

**Birla Institute of Technology & Science, Pilani**  
**Work Integrated Learning Programmes Division**  
**First Semester 2025-2026**  
**Digital Learning Handout**

**Part A: Content Design**

Course Title	Artificial and Computational Intelligence
Course No(s)	AIML ZG557 /SE ZG557
Credit Units	5
Credit Model	1.25 - 1.5 - 2.25
Course Author	Prof. Vimal SP, Raja vadhana Prabhakar
Lead Instructor	Madhusudhanan B.
Version No:	5.0
Date:	24/02/2025

**Course Description:**

Agents and environments, Task Environments, Working of agents; Uninformed Search Algorithms: Informed Search. Local Search Algorithms & Optimization Problems: Genetic Algorithm; Searching with Non-Deterministic Actions, Partial Information and Online search agents, Game Playing, Constraint Satisfaction Problem, Knowledge Representation using Logics: TT-Entail for inference from truth table, Proof by resolution, Forward Chaining and Backward Chaining, Inference in FOL, Unification & Lifting, Forward chaining, Backward Chaining, Resolution; Probabilistic Representation and Reasoning : Inference using full joint distribution, Representation of Conditional Independence using BN, Reinforcement Learning; Difference between crisp and fuzzy logic, shapes of membership function, Fuzzification and defuzzification, fuzzy logic reasoning; Decision making with fuzzy information, Fuzzy Classification; Connectionist Models: Introduction to Neural Networks, Hopfield Networks, Perceptron Learning, Back propagation & Competitive Learning, Applications of Neural Net: Speech, Vision, Traveling Salesman; Genetic Algorithms - Chromosomes, fitness functions, and selection mechanisms, Genetic algorithms: crossover and mutation, Genetic programming.

**Course Objectives**

No	Course Objective
CO1	Identify and recall fundamental concepts and techniques for designing intelligent agents
CO2	Represent and use of knowledge in inference-based problem solving approaches
CO3	Apply probability theory to describe and model agents operating in uncertain environments
CO4	Implement optimization models of computation and processing in real world application of intelligent agents

**Text Book(s):**

<b>T1</b>	Stuart Russell and Peter Norvig, “Artificial Intelligence – A Modern Approach”, Pearson Education, 2006. Third Edition
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**Reference Book(s) & other resources:**

<b>R1</b>	Ryszard S. Michalski, Jaime G. Carbonell and Tom M. Mitchell, "Machine Learning: An Artificial Intelligence Approach", Elsevier, 2014
<b>R2</b>	Dan W Patterson, "Introduction to AI and Expert Systems", Prentice Hall of India, New Delhi, 2010
<b>R3</b>	Elaine Rich and Kevin Knight, "Artificial Intelligence", Tata McGraw Hill Publishing Company, New Delhi, 2003. Second Edition

**Learning Outcomes: Students will be able to**

LO1	Understand and recall agent-environment interactions through architectures and design PEAS descriptions of agents. Measure success by the agent's ability to perform tasks such as pathfinding and decision-making.
LO2	Analysing the working of uninformed search algorithms like Uniform Cost Search, Depth Limited Search and Iterative Deepening Search.
LO3	Design and implement heuristic functions in search algorithms like A* and measure its efficiency through the number of nodes expanded and the solution's optimality.
LO4	Design and implement the local search algorithms like Hill Climbing, simulated annealing and evolutionary techniques like Genetic algorithm, Ant Colony Optimization, particle swarm optimization for designing solution for N-Queen problem or Travelling Salesman problem.
LO5	Design static evaluation measure for building adversarial search agents in multiplayer player Games and implement Game playing using algorithms like Minimax and Alpha Beta pruning.
LO6	Apply logical inference techniques to solve problems like agent navigation in a Grid World. Measure success by the correctness and efficiency of inferred solutions.
LO7	Apply probabilistic models for decision-making under uncertainty using Bayesian networks with exact inferencing, approximate inferencing by direct sampling. Implement solution for temporal problems and infer using Hidden Markov Models.
LO8	Understand the importance of ethical considerations while designing AI solutions.

**Modular Content Structure**

1. Introduction
  - o Artificial Intelligence: Foundations, Overview of Modern AI & Application Domains.
2. Introduction to Intelligent Agents: Notion of Agents and Environments, Rationality, Nature of Environments, Structure of Agents
3. Problem Solving Agent using Search:
  - o Problem Formulation, Uninformed Search Algorithms: Uniform cost Search, Depth Limited Search, Iterative Deepening Search – Informed Search Algorithms: Notion of Heuristics, Greedy best first search, A\* search, Optimality of A\*
  - o Heuristic Functions: Heuristic Accuracy & Algorithm performance, Admissible heuristics from relaxed problems, pattern databases & Experience
  - o Local Search Algorithms & Optimization Problems: Hill Climbing Search, Simulated Annealing, Local Beam Search, Evolutionary Algorithms - Genetic Algorithm, Ant Colony Optimization, Particle Swarm Optimization
4. Game Playing:



- Searching to play games: Minimax Algorithm, Alpha-Beta Pruning
- Making imperfect real time decisions
- 5. Knowledge Representation using Logics:
  - (**Pre-Reading:** Logics- Propositional, Predicate, TT-Entail, Theorem Proving)
  - Logic Representation of a sample agent, Proof by resolution, DPLL Algorithm, Agents based on Propositional logic
  - Overview of First Order Logic semantics, Example representation, Unification & Lifting, forward chaining, Backward Chaining, Resolution
- 6. Probabilistic Representation and Reasoning
  - Inference using full joint distribution & Example, Knowledge representation using Bayesian Networks, semantics of Bayesian Networks, Representation of Conditional Independence using Bayesian Networks
  - Exact Inference - by enumeration and variable elimination, Need for Approximate Inference - Direct Sampling
- 7. Reasoning over time
  - Time and Uncertainty, Inference in temporal models
  - Hidden Markov Models, Algorithms: Filtering, Smoothing, Finding the most likely sequence, EM algorithms for Learning the parameters of HMM
- 8. Ethics in AI
  - Explainable AI- Logically Explained Network, Explainable Bayesian Network

#### Part B: Learning Plan

Contact Session	List of Topic Title	Sub-Topics	Reference
1	<b>Introduction</b>	<ul style="list-style-type: none"> <li>What is Artificial Intelligence: Acting Humanly, Thinking humanly, Thinking rationally, Acting Rationally</li> <li>Foundations of AI</li> <li>Brief Overview of Modern AI &amp; Application Domains.</li> </ul>	T1: 1.1  T1: 1.2, 1.4
2	<b>Introduction to Intelligent Agents</b>	<ul style="list-style-type: none"> <li>Intelligent Agents: Notion of Agents and Environments, Rationality</li> <li>Nature of Environments, Structure of Agents</li> </ul>	T1: Chapter 2
3	<b>Problem Solving Agent using Search</b>	<ul style="list-style-type: none"> <li>Problem Solving Agent</li> <li>Problem Formulation - Examples</li> <li>Uninformed Search Algorithms: Uniform cost Search, Depth Limited Search, Iterative Deepening Search.</li> <li>Notion of Heuristics</li> <li>Informed Search Algorithms :</li> </ul>	T1: Chapter  3.1-3.4, 3.5.1, 3.5.2

**Commented [1]:** MTECH DSE:  
 Uninformed Search discuss only at overview level.  
 Focus on next topics Heuristic design and informed Search



		Greedy best first search, A* search	
4	<b>Problem Solving Agent using Search</b>	<ul style="list-style-type: none"> <li>Optimality of A*</li> <li>Heuristic Functions</li> <li>Heuristic Accuracy &amp; Algorithm performance</li> <li>Admissible heuristics from relaxed problems, pattern databases. &amp; Experience</li> </ul>	T1: Chapter 3.5.2, 3.6
5	<b>Problem Solving Agent using Search</b>	<ul style="list-style-type: none"> <li>Local Search Algorithms &amp; Optimization Problems</li> <li>Hill Climbing Search</li> <li>Simulated Annealing,</li> <li>Local Beam Search</li> </ul>	T1: Chapter 4.1
6	<b>Problem Solving Agent using Search</b>	<ul style="list-style-type: none"> <li>Genetic Algorithm</li> </ul>	T1: Chapter 4.1, Research papers & web resources
7	<b>Problem Solving Agent using Search</b>	<ul style="list-style-type: none"> <li>Ant Colony Optimization</li> <li>Particle Swarm Optimization</li> </ul>	Research papers & web resources
8	<b>Game Playing</b>	<ul style="list-style-type: none"> <li>Searching to play games</li> <li>Minimax Algorithm</li> <li>Alpha-Beta Pruning</li> <li>Making imperfect real time decisions</li> </ul>	T1: Chapter 5.1 to 5.4
9	<b>Knowledge Representation using Logics</b>	<ul style="list-style-type: none"> <li>Logical Agent</li> <li>Logic Representation of a sample agent</li> <li>DPLL Algorithm, Agents based on Propositional logic</li> <li>Overview of First Order Logic semantics, Example representation</li> </ul>	T1: Chapter 7.1, 7.2, 7.5.2, 7.5.3, 7.6.1, 8.1, 8.3.4
10	<b>Knowledge Representation using Logics</b>	<ul style="list-style-type: none"> <li>Inference in First Order Logic</li> <li>Unification &amp; Lifting</li> <li>Forward chaining</li> <li>Backward Chaining</li> </ul>	T1: Chapter 9
11	<b>Probabilistic Representation and Reasoning</b>	<ul style="list-style-type: none"> <li>Resolution</li> <li>Probabilistic Representation and Reasoning</li> <li>Inference using full joint distribution &amp; Example</li> <li>Knowledge representation using</li> </ul>	T1: Chapter 9, 13, 14.1



		Bayesian Networks	
12	<b>Probabilistic Representation and Reasoning</b>	<ul style="list-style-type: none"> <li>Semantics of Bayesian Networks</li> <li>Representation of Conditional Independence using BN</li> </ul>	T1: 14.2, 14.3
13	<b>Probabilistic Representation and Reasoning</b>	<ul style="list-style-type: none"> <li>Exact Inference - by enumeration and variable elimination</li> <li>Need for Approximate Inference - Direct Sampling</li> </ul>	T1: 14.4, 14.5
14	<b>Reasoning over time</b>	<ul style="list-style-type: none"> <li>Reasoning over time</li> <li>Time and Uncertainty</li> <li>Inference in temporal models</li> </ul>	T1: Chapter 15.1, 15.2
15	<b>Reasoning over time</b>	<ul style="list-style-type: none"> <li>Hidden Markov Models</li> <li>Learning HMM Parameters using EM Algorithm</li> <li>Applications of HMM</li> </ul>	T1: Chapter , 15.3, 20.3-20.3.3
16	<b>Ethics in AI</b>	<ul style="list-style-type: none"> <li>Explainable AI- Logically Explained Network, Explainable Bayesian Network</li> </ul>	Research papers & web resources

**Commented [2]:** M Tech AIML:  
 Focus on algorithms & problem for Filtering – Smoothing – Most Likelihood – EM for Parameter Learning

#### Experiential Learning Components:

1. Lab work: 7
2. Project work: 0
3. Case Study: 0
4. Simulation: 0
5. Work Integrated Learning Assignment- 2 Assignments
6. Design work/ Field work: 0

#### Objective of Experiential Learning Component:

Learners will implement informed/uninformed/local search algorithms, adversarial search and Bayesian networks using Python, rule-based systems in Prolog

#### Scope of Experiential Learning Component:

**Programming language** – Python, Prolog

**Tools and libraries:** Jupyter, Numpy, Scipy, Pandas, pgmpy, nltk

#### Lab Infrastructure:

Google Colab, Online: <https://www.swi-prolog.org/>

#### List of Experiments:



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Lab No	Lab Objective	Session Reference
1	Implement Uninformed Search Algorithms like BFS/DFS	3
2	Implement A* algorithm for Informed Search	4
3	Implement Local Search Techniques using Genetic Algorithm	6
4	Implement MINIMAX algorithm for Adversarial Search for game playing	8
5	Represent knowledge using logics and perform reasoning using PROLOG	10
6	Experiment with Bayesian Networks and exact Inferencing	13
7	Experiment with application of Hidden Markov Model in Natural Language Processing	15

#### **Evaluation Scheme:**

**Legend:** EC = Evaluation Component; AN = After Noon Session; FN = Fore Noon Session

Evaluation Component	Name (Quiz, Lab, Project, Mid-term exam, End semester exam, etc.)	Type (Open book, Closed book, Online, etc.)	Weight	Duration	Day, Date, Session, Time
EC – 1*	Quiz I	Online	5%	1 day	September 01-10, 2025
	Lab Assignment	Online	13%	10 days	October 10-20, 2025
	Lab Assignment	Online	12 %	10 days	November 01-10, 2025
EC - 2	Mid-Semester Test	Closed Book	30%	2 hours	21/09/2025 (AN)
EC - 3	Comprehensive Exam	Open Book	40%	2 ½ Hours	30/11/2025 (AN)

EC1\* (30%): Quiz: 5 %, Lab Assignment/Assignment: 25%

Syllabus for Mid-Semester Test (Closed Book): Topics in Contact session: 1 to 8

Syllabus for Comprehensive Exam (Open Book): All topics

#### **Important Links and Information:**

**eLearn Portal:** <https://elearn.bits-pilani.ac.in>

Students must visit the eLearn portal regularly and stay updated with the latest announcements and deadlines.

**Contact Sessions:** Students should attend the online lectures as per the schedule provided on the eLearn portal.

#### **Evaluation Guidelines:**



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1. EC-1 consists of either two Assignments or three Quizzes. Students will attempt them through the course pages on the eLearn portal. Announcements will be made on the portal in a timely manner.
2. For Closed Book tests: No books or reference material of any kind will be permitted.
3. For Open Book exams: “open book” means text/ reference books (publisher copy only) and does not include any other learning material. No other learning material will be permitted during the open book examinations. For Detailed Guidelines refer to the attached document.  
[EC3 Guidelines](#)
4. If a student is unable to appear for the Regular Test/Exam due to genuine exigencies, the student should follow the procedure to apply for the Make-Up Test/Exam, which will be made available on the eLearn portal. The Make-Up Test/Exam will be conducted only at selected exam centres on the dates to be announced later.

It shall be the responsibility of the individual student to be regular in maintaining the self-study schedule as given in the course handout, attend the online lectures, and take all the prescribed evaluation components such as Assignments/Quizzes, Mid-Semester Tests and Comprehensive Exams according to the evaluation scheme provided in the handout.

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