state from the start state is governed by a set of rules known as the **production rules**.

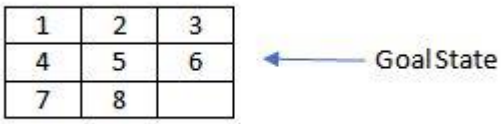
Hence, a state space consists of the following:

- Set of States
- Starting State
- Set of Actions and an Action Function
- Set of Goal States
- Criteria to check the quality of the acceptable solution (optional)

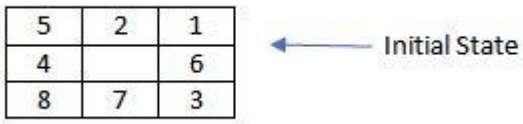
Example of State Space Representation

To understand the concept in a better manner, let us consider an example to solve the 8-puzzle. 8-puzzle is a tile puzzle which consists of numbers from 1-8 arranged in a 3 * 3 cube. One of the squares of the cube is empty which facilitates the motion of the squares numbered 1 to 8.

The aim of the puzzle is to reach the goal state where the numbers are arranged in an ascending order. i.e., as follows



From a state where the numbers 1 to 8 are jumbled i.e.,

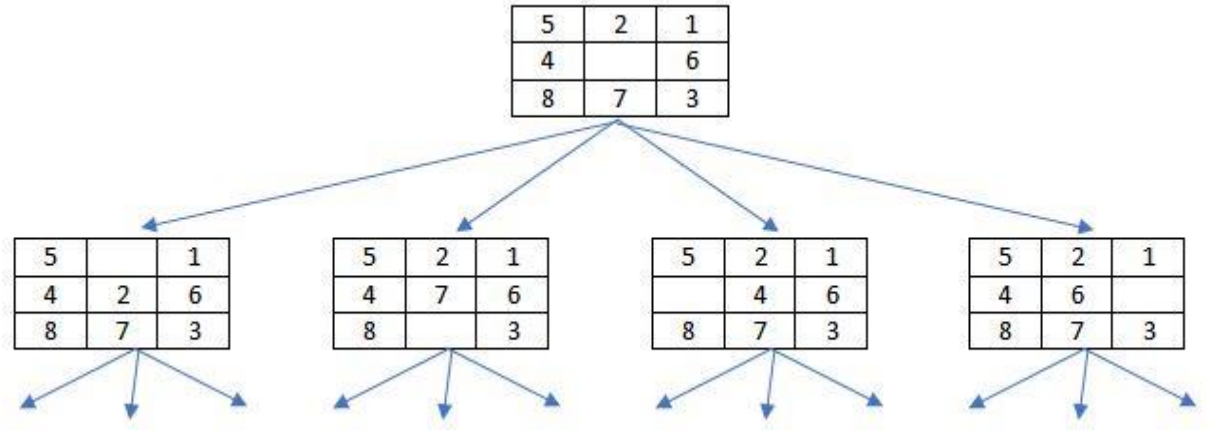


Now, a standard problem formulation of the above will be as follows:

- **States**–It is a set of all possible states where the location of the blank tile and the numbers will differ in each specific state.
- **Initial State –** The state from where the problem starts is its initial state.
- **Goal State –** The state to be reached is the goal state.
- **Legal Moves –** These are the rules which will be followed in order to reach the goal state. Here, the moves which are termed as legal are:
  - Blank square moves Left
  - Blank square moves Right
  - Blank square moves Up
  - Blank square moves Down
- **Cost of Path –** If we assume a cost of 1 here then the cost of the path will be the number of

steps taken in order to reach the goal state.

Now, have a look at a part of the state space representation tree:



This will extend on and on till all the states are represented.

Advantages of State Space Representation

State Space Search has the following advantages:

1. It defines a set of all possible states, operations and goal states.
2. It helps us to trace the path taken starting from the initial state to the goal state. This helps us in identifying or tracing the sequence of operations required in reaching till the goal state.

Disadvantages of State Space Representation

State Space Search has the following disadvantages:

1. It is practically impossible to explore all the states for a given problem.
2. Due to the huge combinational states in the state space, we need a high amount of CPU resources for the computer system to handle the load efficiently.

b) Describe uninformed search strategies with example. CO1 L2 7M

Ans:

Uninformed Search Algorithms [1 mark]

Uninformed search is a class of general-purpose search algorithms which operates in brute force-way. Uninformed search algorithms do not have additional information about state or search space other than how to traverse the tree, so it is also called blind search.

Following are the various types of uninformed search algorithms:

1. **Breadth-first Search [1 mark]**

Breadth-first search is the most common search strategy for traversing a tree or graph. This

algorithm searches breadthwise in a tree or graph, so it is called breadth-first search.

BFS algorithm starts searching from the root node of the tree and expands all successor node at the current level before moving to nodes of next level.

The breadth-first search algorithm is an example of a general-graph search algorithm.

Breadth-first search implemented using FIFO queue data structure.

2. **Depth-first Search [1 mark]**

Depth-first search isa recursive algorithm for traversing a tree or graph data structure.

It is called the depth-first search because it starts from the root node and follows each path to its greatest depth node before moving to the next path.

DFS uses a stack data structure for its implementation.

The process of the DFS algorithm is similar to the BFS algorithm.

3. **Depth-limited Search [1 mark]**

A depth-limited search algorithm is similar to depth-first search with a predetermined limit. Depth-limited search can solve the drawback of the infinite path in the Depth-first search. In this algorithm, the node at the depth limit will treat as it has no successor nodes further.

Depth-limited search can be terminated with two Conditions of failure:

Standard failure value: It indicates that problem does not have any solution.

Cutoff failure value: It defines no solution for the problem within a given depth limit.

4. **Iterative deepening depth-first search [1 mark]**

The iterative deepening algorithm is a combination of DFS and BFS algorithms. This search algorithm finds out the best depth limit and does it by gradually increasing the limit until a goal is found.

This algorithm performs depth-first search up to a certain "depth limit", and it keeps increasing the depth limit after each iteration until the goal node is found.

This Search algorithm combines the benefits of Breadth-first search's fast search and depth-first search's memory efficiency.

The iterative search algorithm is useful uninformed search when search space is large, and depth of goal node is unknown.

5. Uniform cost search [1 mark]

Uniform-cost search is a searching algorithm used for traversing a weighted tree or graph. This algorithm comes into play when a different cost is available for each edge. The primary goal of the uniform-cost search is to find a path to the goal node which has the lowest cumulative cost. Uniform-cost search expands nodes according to their path costs form the root node. It can be used to solve any graph/tree where the optimal cost is in demand. A uniform-cost search algorithm is implemented by the priority queue. It gives maximum priority to the lowest cumulative cost. Uniform cost search is equivalent to BFS algorithm if the path cost of all edges is the same.

6. Bidirectional Search [1 mark]

Bidirectional search algorithm runs two simultaneous searches, one form initial state called as forward-search and other from goal node called as backward-search, to find the goal node. Bidirectional search replaces one single search graph with two small subgraphs in which one starts the search from an initial vertex and other starts from goal vertex. The search stops when these two graphs intersect each other.

Bidirectional search can use search techniques such as BFS, DFS, DLS, etc.

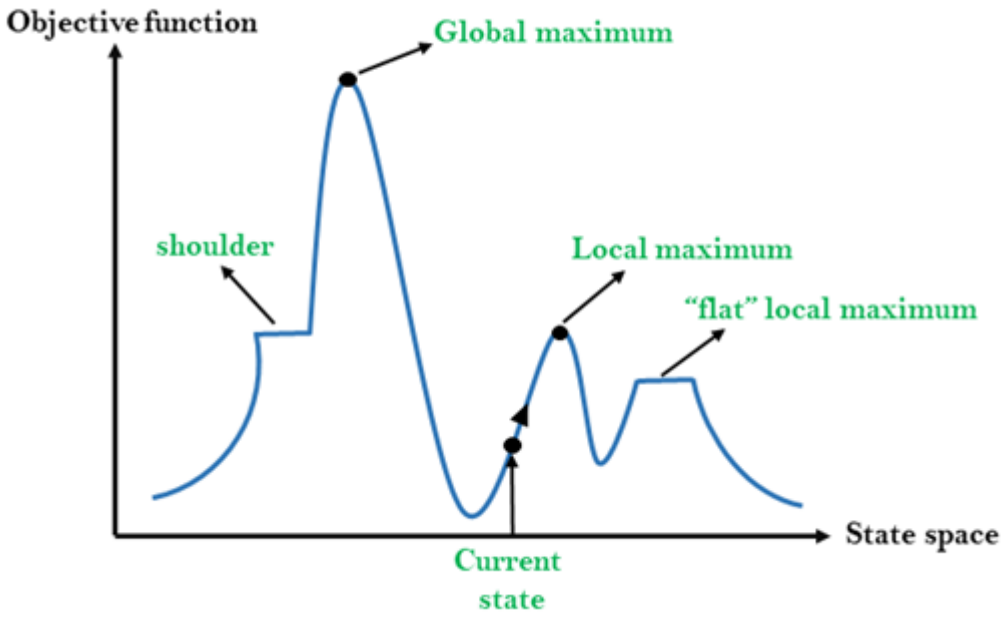
Unit-II

4 a) Explain Hill Climbing algorithm with an example. CO2 L2 7M

Ans: **Theory [4 marks]**

- Hill climbing algorithm is a local search algorithm which continuously moves in the direction of increasing elevation/value to find the peak of the mountain or best solution to the problem. It terminates when it reaches a peak value where no neighbor has a higher value.
- Hill climbing algorithm is a technique which is used for optimizing the mathematical problems. One of the widely discussed examples of Hill climbing algorithm is Traveling-salesman Problem in which we need to minimize the distance traveled by the salesman.
- It is also called greedy local search as it only looks to its good immediate neighbor state and not beyond that.
- A node of hill climbing algorithm has two components which are state and value.
- Hill Climbing is mostly used when a good heuristic is available.
- In this algorithm, we don't need to maintain and handle the search tree or graph as it only keeps a single current state.

Diagram [3 marks]



b) Derive the proof of optimality of A* searching algorithm. CO2 L4 7M

Ans:

A* Algorithm-

- A* Algorithm is one of the best and popular techniques used for path finding and graph traversals.
- A lot of games and web-based maps use this algorithm for finding the shortest path efficiently.
- It is essentially a best first search algorithm.

A* Algorithm works as- **[working 2 Marks]**

- It maintains a tree of paths originating at the start node.
- It extends those paths one edge at a time.
- It continues until its termination criterion is satisfied.

A* Algorithm extends the path that minimizes the following function-

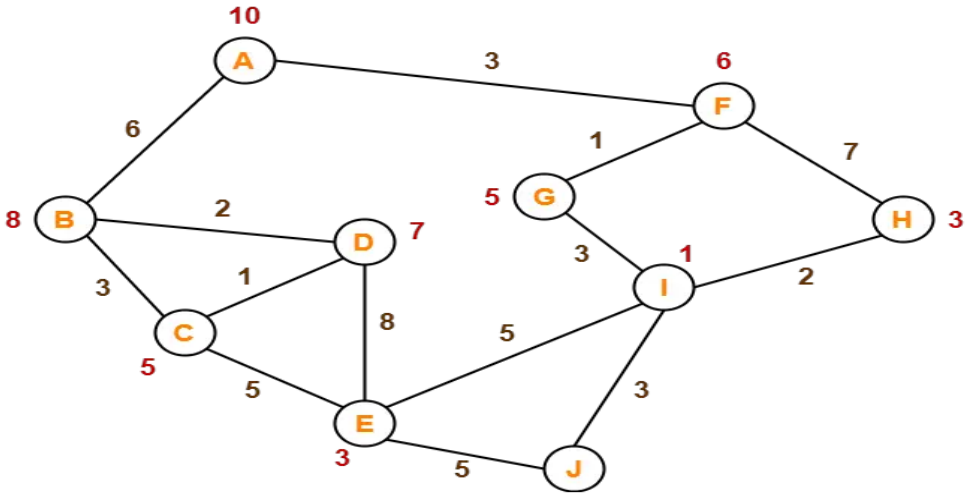
$$f(n) = g(n) + h(n)$$

Here,

- 'n' is the last node on the path
- g(n) is the cost of the path from start node to node 'n'
- h(n) is a heuristic function that estimates cost of the cheapest path from node 'n' to the goal node

Example **[6 Marks]**

Consider the following graph-



The numbers written on edges represent the distance between the nodes.

The numbers written on nodes represent the heuristic value.

Find the most cost-effective path to reach from start state A to final state J using A* Algorithm.

Solution-

Step-01:

- We start with node A.
- Node B and Node F can be reached from node A.

A* Algorithm calculates f(B) and f(F).

- f(B) = 6 + 8 = 14
- f(F) = 3 + 6 = 9

Since f(F) < f(B), so it decides to go to node F.

Path- A → F

Step-02:

Node G and Node H can be reached from node F.

A* Algorithm calculates f(G) and f(H).

- f(G) = (3+1) + 5 = 9
- f(H) = (3+7) + 3 = 13

Since f(G) < f(H), so it decides to go to node G.

Path- A → F → G

Step-03:

Node I can be reached from node G.

A* Algorithm calculates f(I).

f(I) = (3+1+3) + 1 = 8

It decides to go to node I.

Path- A → F → G → I

Step-04:

Node E, Node H and Node J can be reached from node I.

A* Algorithm calculates f(E), f(H) and f(J).

- f(E) = (3+1+3+5) + 3 = 15
- f(H) = (3+1+3+2) + 3 = 12
- f(J) = (3+1+3+3) + 0 = 10

Since f(J) is least, so it decides to go to node J.

Path- A → F → G → I → J

This is the required shortest path from node A to node J.

(OR)

5 a) Explain in detail about intelligent agents. CO2 L2 4M

Ans:

Theory [4 Marks]

Agents in Artificial Intelligence

An AI system can be defined as the study of the rational agent and its environment. The agents sense the environment through sensors and act on their environment through actuators. An AI agent can have mental properties such as knowledge, belief, intention, etc.

What is an Agent?

An agent can be anything that perceiveits environment through sensors and act upon that environment

through actuators. An Agent runs in the cycle of **perceiving**, **thinking**, and **acting**. An agent can be:

- **Human-Agent:** A human agent has eyes, ears, and other organs which work for sensors and hand, legs, vocal tract work for actuators.
- **Robotic Agent:** A robotic agent can have cameras, infrared range finder, NLP for sensors and various motors for actuators.
- **Software Agent:** Software agent can have keystrokes, file contents as sensory input and act on those inputs and display output on the screen.

Hence the world around us is full of agents such as thermostat, cellphone, camera, and even we are also agents.

Before moving forward, we should first know about sensors, effectors, and actuators.

Sensor: Sensor is a device which detects the change in the environment and sends the information to other electronic devices. An agent observes its environment through sensors.

Actuators: Actuators are the component of machines that converts energy into motion. The actuators are only responsible for moving and controlling a system. An actuator can be an electric motor, gears, rails, etc.

Effectors: Effectors are the devices which affect the environment. Effectors can be legs, wheels, arms, fingers, wings, fins, and display screen.

Intelligent Agents:

An intelligent agent is an autonomous entity which act upon an environment using sensors and actuators for achieving goals. An intelligent agent may learn from the environment to achieve their goals. A thermostat is an example of an intelligent agent.

Following are the main four rules for an AI agent:

- **Rule 1:** An AI agent must have the ability to perceive the environment.
- **Rule 2:** The observation must be used to make decisions.
- **Rule 3:** Decision should result in an action.
- **Rule 4:** The action taken by an AI agent must be a rational action.

b) Write short note on Agent types and agent program. CO2 L3 10M

Ans:

Types of AI Agents

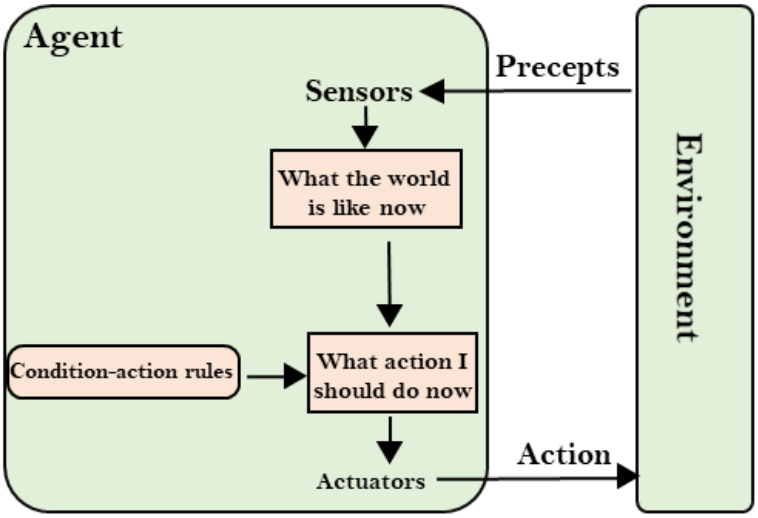
Agents can be grouped into five classes based on their degree of perceived intelligence and capability. All these agents can improve their performance and generate better action over the time. These are given below:

- Simple Reflex Agent [2 marks]
- Model-based reflex agent [2 marks]
- Goal-based agents [2 marks]

- Utility-based agent [2 marks]
- Learning agent [2 marks]

1. Simple Reflex agent:

- The Simple reflex agents are the simplest agents. These agents take decisions on the basis of the current percepts and ignore the rest of the percept history.
- These agents only succeed in the fully observable environment.
- The Simple reflex agent does not consider any part of percepts history during their decision and action process.
- The Simple reflex agent works on Condition-action rule, which means it maps the current state to action. Such as a Room Cleaner agent, it works only if there is dirt in the room.
- Problems for the simple reflex agent design approach:
  - They have very limited intelligence
  - They do not have knowledge of non-perceptual parts of the current state
  - Mostly too big to generate and to store.
  - Not adaptive to changes in the environment.



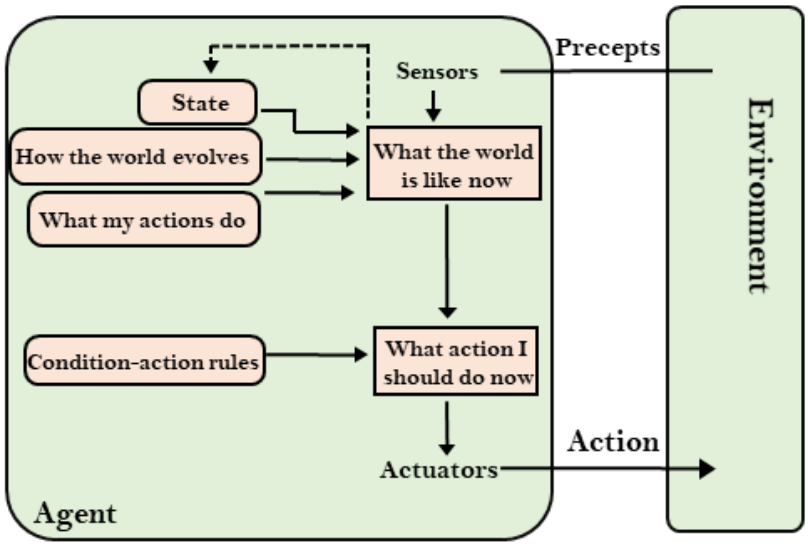
2. Model-based reflex agent

- The Model-based agent can work in a partially observable environment, and track the situation.
- A model-based agent has two important factors:
  - **Model:** It is knowledge about "how things happen in the world," so it is called a Model-based agent.
  - **Internal State:** It is a representation of the current state based on percept history.

- These agents have the model, "which is knowledge of the world" and based on the model they perform actions.
- Updating the agent state requires information about:

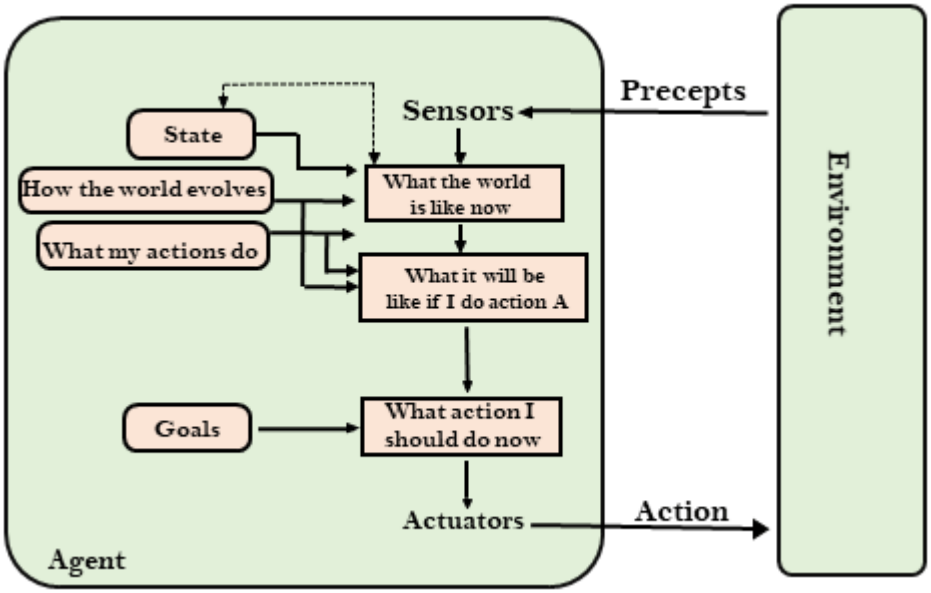
a. How the world evolves

b. How the agent's action affects the world.



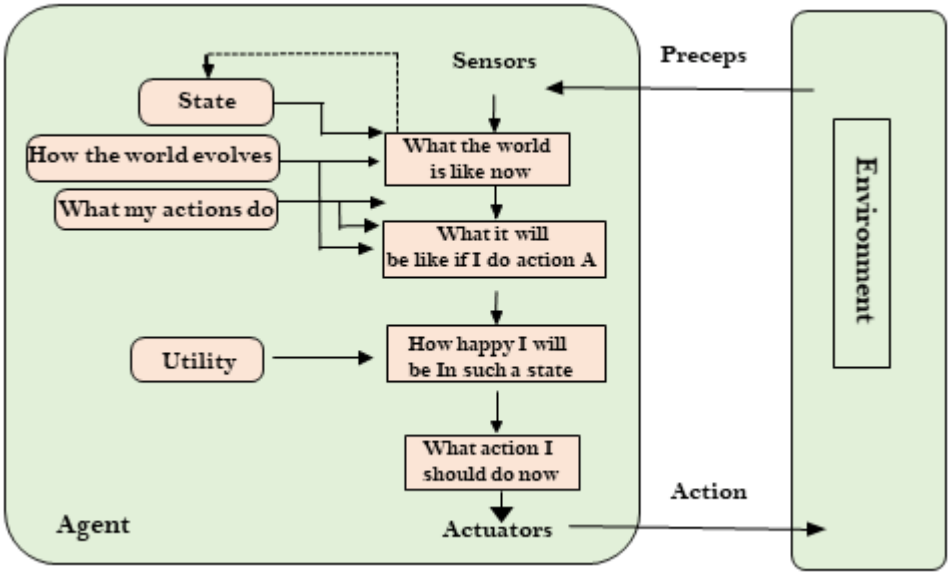
3. Goal-based agents

- The knowledge of the current state environment is not always sufficient to decide for an agent to what to do.
- The agent needs to know its goal which describes desirable situations.
- Goal-based agents expand the capabilities of the model-based agent by having the "goal" information.
- They choose an action, so that they can achieve the goal.
- These agents may have to consider a long sequence of possible actions before deciding whether the goal is achieved or not. Such considerations of different scenario are called searching and planning, which makes an agent proactive.



Utility-based agents

- These agents are similar to the goal-based agent but provide an extra component of utility measurement which makes them different by providing a measure of success at a given state.
- Utility-based agent act based not only goals but also the best way to achieve the goal.
- The Utility-based agent is useful when there are multiple possible alternatives, and an agent has to choose in order to perform the best action.
- The utility function maps each state to a real number to check how efficiently each action achieves the goals.



5. Learning Agents

- A learning agent in AI is the type of agent which can learn from its past experiences, or it has learning capabilities.
- It starts to act with basic knowledge and then able to act and adapt automatically through learning.

- A learning agent has mainly four conceptual components, which are:

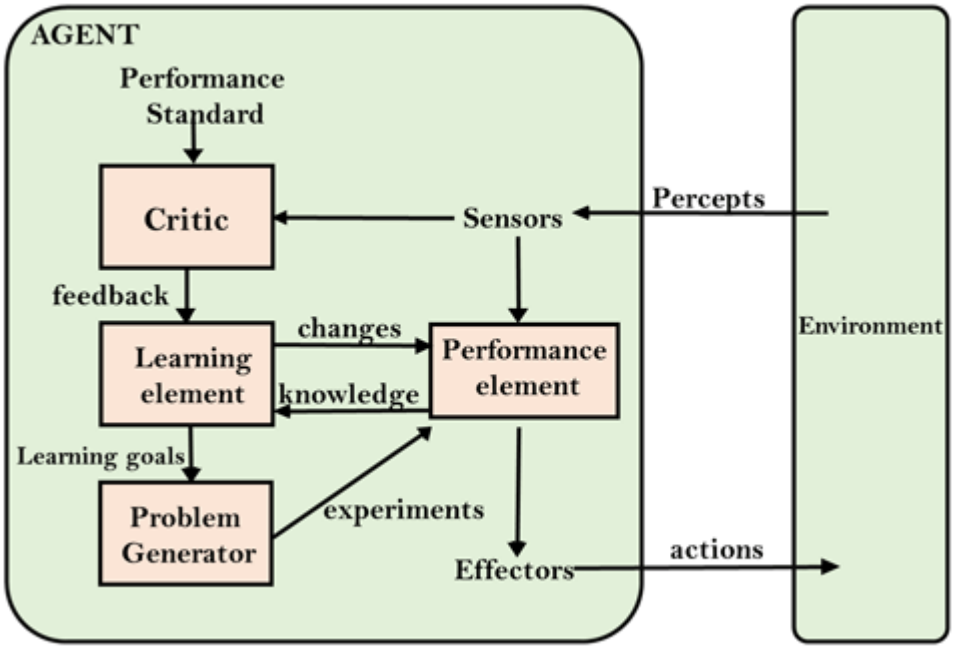
a. **Learning element:** It is responsible for making improvements by learning from environment

b. **Critic:** Learning element takes feedback from critic which describes that how well the agent is doing with respect to a fixed performance standard.

c. **Performance element:** It is responsible for selecting external action

d. **Problem generator:** This component is responsible for suggesting actions that will lead to new and informative experiences.

- Hence, learning agents are able to learn, analyze performance, and look for new ways to improve the performance.



Unit-III

6 a) What are the properties of knowledge based system? Describe various knowledge representation techniques. CO3 L2 7M

Ans:

Properties for knowledge Representation [2 marks]

The following properties should be possessed by a knowledge representation system.

a. **Representational Adequacy:** It is the ability to represent the required knowledge.

b. **Inferential Adequacy:** It is the ability to manipulate the knowledge represented to produce new knowledge corresponding to that inferred from the original.

c. **Inferential Efficiency:** The ability to direct the inferential mechanisms into the most productive directions by storing appropriate guides.

d. **Acquisitional Efficiency:** The ability to acquire new knowledge using automatic methods wherever possible rather than reliance on human intervention.

Various knowledge representation techniques are **[5 marks]**

1. Propositional logic
2. Predicate logic/ first order logic
3. Semantic Networks
4. Frames
5. Scripts

b) Explain semantic networks for knowledge representation. CO3 L2 7M

Ans:

Semantic Network Representation **[Theory 5 Marks, Example 3 Marks]**

Semantic networks are alternative of predicate logic for knowledge representation. In Semantic networks, we can represent our knowledge in the form of graphical networks. This network consists of nodes representing objects and arcs which describe the relationship between those objects. Semantic networks can categorize the object in different forms and can also link those objects. Semantic networks are easy to understand and can be easily extended.

This representation consist of mainly two types of relations:

a. IS-A relation (Inheritance)

b. Kind-of-relation

Example: Following are some statements which we need to represent in the form of nodes and arcs.

Statements:

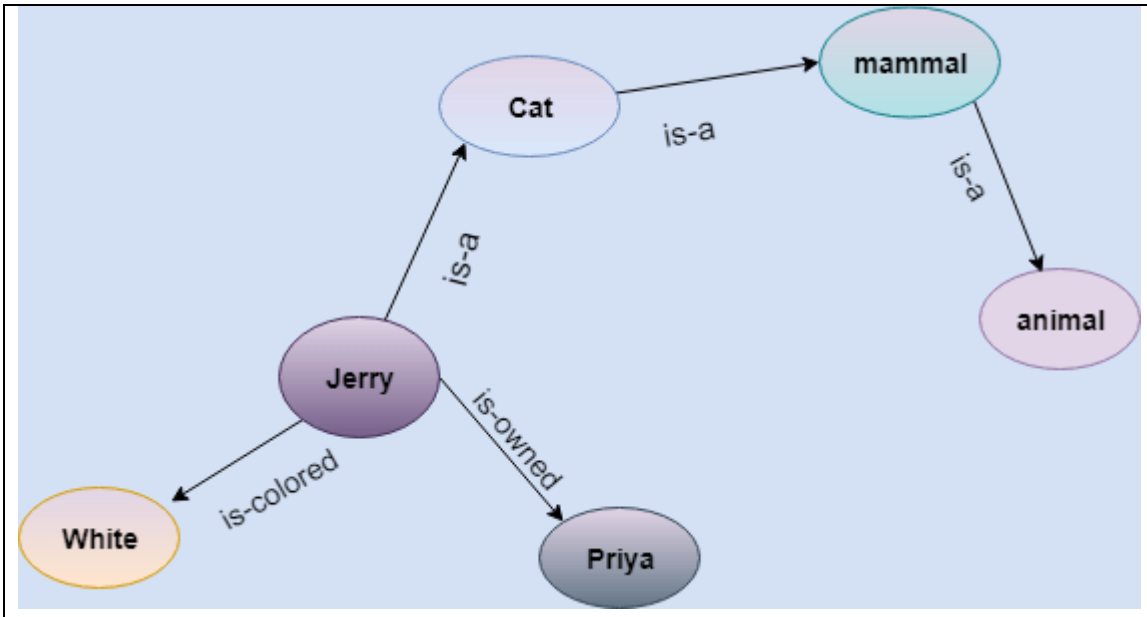
a. Jerry is a cat.

b. Jerry is a mammal

c. Jerry is owned by Priya.

d. Jerry is brown colored.

e. All Mammals are animal.



In the above diagram, we have represented the different type of knowledge in the form of nodes and arcs. Each object is connected with another object by some relation.

Drawbacks in Semantic representation:

1. Semantic networks take more computational time at runtime as we need to traverse the complete network tree to answer some questions. It might be possible in the worst case scenario that after traversing the entire tree, we find that the solution does not exist in this network.
2. Semantic networks try to model human-like memory (Which has 1015 neurons and links) to store the information, but in practice, it is not possible to build such a vast semantic network.
3. These types of representations are inadequate as they do not have any equivalent quantifier, e.g., for all, for some, none, etc.
4. Semantic networks do not have any standard definition for the link names.
5. These networks are not intelligent and depend on the creator of the system.

Advantages of Semantic network:

1. Semantic networks are a natural representation of knowledge.
2. Semantic networks convey meaning in a transparent manner.
3. These networks are simple and easily understandable.

(OR)

7 a) What is predicate logic? Explain the predicate logic representation with reference to suitable example. CO3 L2 7M

Ans:

First-Order Logic in Artificial intelligence **[definition 1 Mark, Theory 4 Marks, Example 2 Marks]**

In the topic of Propositional logic, we have seen that how to represent statements using propositional logic. But unfortunately, in propositional logic, we can only represent the facts, which are either true or false. PL is not sufficient to represent the complex sentences or natural language statements. The propositional logic has very limited expressive power. Consider the following sentence, which we

cannot represent using PL logic.

- **"Some humans are intelligent", or**
- **"Sachin likes cricket."**

To represent the above statements, PL logic is not sufficient, so we required some more powerful logic, such as first-order logic.

First-Order logic:

- First-order logic is another way of knowledge representation in artificial intelligence. It is an extension to propositional logic.
- FOL is sufficiently expressive to represent the natural language statements in a concise way.
- First-order logic is also known as **Predicate logic or First-order predicate logic**. First-order logic is a powerful language that develops information about the objects in a more easy way and can also express the relationship between those objects.
- First-order logic (like natural language) does not only assume that the world contains facts like propositional logic but also assumes the following things in the world:
  - **Objects:** A, B, people, numbers, colors, wars, theories, squares, pits, wumpus, ...
  - **Relations: It can be unary relation such as:** red, round, is adjacent, **or n-any relation such as:** the sister of, brother of, has color, comes between
  - **Function:** Father of, best friend, third inning of, end of, ...
- As a natural language, first-order logic also has two main parts:
  a. **Syntax**
  b. **Semantics**

Syntax of First-Order logic:

The syntax of FOL determines which collection of symbols is a logical expression in first-order logic. The basic syntactic elements of first-order logic are symbols. We write statements in short-hand notation in FOL.

1. All birds fly.

In this question the predicate is "fly(bird)."

And since there are all birds who fly so it will be represented as follows.

$\forall x \text{ bird}(x) \rightarrow \text{fly}(x)$.

2. Every man respects his parent.

In this question, the predicate is "respect(x, y)," where x=man, and y= parent.

Since there is every man so will use ∀, and it will be represented as follows:

$\forall x \text{ man}(x) \rightarrow \text{respects}(x, \text{parent})$.

3. Some boys play cricket.

In this question, the predicate is "play(x, y)," where x= boys, and y= game. Since there are some boys so we will use ∃, and it will be represented as:

$\exists x \text{ boys}(x) \rightarrow \text{play}(x, \text{cricket})$.

4. Not all students like both Mathematics and Science.

In this question, the predicate is "like(x, y)," where x= student, and y= subject.

Since there are not all students, so we will use ∀ with negation, so following representation for this:

$\neg\forall (x) [\text{ student}(x) \rightarrow \text{like}(x, \text{Mathematics}) \wedge \text{like}(x, \text{Science})]$.

5. Only one student failed in Mathematics.

In this question, the predicate is "failed(x, y)," where x= student, and y= subject.

Since there is only one student who failed in Mathematics, so we will use following representation for this:

$\exists(x) [\text{ student}(x) \rightarrow \text{failed } (x, \text{Mathematics}) \wedge\forall (y) [\neg(x==y) \wedge \text{student}(y) \rightarrow \neg\text{failed } (x, \text{Mathematics})]$.

b) Explain the concept of frames as a knowledge representation technique in AI. CO3 L5 7M

Ans:

Frame Representation [Theory 4 Marks , examples 3 marks]

A frame is a record like structure which consists of a collection of attributes and its values to describe an entity in the world. Frames are the AI data structure which divides knowledge into substructures by representing stereotypes situations. It consists of a collection of slots and slot values. These slots may be of any type and sizes. Slots have names and values which are called facets.

Facets: The various aspects of a slot is known as **Facets**. Facets are features of frames which enable us to put constraints on the frames. Example: IF-NEEDED facts are called when data of any particular slot is needed. A frame may consist of any number of slots, and a slot may include any number of facets and facets may have any number of values. A frame is also known as **slot-filter knowledge representation** in artificial intelligence.

Frames are derived from semantic networks and later evolved into our modern-day classes and objects. A single frame is not much useful. Frames system consist of a collection of frames which are connected. In the frame, knowledge about an object or event can be stored together in the knowledge base. The frame is a type of technology which is widely used in various applications including Natural language processing and machine visions.

Example: 1

Let's take an example of a frame for a book

Slots	Filters
Title	Artificial Intelligence
Genre	Computer Science
Author	Peter Norvig
Edition	Third Edition
Year	1996
Page	1152

Example 2:

Let's suppose we are taking an entity, Peter. Peter is an engineer as a profession, and his age is 25, he lives in city London, and the country is England. So following is the frame representation for this:

Slots	Filter
Name	Peter
Profession	Doctor
Age	25
Marital status	Single
Weight	78

Advantages of frame representation:

1. The frame knowledge representation makes the programming easier by grouping the related data.
2. The frame representation is comparably flexible and used by many applications in AI.
3. It is very easy to add slots for new attribute and relations.
4. It is easy to include default data and to search for missing values.
5. Frame representation is easy to understand and visualize.

Disadvantages of frame representation:

1. In frame system inference mechanism is not be easily processed.
2. Inference mechanism cannot be smoothly proceeded by frame representation.
3. Frame representation has a much generalized approach.

Unit-IV

8 a) Explain the basic components of an expert system. CO4 L2 7M

Ans:

An expert system mainly consists of three components: **[types 1 mark, explanation 6 marks]**

- **User Interface**
- **Inference Engine**
- **Knowledge Base**

1. User Interface

With the help of a user interface, the expert system interacts with the user, takes queries as an input in a readable format, and passes it to the inference engine. After getting the response from the inference engine, it displays the output to the user. In other words, **it is an interface that helps a non-expert user to communicate with the expert system to find a solution**.

2. Inference Engine(Rules of Engine)

- The inference engine is known as the brain of the expert system as it is the main processing unit of the system. It applies inference rules to the knowledge base to derive a conclusion or deduce new information. It helps in deriving an error-free solution of queries asked by the user.
- With the help of an inference engine, the system extracts the knowledge from the knowledge base.
- There are two types of inference engine:
- **Deterministic Inference engine:** The conclusions drawn from this type of inference engine are assumed to be true. It is based on **facts** and **rules**.
- **Probabilistic Inference engine:** This type of inference engine contains uncertainty in conclusions, and based on the probability.

Inference engine uses the below modes to derive the solutions:

- **Forward Chaining:** It starts from the known facts and rules, and applies the inference rules to add their conclusion to the known facts.
- **Backward Chaining:** It is a backward reasoning method that starts from the goal and works backward to prove the known facts.

3. Knowledge Base

- The knowledgebase is a type of storage that stores knowledge acquired from the different experts of the particular domain. It is considered as big storage of knowledge. The more the knowledge base, the more precise will be the Expert System.

- It is similar to a database that contains information and rules of a particular domain or subject.
- One can also view the knowledge base as collections of objects and their attributes. Such as a Lion is an object and its attributes are it is a mammal, it is not a domestic animal, etc.

Components of Knowledge Base

- **Factual Knowledge:** The knowledge which is based on facts and accepted by knowledge engineers comes under factual knowledge.
- **Heuristic Knowledge:** This knowledge is based on practice, the ability to guess, evaluation, and experiences.

Knowledge Representation: It is used to formalize the knowledge stored in the knowledge base using the If-else rules.

Knowledge Acquisitions: It is the process of extracting, organizing, and structuring the domain knowledge, specifying the rules to acquire the knowledge from various experts, and store that knowledge into the knowledge base.

b) Compare and contrast expert system and traditional system. CO4 L4 7M

Ans: **[differences 7 Marks]**

Traditional Systems versus Expert Systems A key distinction between the traditional system as opposed to the expert system is the way in which the problem-related expertise is coded. Essentially, in conventional applications, the problem expertise is encoded in both programs as well as data structures. On the other hand, in expert systems, the approach of the problem related expertise is encoded in data structures only. Moreover, the use of knowledge in expert systems is vital. However, traditional systems use data more efficiently than expert systems.

One of the biggest limitations of conventional systems is that they cannot explain a problem's conclusion. That is because these systems try to solve problems in a straightforward manner. However, expert systems can provide explanations and simplify the understanding of a particular conclusion.

Generally, an expert system uses symbolic representations to perform computations. On the contrary, conventional systems are incapable of expressing these terms. They only simplify the problems without being able to answer the "how" and "why" questions. Moreover, problem-solving tools are present in expert systems as opposed to traditional ones; hence, various problems are often entirely solved by the system's experts.

(OR)

9 a) Write the characteristic features of expert system. CO4 L3 7M

Ans:

CHARACTERISTICS OF AN EXPERT SYSTEM [Theory 7 Marks]

The growth of expert system is expected to continue for several years. With the continuing growth, many new and exciting applications will emerge. An expert system operates as an interactive system that responds to questions, asks for clarification, makes recommendations and generally aids the decision making process. Expert system provides expert advice and guidance in a wide variety of activities from computer diagnosis to delicate medical surgery.

An expert system is usually designed to have the following general characteristics.

1. **High level Performance:** The system must be capable of responding at a level of competency equal to or better than an expert system in the field. The quality of the advice given by the system should be in a high level integrity and for which the performance ratio should be also very high.
2. **Domain Specificity:** Expert systems are typically very domain specific. For ex., a diagnostic expert system for troubleshooting computers must actually perform all the necessary data manipulation as a human expert would. The developer of such a system must limit his or her scope of the system to just what is needed to solve the target problem. Special tools or programming languages are often needed to accomplish the specific objectives of the system.
3. **Good Reliability:** The expert system must be as reliable as a human expert.
4. **Understandable:** The system should be understandable i.e. be able to explain the steps of reasoning while executing. The expert system should have an explanation capability similar to the reasoning ability of human experts.
5. **Adequate Response time:** The system should be designed in such a way that it is able to perform within a small amount of time, comparable to or better than the time taken by a human expert to reach at a decision point. An expert system that takes a year to reach a decision compared to a human expert's time of one hour would not be useful.
6. **Use symbolic representations:** Expert system use symbolic representations for knowledge (rules, networks or frames) and perform their inference through symbolic computations that closely resemble manipulations of natural language.
7. **Linked with Metaknowledge:** Expert systems often reason with metaknowledge i.e. they reason with knowledge about themselves and their own knowledge limits and capabilities. The use of metaknowledge is quite interactive and simple for various data representations.
8. **Expertise knowledge:** Real experts not only produce good solutions but also find them quickly. So, an expert system must be skillful in applying its knowledge to produce solutions both efficiently and effectively by using the intelligence human experts.
9. **Justified Reasoning:** This allows the users to ask the expert system to justify the solution or advice provided by it. Normally, expert systems justify their answers or advice by explaining their reasoning. If a system is a rule based system, it provides to the user all the rules and facts it has used to achieve its answer.
10. **Explaining capability:** Expert systems are capable of explaining how a particular conclusion was reached and why requested information is needed during a consultation. This is very important as it gives the user a chance to access and understand the system's reasoning ability, thereby improving the user's confidence in the system.
11. **Special Programming Languages:** Expert systems are typically written in special programming languages. The use of languages like LISP and PROLOG in the development of an expert system simplifies the coding process.

b) Write a brief summary on expert system shell. CO4 L6 7M

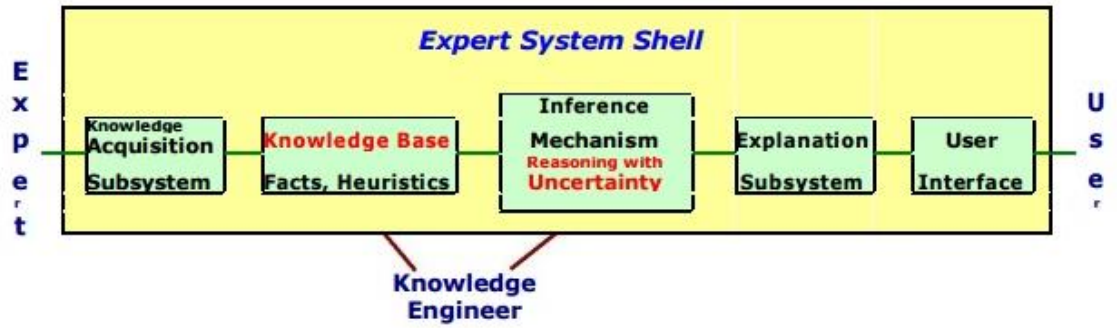
Ans:

Expert System Shells [def 1 mark, diagram 2 marks, explanation 4 marks]

An Expert system shell is a software development environment. It contains the basic components of expert systems. A shell is associated with a prescribed method for building applications by configuring and instantiating these components.

Shell components and description

The generic components of a shell : the knowledge acquisition, the knowledge Base, the reasoning, the explanation and the user interface are shown below. The knowledge base and reasoning engine are the core components.



■ **Knowledge Base**

A store of factual and heuristic knowledge. Expert system tool provides one or more knowledge representation schemes for expressing knowledge about the application domain. Some tools use both Frames (objects) and IF-THEN rules. In PROLOG the knowledge is represented as logical statements.

■ **Reasoning Engine**

Inference mechanisms for manipulating the symbolic information and knowledge in the knowledge base form a line of reasoning in solving a problem. The inference mechanism can range from simple modus ponens backward chaining of IF-THEN rules to Case-Based reasoning.

Knowledge Acquisition subsystem

A subsystem to help experts in build knowledge bases. However, collecting knowledge, needed to solve problems and build the knowledge base, is the biggest bottleneck in building expert systems.

Explanation subsystem

A subsystem that explains the system's actions. The explanation can range from how the final or intermediate solutions were arrived at justifying the need for additional data.

User Interface

A means of communication with the user. The user interface is generally not a part of the expert system technology. It was not given much attention in the past. However, the user interface can make a critical difference in the pe eived utility of an Expert system.