JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

DEPARTMENT OF COMPUTER SCIENCE ENGINEERING

R25 M.TECH ARTIFICIAL INTELLIGENCE SYLLABUS

Vision and Mission of the University

VISION

The University is primarily promoting quality of education in the areas of Science, Technology, Engineering and Mathematics (STEM) as four academic pillars of education, to excel in teaching, learning, research, consultancy and placements through innovative practices with global perspective.

MISSION

1. Design an Industry relevant curriculum from time to time with a Global perspective
2. Promoting quality education by embracing ICT delivery mechanism with continuous pedagogy through e-learning mechanism
3. Spread across for industry collaborations with a focus to pre-training and placements for technology transfer to society
4. Establishing centers of excellence to promote research and innovations in multidisciplinary areas to bring in patent culture and consultancy practices
5. International Collaborations for student outreach
6. Facilitating international students to study in JNTUK to infuse cross culture learning practices.

Vision and Mission of the Institute

Vision and Mission of the Department

Programme Education Objectives (PEOs)of the M.Tech (Artificial Intelligence)

PEO1: Graduates will apply advanced knowledge of mathematics, machine learning, and optimization to design and implement AI-based solutions for complex, real-world problems across interdisciplinary domains.

PEO2: Graduates will contribute to the advancement of Artificial Intelligence through independent research, innovation, and continuous learning, including pursuit of doctoral studies, patents, publications, or professional certifications.

PEO3: Graduates will demonstrate leadership, ethical responsibility, effective communication, and a commitment to sustainability and social good in their professional practice, addressing contemporary challenges with awareness of global and societal contexts.

Mapping of Mission statements to PEOs

Programme Outcomes (POs)

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PO4: Model, design, and implement intelligent systems using advanced AI techniques

PO5: Assess and analyze the complexity of AI problems, identify key characteristics, and evaluate potential solutions for effective decision-making and problem-solving

PO6: Propose innovative, original solutions by exploring contemporary research trends in AI and identify gaps in existing knowledge

Mapping of Programme Outcomes to PEOs

POs/ PEOs	PEO1	PEO2	PEO3
PO1	M	H	L
PO2	L	M	H
PO3	H	H	M
PO4	H	M	L
PO5	H	M	M
PO6	M	H	L

M.Tech.

ARTIFICIAL INTELLIGENCE

Course Structure & Syllabus

M.TECH- ARTIFICIAL INTELLIGENCE
PROGRAMME STRUCTURE

I Semester

S. No.	Course Title	L	T	P	C
1	Program Core – 1 Advances in Artificial Intelligence	3	1	0	4
2	Program Core – 2 Knowledge Representation and Reasoning	3	1	0	4
3	Program Core – 3 Machine Learning	3	1	0	4
4	Program Elective – I • Problem-Solving Methods • Pattern Recognition • Robotics & Automation	3	0	0	3
5	Program Elective – II • Logic Programming using Prolog & Lisp • Social Network Analysis • Intelligent Systems	3	0	0	3
6	Laboratory – 1 Artificial Intelligence & Functional Programming Lab	0	1	2	2
7	Laboratory – 2 Machine Learning Lab	0	1	2	2
8	Seminar-I	0	0	2	1
	TOTAL	**15**	**5**	**6**	**23**

List of Professional Elective Courses in I Semester (Electives – I & II)

S.No.	Course Title
1	Problem-Solving Methods
2	Pattern Recognition
3	Robotics & Automation
4	Logic Programming using Prolog & Lisp
5	Social Network Analysis
6	Intelligent Systems

@ Minimum 2/3 themes per elective

II Semester

S. No.	Course Title	L	T	P	C
1	Program Core – 4 Generative AI	3	1	0	4
2	Program Core – 5 Natural Language Processing	3	1	0	4
3	Program Core – 6 Deep Learning	3	1	0	4
4	Program Elective – III • Deep Reinforcement Learning • Big Data Analytics • Computational Intelligence	3	0	0	3
5	Program Elective – IV • Text Processing • Genetic Algorithms & Applications • Bio-Inspired Computing	3	0	0	3
6	Laboratory – 3 Generative AI Lab	0	1	2	2
7	Laboratory – 4 Deep Learning Lab	0	1	2	2
8	Seminar – II	0	0	2	1
	TOTAL	**15**	**5**	**6**	**23**

* During the summer break, students need to pursue Summer Internship/ Industrial Training, which will be evaluated in the III Sem.

List of Professional Elective Courses in II Semester (Electives III & IV)

S.No.	Course Title
1	Deep Reinforcement Learning
2	Big Data Analytics
3	Computational Intelligence
4	Text Processing
5	Genetic Algorithms & Applications
6	Bio-Inspired Computing

@ Minimum 2/3 themes per elective

III Semester

Sl. No.	Course Title	L	T	P	C
1	Research Methodology and IPR / *Swayam 12 week MOOC course – RM&IPR*	3	0	0	3
2	Summer Internship/ Industrial Training (8-10 weeks)*	-	-	-	3
3	Comprehensive Viva#	-	-	-	2
4	Dissertation Part – A$	-	-	20	10
	TOTAL	**3**	**-**	**20**	**18**

* Student attended during summer / year break and assessment will be done in 3rd Sem.

Comprehensive viva can be conducted courses completed upto second sem.

$ Dissertation – Part A, internal assessment

IV Semester

Sl. No.	Course Code	Course Title	L	T	P	C
1		Dissertation Part – B%	-	-	32	16
		TOTAL	**-**	**-**	**32**	**16**

% External Assessment

I Semester	ADVANCES IN ARTIFICIAL INTELLIGENCE	L	T	P	C
		3	1	0	4

Course Objectives:

The objectives of this course are to

1. Provide students with a comprehensive understanding of the foundations, history, and key concepts of Artificial Intelligence (AI), including the role of agents and environments in AI systems.
2. introduce students to knowledge representation and reasoning, focusing on propositional and first-order logic, and how they are used for inference and decision-making in AI systems
3. Provide practical experience in natural language processing (NLP), including efficient parsing, scaling up the lexicon, handling ambiguity, and developing speech recognition and synthesis systems.
4. Introduce students to the field of robotics, covering key concepts such as motion planning, navigation, sensors, and AI-based programming tools for building intelligent robotic systems.

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Formulate AI problems effectively and implement different search algorithms to solve problem scenarios in dynamic environments	K4
CO2	Develop knowledge-based AI systems using propositional and first-order logic, and apply inference techniques like forward and backward chaining to draw conclusions	K3
CO3	Apply learning algorithms such as decision trees and neural networks to real-world datasets, and demonstrate the ability to train, test, and evaluate learning models	K3
CO4	Implement natural language processing tasks, including parsing, lexicon scaling, and resolving ambiguities, while demonstrating proficiency in speech recognition and synthesis techniques	K6
CO5	Design and simulate basic robotic systems, utilizing AI-based programming tools to enable robots to navigate, perform tasks, and interact with their environment using sensors and effectors	K6

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	L	M	H	H	M
CO2	M	L	M	H	M	M
CO3	M	L	H	H	H	M
CO4	M	M	M	H	M	H
CO5	M	L	H	H	M	H

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	Introduction: AI, Foundations of AI, History of AI, Agents and environments, The nature of the Environment, Problem-solving Agents, Problem Formulation, Search Strategies	12
UNIT – 2	Knowledge and Reasoning: Knowledge-based Agents, Representation, Reasoning and Logic, Prepositional logic, First-order logic, Using First-order logic, Inference in First-order logic, forward and Backward Chaining	12
UNIT – 3	Learning: Learning from observations, Forms of Learning, Inductive Learning, learning decision trees, why learning works, Learning in Neural and Belief networks	12
UNIT – 4	Practical Natural Language Processing: Practical applications, Efficient parsing, scaling up the lexicon, Scaling up the Grammar, Ambiguity, Perception, Image formation, Image processing operations for early vision, Speech recognition and Speech Synthesis	12
UNIT – 5	Robotics: Introduction, Tasks, parts, effectors, Sensors, Architectures, Configuration spaces, Navigation and motion planning, Introduction to AI-based programming Tools	12
	Total	60

Text Books:

1. Stuart Russell, Peter Norvig: “Artificial Intelligence: A Modern Approach”,2nd Edition, Pearson Education, 2007.

Reference Books:

1. Artificial Neural Networks, B. Yagna Narayana, PHI.
2. Artificial Intelligence, 2nd Edition, E.Rich, K.Knight, TMH.
3. Artificial Intelligence and Expert Systems, Patterson PHI.
4. Expert Systems: Principles and Programming, Fourth Edition, Giarrantana/ Riley, Thomson.
5. PROLOG Programming for Artificial Intelligence, Ivan Bratka- Third Edition, Pearson Education.
6. Neural Networks, Simon Haykin, PHI.

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R25 M.TECH ARTIFICIAL INTELLIGENCE SYLLABUS

I Semester	KNOWLEDGE REPRESENTATION AND REASONING	L	T	P	C
		3	1	0	4

Course Objectives:

The objectives of this course are to

1. Understand the principles of knowledge representation and reasoning, and explore how logic is used to structure and manage knowledge in AI systems.
2. Examine various logic systems (classical, fuzzy, non-monotonic) and their application in reasoning under uncertainty, vagueness, and dynamic environments.
3. Learn to design and implement AI systems by representing knowledge using structured approaches like frames, object-oriented systems, and semantic models.
4. Investigate techniques for knowledge acquisition and sharing, focusing on ontologies, conceptual schemas, and tools for integrating multiple paradigms of knowledge representation.

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Demonstrate knowledge of different knowledge representation techniques and their role in AI, including logical and semantic frameworks.	K2
CO2	Apply various logic systems such as classical, fuzzy, and non-monotonic logic to handle uncertainty and change in AI problem-solving scenarios	K3
CO3	Design and implement AI knowledge systems using representation techniques like frames, object-oriented approaches, and natural language semantics.	K5
CO4	Analyze and model processes and events in AI systems, using methods like constraint satisfaction and concurrent processing for effective decision-making	K4
CO5	Develop strategies for knowledge acquisition and sharing by creating ontologies and using tools to integrate multiple knowledge representation schemes in AI applications	K5

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	L	M	H	M	L
CO2	M	L	M	H	H	M
CO3	M	M	H	H	M	H
CO4	H	M	M	H	H	M
CO5	M	M	H	H	M	H

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	**The Key Concepts**: Knowledge, Representation, Reasoning, why knowledge representation and reasoning, Role of logic **Logic:** Historical background, representing knowledge in logic, Varieties of logic, Name, Type, Measures, Unity Amidst diversity	12
UNIT – 2	**Ontology:** Ontological categories, Philosophical background, Top-level categories, describing physical entities, Defining abstractions, Sets, Collections, Types and Categories, Space and Time	12
UNIT – 3	**Knowledge Representations:** Knowledge Engineering, Representing structure in frames, Rules and data, Object-oriented systems, Natural language Semantics, Levels of representation	12
UNIT – 4	**Processes:** Times, Events and Situations, Classification of processes, Procedures, Processes and Histories, Concurrent processes, Computation, Constraint satisfaction, Change **Contexts:** Syntax of contexts, Semantics of contexts, First-order reasoning in contexts, Modal reasoning in contexts, Encapsulating objects in contexts.	12
UNIT – 5	**Knowledge Soup**: Vagueness, Uncertainty, Randomness and Ignorance, Limitations of logic, Fuzzy logic, Non-monotonic Logic, Theories, Models and the world, Semiotics **Knowledge Acquisition and Sharing:** Sharing Ontologies, Conceptual schema, accommodating multiple paradigms, relating different knowledge representations, Language patterns, Tools for knowledge acquisition	12
	Total	60

Text Books:

1. Knowledge Representation Logical, Philosophical, and Computational Foundations by John F. Sowa, Thomson Learning.
2. Knowledge Representation and Reasoning by Ronald J. Brachman, Hector J. Levesque, Elsevier.

I Semester	MACHINE LEARNING	L	T	P	C
		3	1	0	4

Course Objectives:

The main objectives of this course are

1. Develop an understanding of key machine learning techniques such as decision tree learning, neural networks, and genetic algorithms.
2. Apply statistical models and algorithms like Naive Bayes, Bayesian Networks, and EM algorithms to solve learning problems involving uncertainty.
3. Implement and optimize instance-based learning algorithms, including K-Nearest Neighbour (K-NN) and case-based learning, for practical AI applications.
4. Understand and implement heuristic search strategies, inductive bias, and rule-based learning techniques for improving AI system performance.

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Apply decision tree learning and heuristic search strategies for AI problem-solving.	K2
CO2	Implement neural networks and genetic algorithms for classification and optimization problems.	K3
CO3	Develop and apply Bayesian learning models such as Naive Bayes and Gibbs algorithms	K3
CO4	Implement instance-based learning techniques like K-Nearest Neighbour (K-NN) and case-based reasoning.	K3
CO5	Utilize reinforcement learning algorithms like Q-learning and temporal difference learning to solve sequential decision-making tasks.	K5

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	L	M	H	M	L
CO2	M	L	H	H	M	M
CO3	M	M	M	H	M	M
CO4	M	L	M	H	M	L
CO5	M	L	H	H	H	H

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	Learning Problems, Perspectives and Issues, Concept Learning, Version Spaces and Candidate Eliminations, Inductive bias, Decision Tree learning, Representation, Algorithm, Heuristic Space Search.	12
UNIT – 2	Neural Networks And Genetic Algorithms: Neural Network Representation, Problems, Perceptrons, Multilayer Networks and Back Propagation Algorithms, Advanced Topics, Genetic Algorithms, Hypothesis Space Search, Genetic Programming, Models of Evalution and Learning.	12
UNIT – 3	Bayesian And Computational Learning: Bayes Theorem, Concept Learning, Maximum Likelihood, Minimum Description Length Principle, Bayes Optimal Classifier, Gibbs Algorithm, Naive Bayes Classifier, Bayesian Belief Network, EM Algorithm, Probability Learning, Sample Complexity, Finite and Infinite Hypothesis Spaces, Mistake Bound Model.	12
UNIT – 4	Instant Based Learning: K- Nearest Neighbour Learning, Locally weighted Regression, Radial Bases Functions, Case Based Learning	12
UNIT – 5	Advanced Learning: Learning Sets of Rules, Sequential Covering Algorithm, Learning Rule Set, First Order Rules, Sets of First Order Rules, Induction on Inverted Deduction, Inverting Resolution, Analytical Learning, Perfect Domain Theories, Explanation Base Learning, FOCL Algorithm, Reinforcement Learning, Task, Q-Learning, Temporal Difference Learning	12
	Total	60

Text Books:

1. Machine Learning, Tom M. Mitchell, MGH.

Reference Books

1. Machine Learning: An Algorithmic Perspective, Stephen Marsland, Taylor & Francis.

I Semester	PROBLEM SOLVING METHODS	L	T	P	C
		3	0	0	3

Course Objectives:

The main objectives of the course are to

1. Understand the fundamental concepts of AI, its history, and its applications across various domains. Develop a clear understanding of intelligent agents and their components, including environments and behaviors.
2. Learn how to solve complex problems by applying search algorithms, both uninformed and informed, and understand the differences between different search strategies for optimization and decision-making.
3. Explore and apply constraint satisfaction problems (CSPs) and adversarial search strategies, including games, optimal decision-making, and techniques like alpha-beta pruning for improving game-playing AI.
4. Gain knowledge of formalized symbolic logic and planning techniques, such as state-space search, partial-order planning, hierarchical task networks, and execution monitoring in real-world AI systems.

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Demonstrate knowledge of AI foundations, history, intelligent agents, and applications, explaining the role of agents and environments in creating intelligent behavior.	K2
CO2	Apply search algorithms effectively in problem-solving scenarios, using both uninformed and informed search strategies to find optimal solutions.	K3
CO3	Solve constraint satisfaction problems (CSPs) using backtracking search, local search methods, and optimization techniques to handle complex constraints.	K4
CO4	Develop decision-making algorithms for adversarial search, including game-playing AI and alpha-beta pruning techniques for optimizing real-time decisions.	K5
CO5	Design and implement AI planning systems, using techniques like state-space planning, partial-order planning, and hierarchical task networks, while considering time, resources, and conditions in real-world applications.	K6

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	M	L	L	L
CO2	M	L	M	H	M	M
CO3	H	L	M	H	H	M
CO4	M	L	H	H	M	M
CO5	M	M	H	H	M	H

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	**General introduction of AI:** What is AI, The foundations of AI, The history of AI, The state of the art. **Intelligent agents:** Agents and environments, Good behavior: The concept of reality, The nature of environments, The structure of agents, AI applications.	**12**
UNIT – 2	**Solving problems by searching:** Problem-solving agents, Example problems, searching for solutions, Uninformed search strategies, Avoiding repeated states, Searching with partial information. **Informed search and exploration**: Informed search strategies, Heuristic functions, Local search algorithms and optimization problems, Local search in continuous spaces, Online search agents and unknown environments.	12
UNIT – 3	**Constraint satisfaction problems:** Backtracking search for CSPs, Local search for constraint satisfaction problems, The structure of problems. **Adversarial search:** Games, Optimal decisions in games, Alpha-beta pruning, Imperfect real-time decisions, Games that include an element of chance, State-of-the-art game programs.	12
UNIT – 4	Formalized symbolic logics: Introduction, Syntax and semantics for propositional logic, Syntax and semantics for first order propositional logic, Properties of WFFS, Connection to clausal form, Inference rules, the resolution principle, Non-deductive inference methods, Representations using rules. **Resolution refutation systems:** Production systems for resolution refutations, Control strategies for resolution methods, Simplification strategies, and Extracting answers from resolution refutations.	12
UNIT – 5	**The Planning problem**: Planning with state-space search, Partial-order planning, planning graphs, planning with propositional logic, Analysis of planning approaches. **Planning and acting in the real world**: Time, schedules, and resources, Hierarchical task network planning, planning and acting in nondeterministic domains, Conditional planning, Execution monitoring and preplanning, Continuous planning, Multi-agent planning. AI system architectures, Knowledge acquisition, Representational formalisms.	12
	Total	60

Text Books:

1. D. W. Patterson: Introduction to AI & Expert System, PHI.
2. S. Russell and P. Norvig. AI: A Modern Approach, 2^{nd}Edn., McGraw-Hill, 2003.

Reference Books:

1. J. Siekmann, R. Goebel, and W. Wahlster: Problem Solving Methods, Springer, 2000edition
2. N.J.Nilsson: Principles of Artificial Intelligence, Narosa Publications.

I Semester	PATTERN RECOGNITION	L	T	P	C
		3	0	0	3

Course Objectives:
The main objectives of the course are to
1. Understand the foundational concepts of pattern recognition, probability, statistics, and linear algebra as they apply to various machine learning and classification problems.
2. Develop proficiency in supervised learning, including techniques like discriminant functions, parametric estimation, and Bayesian estimation, and understand their applications in pattern recognition.
3. Gain practical experience with unsupervised learning methods such as clustering, feature extraction, and feature selection, and apply these techniques to improve the performance of pattern recognition systems.
4. Learn to apply advanced classification methods, including Support Vector Machines, Hidden Markov Models, Fuzzy Logic, and Genetic Algorithms, to solve real-world pattern recognition and machine learning problems.

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Demonstrate a deep understanding of the probability theory, statistics, and linear algebra techniques used in pattern recognition, including their applications in data preprocessing and model building.	K2
CO2	Apply supervised learning algorithms such as discriminant functions and Bayesian parameter estimation to perform classification and handle problems associated with traditional methods in pattern recognition.	K3
CO3	Implement and evaluate unsupervised learning techniques, including clustering algorithms (e.g., C-Means, Hierarchical clustering) and feature extraction methods such as PCA and Fourier transforms.	K3
CO4	Use advanced classification methods such as Support Vector Machines (SVM) and Hidden Markov Models (HMMs) for effective pattern classification, and understand their strengths and limitations in real-world scenarios	K4
CO5	Implement fuzzy logic, genetic algorithms, and other adaptive techniques for pattern classification and evaluate their effectiveness in real-world classification tasks.	K5

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	M	L	L	L
CO2	M	L	M	H	M	M
CO3	M	L	M	H	H	M
CO4	H	L	H	H	M	M
CO5	M	M	H	H	M	H

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	Overview of Pattern recognition, Basics of Probability and Statistics, Linear Algebra, Linear Transformations, Components of Pattern Recognition System, Learning and adaptation, Discriminant functions, Supervised learning, Parametric estimation, Maximum Likelihood Estimation, Bayesian parameter Estimation, Problems with Bayes approach, Pattern classification by distance functions, Minimum distance pattern classifier.	12
UNIT – 2	Clustering for unsupervised learning and classification, Clustering concept, CMeans algorithm, Hierarchical clustering, Graph theoretic approach to pattern Clustering, Validity of Clusters.	12
UNIT – 3	Feature Extraction and Feature Selection: Feature extraction, discrete cosine and sine transform, Discrete Fourier transform, Principal Component analysis, Kernel Principal Component Analysis. Feature selection, class separability measures, Feature Selection Algorithms, Branch and bound algorithm, sequential forward /backward selection algorithms. Principle component analysis, Independent component analysis, Linear discriminant analysis, Feature selection through functional approximation, Elements of formal grammars, Syntactic description, Stochastic grammars, Structural Representation.	12
UNIT – 4	State Machines, Hidden Markov Models, Training, Classification, Support vector Machine, Feature Selection.	12
UNIT – 5	Fuzzy logic, Fuzzy Pattern Classifiers, Pattern Classification using Genetic Algorithms, Case Study Using Fuzzy Pattern Classifiers and Perception	12
	Total	60

Text Books:

1. Robert Schalkoff, Pattern Recognition: Statistical, Structural and Neural Approaches Wiley– India, 2009
2. Theodoridis, S. and K. Koutroumbas, “Pattern Recognition”, Fourth Edition, San Diego, CA: Academic Press, 2009.

Reference Books:

1. Andrew Webb, "Stastical Pattern Recognition", Arnold publishers, London,1999.
2. C.M.Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.
3. M. Narasimha Murthy, V. Susheela Devi, "Pattern Recognition", Springer 2011.
4. Menahem Friedman, Abraham Kandel, "Introduction to Pattern Recognition Statistical,Structural, Neural and Fuzzy Logic Approaches", World Scientific publishing Co. Ltd,2000.
5. Robert J.Schalkoff, "Pattern Recognition Statistical, Structural and Neural Approaches",John Wiley & Sons Inc., New York, 1992.
6. R.O.Duda, P.E.Hart and D.G.Stork, "Pattern Classification", John Wiley, 2001.
7. S.Theodoridis and K.Koutroumbas, "Pattern Recognition", 4th Ed., Academic Press. 2009.

I Semester	ROBOTICS & AUTOMATION	L	T	P	C
		3	0	0	3

Course Objectives:
The main objectives of the course are to
1. Understand the basic anatomy, terminology, and classification of robots, and explore their specifications, including accuracy, repeatability, and speed.
2. Gain knowledge of end effectors, robot control systems, and the design of grippers and motion interpolations, including their applications in robotic systems.
3. Develop an understanding of robot kinematics, robot transformations, and sensor integration, including the application of various sensors like tactile, proximity, range, and vision sensors in robots.
4. Explore the design and application of robot work cells, robot mobile systems, and micro/nano robotics, and understand the role of robots in various industrial and biomedical applications.

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Demonstrate an understanding of robot anatomy, including robot joints, links, laws of robotics, and various robot classifications. Analyze the specifications and capabilities of robots.	K2
CO2	Analyze and design robot end effectors (grippers, actuators) using various mechanisms, and understand the principles of robot control systems, including point-to-point and continuous path control.	K4
CO3	Apply robot kinematics and transformations (2D, 3D) to solve real-world problems, and integrate various robot sensors like tactile, range, force, and vision sensors into robotic systems.	K3
CO4	Design robot work cells for specific industrial applications, including material handling, welding, and inspection, and explore the use of mobile robots for various practical applications.	K5
CO5	Understand the concepts and applications of micro/nano robotics, including swarm robots, biomimetic robots, and their use in targeted drug delivery systems and other biomedical applications.	K6

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	M	L	M	L
CO2	M	M	M	H	M	M
CO3	M	L	M	H	M	M
CO4	M	M	H	H	M	H
CO5	M	M	H	H	M	H

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	**Introduction:** Robot anatomy-Definition, law of robotics, History and Terminology of Robotics-Accuracy and repeatability of Robotics-Simple problems Specifications of Robot-Speed of Robot-Robot joints and links-Robot classifications-Architecture of robotic systems	12
UNIT – 2	**End Effectors And Robot Controls:** Mechanical grippers-Slider crank mechanism, Screw type, Rotary actuators, cam type-Magnetic grippers-Vacuum grippers-Air operated grippers-Gripper force analysis-Gripper design-Simple problems-Robot controls-Point to point control, Continuous path control, Intelligent robot- Control system for robot joint-Control actions-Feedback devices-Encoder, Resolver, LVDT Motion Interpolations-Adaptive control.	12
UNIT – 3	**Robot Transformations and Sensors:** Robot kinematics-Types- 2D, 3D Transformation-Scaling, Rotation, Translation- Homogeneous coordinates, multiple transformation-Simple problems. Sensors in robot – Touch sensors-Tactile sensor – Proximity and range sensors – Robotic vision sensor-Force sensor-Light sensors, Pressure sensors.	12
UNIT – 4	**Robot Cell Design And Applications :** Robot work cell design and control-Sequence control, Operator interface, Safety monitoring devices in Robot-Mobile robot working principle, actuation using MATLAB, NXT Software Introductions-Robot applications Material handling, Machine loading and unloading, assembly, Inspection, Welding, Spray painting and undersea robot.	12
UNIT – 5	**Micro/Nano Robotics System:** Micro/Nanorobotics system overview-Scaling effect-Top down and bottom up approach- Actuators of Micro/Nano robotics system-Nano robot communication techniques-Fabrication of micro/nano grippers-Wall climbing micro robot working principles-Biomimetic robot-Swarm robot-Nanorobot in targeted drug delivery system	12
	Total	60

Text Books:

1. S.R. Deb, Robotics Technology and flexible automation, Tata McGraw-Hill Education.,2009
2. Mikell P Groover & Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, AshishDutta,Industrial Robotics, Technology programming and Applications, McGraw Hill, 2012.

Reference Books:

1. Carl D. Crane, Joseph Duffy, Kinematic Analysis of Robot manipulators, CambridgeUniversity press, 2008.
2. Fu. K. S., Gonzalez. R. C. & Lee C.S.G., "Robotics control, sensing, vision andintelligence", McGraw-Hill Book co, 1987
3. Craig. J. J. "Introduction to Robotics mechanics and control", Addison- Wesley, 1999.
4. Ray Asfahl. C., "Robots and Manufacturing Automation", John Wiley & Sons Inc.,1985.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

DEPARTMENT OF COMPUTER SCIENCE ENGINEERING

R25 M.TECH ARTIFICIAL INTELLIGENCE SYLLABUS

I Semester	LOGIC PROGRAMMING USING PROLOG & LISP	L	T	P	C
		3	0	0	3

Course Objectives:

The main objectives of the course are to

- Understand the fundamental concepts of logic-based representation using Prolog, including syntax, lists, recursion, and computation tracing.
- Learn the principles of structured representation and inheritance search, and apply abstract data types (ADTs) and search techniques in Prolog to model complex systems.
- Gain proficiency in implementing machine learning algorithms (such as Version Space Search and Explanation-Based Learning) in Prolog to create intelligent systems.
- Explore programming in Lisp, semantic networks, inheritance, and machine learning algorithms such as ID3, and understand the use of Java and object-oriented programming for building expert systems.

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Demonstrate knowledge of Prolog representation, including its syntax, lists, recursion, and the process of creating and tracing Prolog computations	K2
CO2	Apply abstract data types (ADTs) and search strategies (depth-first, breadth-first, and best-first) in Prolog to model and solve problems effectively.	K3
CO3	Implement machine learning algorithms such as Version Space Search and Explanation-Based Learning in Prolog, and understand their application in intelligent system design.	K3
CO4	Develop proficiency in Lisp programming, understanding S-expressions, recursive search, logic programming, and their application in creating intelligent systems.	K3
CO5	Understand and implement semantic networks, inheritance, and the ID3 machine learning algorithm, and develop expert systems using Java and object-oriented programming	K4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	M	L	M	L
CO2	M	M	M	H	H	M
CO3	M	L	M	H	H	M
CO4	M	M	M	H	M	M
CO5	M	M	H	H	H	H

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	Prolog Representation: Introduction, Logic-Based Representation, Prolog Syntax, Creating, Changing, and Tracing a Prolog Computation, Lists and Recursion in Prolog. **Structured Representation and Inheritance Search:** Abstract Data Types and Search, Using cut, Control Search in prolog, Abstract Data Types (ADTs) in Prolog.	12
UNIT – 2	**Depth-First, Breadth-First and Best-First Search:** Production System Search, Designing Alternative Search Strategies. **Meta-Linguistic Abstraction, Types and Meta-Interpreters:** Meta-Interpreters, Types, and Unification, Types in prolog, Unification, Variable Binding, and Evaluation.	12
UNIT – 3	**Machine Learning Algorithms in Prolog:** Machine Learning: Version Space Search, Explanation Based Learning in Prolog. **Programming in Lisp:** S-Expressions, Syntax of LISP, Lists and Recursive Search, Variables,Datatypes, High Order Functions, Logic Programming in LISP, Lisp-Shell.	12
UNIT – 4	**Semantic Networks, Inheritance and Machine Learning:** Sematic Nets, Inheritance, Object Oriented Lisp, Learning ID3 Algorithm, Implementing ID3 Algorithm	12
UNIT – 5	Java, Representation and Object-Oriented Programming, Problem Spaces and Search, A Logic-Based Reasoning System, An Expert System Shell	12
	Total	60

Text Books:

1. George F. Luger, William A. Stubblefield, Pearson Publishers, AI Algorithms, Data Structures, and Idioms in Prolog, Lisp and Java 6th Edition.

Reference Books:

1. Logic, Programming and Prolog by Ulf Nilsson, Jan Maluszynski.Wiley; 2 edition (August1995)
2. The Art of Prolog: Advanced Programming Techniques (Mit Press Series in Logic Programming), Leon Sterling and Ehud Shapiro (Oct 1986).
3. Prolog Programming for Artificial Intelligence (4^{th}Edition) (International Computer Science Series), Ivan Bratko (Aug 31, 2011)
4. Paradigms of Artificial Intelligence Programming: Case Studies in Common Lisp, PeterNorvig (Oct 15, 1991).
5. Common LISP: The Language, Guy L. Steele (Mar 16, 1984).
6. Artificial Intelligence Common LISP, 1st Edition (Hardcover) by Noyes, James S. Noyer,James L. Noyes.

I Semester	SOCIAL NETWORK ANALYSIS	L	T	P	C
		3	0	0	3

Course Objectives:

The main objectives of the course are to

1. Understand the limitations of the current Web, and explore the development and emergence of the Semantic Web and Social Web.
2. Learn about Ontology-based knowledge representation and its role in the Semantic Web, including the Resource Description Framework (RDF) and Web Ontology Language (OWL).
3. Explore the extraction and mining of social networks on the Web, including community detection and the evaluation of dynamic network data.
4. Analyze human behavior prediction, privacy issues in online social networks, and the application of trust models for online environments, alongside the visualization of social networks using graph theory.

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Describe the limitations of the current Web and explain the concepts of Semantic Web and Social Web, and their applications in modern networks.	K2
CO2	Demonstrate the ability to model and aggregate social network data, apply ontology-based knowledge representation, and utilize tools like RDF and OWL.	K3
CO3	Detect and evaluate communities in social networks, understand methods for community mining, and implement algorithms for extracting social network data.	K3
CO4	Predict human behavior in online social networks, understand privacy concerns, and explain trust models and how they are used in decentralized environments	K4
CO5	Visualize social networks using graph theory, centrality, clustering, node-edge diagrams, and matrix-based representations for applications such as collaboration networks and community welfare.	K3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	M	L	M	M
CO2	M	M	H	H	M	H
CO3	M	M	H	H	H	M
CO4	H	M	H	M	H	H
CO5	M	M	M	H	M	M

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	Introduction: Introduction to Semantic Web: Limitations of current Web, Development of Semantic Web, Emergence of the Social Web, Social Network analysis: Development of Social Network Analysis, Key concepts and measures in network analysis, Electronic sources for network analysis: Electronic discussion networks, Blogs and online communities, Web-based networks, Applications of Social Network Analysis	12
UNIT – 2	Modelling, Aggregating And Knowledge Representation: Ontology and their role in the Semantic Web: Ontology-based knowledge Representation, Ontology languages for the Semantic Web: Resource Description Framework Web Ontology Language, Modelling and aggregating social network data: State-of-the-art in network data representation, Ontological representation of social individuals, Ontological representation of social relationships, Aggregating and reasoning with social network data, Advanced representations.	12
UNIT – 3	Extraction And Mining Communities In Web Social Networks: Extracting evolution of Web Community from a Series of Web Archive, Detecting communities in social networks, Definition of community, Evaluating communities, Methods for community detection and mining, Applications of community mining algorithms, Tools for detecting communities social network infrastructures and communities, Decentralized online social networks, Multi-Relational characterization of dynamic social network communities.	12
UNIT – 4	Predicting Human Behavior And Privacy Issues: Understanding and predicting human behavior for social communities, User data management, Inference and Distribution, Enabling new human experiences, Reality mining, Context – Awareness, Privacy in online social networks, Trust in online environment, Trust models based on subjective logic, Trust network analysis, Trust transitivity analysis, Combining trust and reputation, Trust derivation based on trust comparisons, Attack spectrum and counter measures.	12
UNIT – 5	Visualization and Applications of Social Networks: Graph theory, Centrality, Clustering, Node-Edge Diagrams, Matrix representation, Visualizing online social networks, visualizing social networks with matrix-based representations, Matrix and Node-Link Diagrams, Hybrid representations, Applications, Cover networks, Community welfare, Collaboration networks, Co-Citation networks.	12
	Total	60

Text Books:

1. Peter Mika, Social Networks and the Semantic Web, First Edition, Springer 2007.
2. BorkoFurht, Handbook of Social Network Technologies and Applications, 1stEdition, Springer, 2010.

I Semester	INTELLIGENT SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:
The main objectives of this course are to
1. Understand the fundamental concepts of knowledge representation and reasoning, including various knowledge representation models such as frames, semantic nets, and rules.
2. Learn about different rule-based systems, including forward and backward reasoning techniques, and their application in problem-solving through various search methods.
3. Gain proficiency in using tools like Lisp and Prolog for knowledge representation and reasoning, and understand how expert system shells can be developed and used in real-time applications.
4. Explore qualitative reasoning methods, such as qualitative simulation, and understand the application of Petri nets for intelligent control and system analysis.

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Demonstrate the ability to represent and reason with data in various knowledge representation schemes like semantic nets, frames, and rules.	K3
CO2	Apply forward and backward reasoning techniques to solve real-world problems, and execute these methods through depth-first search, breadth-first search, and A* search.	K4
CO3	Develop knowledge-based systems using tools like Lisp and Prolog, and implement expert system shells for decision-making.	K5
CO4	Solve real-time system problems by designing intelligent subsystems and synchronizing them with real-time subsystems, using appropriate communication methods.	K4
CO5	Analyze and apply qualitative reasoning techniques like qualitative simulation and Petri nets for intelligent control and decision-making in dynamic systems.	K4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	L	M	L	M	L	H
CO2	M	L	H	M	L	M
CO3	L	M	H	H	M	L
CO4	M	L	M	H	M	M
CO5	M	M	H	L	M	H

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	**Knowledge Representation:** **Data and knowledge**: Data representation and data items in traditional databases, Data representation and data items in relational databases. Rules: Logical operations, Syntax and semantics of rules, Data log rule sets ,The dependence graph of data log rule sets, Objects Frames ,Semantic nets, Solving problems by reasoning: The structure of the knowledge base, The reasoning algorithm, Conflict resolution, Explanation of the reasoning.	12
UNIT – 2	**Rule Based Systems:** **Forward reasoning:** The method of forward reasoning, A simple case study of forward reasoning. **Backward reasoning:** Solving problems by reduction, The method of backward reasoning, A simple case study of backward reasoning, Bidirectional reasoning. Search Methods: Depth-first search, Breadth-first search, Hill climbing search, A* search. **Contradiction freeness:** The notion of contradiction freeness, Testing contradiction freeness, The search problem of contradiction freeness **Completeness:** The notion of completeness, Testing Completeness, The search problem of completeness .Decomposition of knowledge bases: Strict decomposition, Heuristic decomposition	12
UNIT – 3	**Tools for Representation and Reasoning:** **The Lisp programming language:** The fundamental data types in Lisp, Expressions and their evaluation, Some useful Lisp primitives, Some simple examples in Lisp, The Prolog programming **Language:** The elements of Prolog programs, The execution of Prolog programs, Built-in predicates, and Some simple examples in Prolog. Expert system shells: Components of an expert system shell, Basic functions and services in an expert system shell.	12
UNIT – 4	**Real-Time Expert Systems:** **The architecture of real-time expert systems**: The real-time subsystem, The intelligent subsystem. Synchronization and communication between real-time and intelligent subsystems:Synchronization and communication primitives, Priority handling and time-out. Data exchange between the real-time and the intelligent subsystems: Loose data exchange, The blackboardarchitecture. Software engineering of real-time expert systems: The software lifecycle of real-time expert systems, Special steps and tool, An Example of A Real-Time expert System.	12
UNIT – 5	**Qualitative Reasoning and Petri Nets:** Sign and interval calculus, Qualitative simulation: Constraint type	12

	qualitative differential equations, The solution of QDEs: the qualitative simulation algorithm: Initial data for the simulation, Steps of the simulation algorithm, Simulation results. Qualitative physics, Signed directed graph (SDG) models, The Notion of Petri nets, the firing of transitions, Special cases and extensions, the state-space of Petri nets the use of Petri nets for intelligent control, The analysis of Petri nets: Analysis Problems for Petri Nets, Analysis techniques.	
	Total	60

Text Books:

1. Intelligent Control Systems-An Introduction with Examples, Katalin M. Hangos, RozáliLakner , Miklós Gerzson, Kluwer Academic Publishers.

References Books:

1. Intelligent Systems and Control: Principles and Applications Paperback, 12 Nov 2009, LaxmidharBehera, IndraniKar by OXFORD.
2. Intelligent Systems and Technologies Methods and Applications, Springer publications.
3. Intelligent Systems - Modeling, Optimization and Control, Yung C. Shin and ChengyingXu, CRC Press, Taylor & Francis Group, 2009.

I Semester	ARTIFICIAL INTELLIGENCE & FUNCTIONAL PROGRAMMING LAB	L	T	P	C
		0	1	2	2

Course Objectives:

The main objectives of the course are

1. To understand and implement various search algorithms, including DFS, BFS, A*, Hill Climbing, and Simulated Annealing, in solving AI problems.
2. To develop problem-solving skills using classical AI problems like the 8-puzzle problem and Tower of Hanoi, and understand how to solve them algorithmically.
3. To understand the application of expert systems and explore the workings of expert system shells like JESS and RVD.
4. To gain proficiency in Prolog programming by implementing algorithms and solving basic problems like calculating arithmetic mean and checking **for vowels.**

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Implement and compare the performance of various search algorithms like DFS, BFS, Simulated Annealing, and A* to solve AI-related problems.	K3
CO2	Solve classical AI problems like the 8-puzzle and Tower of Hanoi using appropriate search and problem-solving techniques.	K3
CO3	Implement expert systems using JESS and RVD expert system tools to develop AI applications that mimic human decision-making.	K4
CO4	Use Prolog programming language to solve problems, such as finding the arithmetic mean and checking for vowels, with a focus on logic programming.	K3
CO5	Understand the theoretical aspects of AI and implement them in real-world scenarios through coding exercises and expert systems.	K5

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	H	H	M	L
CO2	H	M	H	H	M	L
CO3	H	M	H	H	H	M
CO4	H	M	H	H	H	M
CO5	H	M	H	H	H	M

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS
Week 1	1. Write a program to implementation of DFS
Week– 2	Write a program to implementation of BFS
Week– 3	1. Write a program to implement Simulated Annealing Algorithm 2. Write a program to find the solution for wampus world problem
Week– 4	Write a program to implement 8 puzzle problem
Week– 5	Write a program to implement Tower of Hanoi problem
Week-6	Write a program to implement A* Algorithm
Week– 7	Write a program to implement Hill Climbing Algorithm
Week– 8	To Study JESS expert system
Week– 9	1. Write a Program to Perform Fibonacci Series 2. Write a Program to Check Sides of a Triangle
Week– 10	1. Write a Program to Perform Length of List 2. Write a Program to Perform Reverse in List.
Week– 11	1. Write a Prolog program to perform Arithmetic Mean. 2. Write a Program to Check Vowels or Not.

I Semester	MACHINE LEARNING LAB	L	T	P	C
		0	1	2	2

Course Objectives:
The main objectives of the course are

1. Understand and apply various machine learning algorithms to solve classification and regression problems using real-world datasets.
2. Preprocess and analyze datasets to extract useful features for building machine learning models.
3. Evaluate and compare the performance of different machine learning models using suitable evaluation metrics.
4. Implement various machine learning algorithms such as decision trees, logistic regression, neural networks, and clustering algorithms for solving practical problems.

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Demonstrate the ability to apply machine learning algorithms to solve classification problems (e.g., Iris Species Classification, Titanic Survival Prediction).	K3
CO2	Perform data preprocessing, feature engineering, and visualization techniques to prepare datasets for machine learning models (e.g., Titanic dataset, Boston Housing dataset).	K4
CO3	Evaluate the performance of machine learning models using appropriate metrics (accuracy, F1-score, RMSE, etc.) and perform hyperparameter tuning	K5
CO4	Implement and train regression models to predict continuous values, such as stock prices and housing prices.	K3
CO5	Understand and implement natural language processing techniques for text classification tasks, such as sentiment analysis and spam email detection.	K3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	H	M	M	H	M	L
CO2	M	M	M	H	H	L
CO3	H	M	M	H	H	M
CO4	M	M	M	H	M	L
CO5	M	M	M	H	M	H

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS
Week 1	**Iris Species Classification** **Objective:** Identify the species of iris plants (setosa, versicolor, or virginica) based on the measurements of their petals and sepals. Dataset: The Iris dataset includes 150 records of iris plants, with four features: the lengths and the widths of the sepals and petals.
Week– 2	**Titanic Survival Prediction** **Objective:** Predict whether a passenger survived the Titanic disaster based on features such as age, gender, and ticket class. Dataset: The Titanic dataset includes passenger data like name, age, gender, ticket class, and survival status.
Week– 3	**Boston Housing Price Prediction** **Objective:** Predict the median value of homes in various Boston districts using features like crime rate, property tax rate, and pupil-teacher ratio. **Dataset:** The Boston Housing dataset contains information on various housing attributes along with the median value of homes in various areas of Boston.
Week– 4	**Diabetes Progression Prediction** **Objective:** Predict the progression of diabetes in patients one year after baseline using various diagnostic measurements. **Dataset:** The dataset includes measurements such as body mass index, blood sugar levels, and age, collected from a study on diabetes progression.
Week– 5	**Spam Email Detection** **Objective:** Classify emails as spam or not spam by analyzing their text content. **Dataset:** The dataset typically consists of a collection of email texts labeled as 'spam' or 'not spam'.
Week-6	**MNIST Handwritten Digit Classification** **Objective:** Recognize handwritten digits (0-9). **Dataset:** The MNIST dataset consists of 70,000 grayscale images, each 28x28 pixels, of handwritten digits. It's divided into a training set of 60,000 images and a test set of 10,000 images.
Week– 7	**Movie Recommendation System** **Objective:** Recommend movies to users based on their past viewing history and preferences. **Dataset:** Datasets for this task often include user ratings for various movies, which can be used to learn individual user's preference profiles.
Week– 8	**Stock Prices Prediction** **Objective:** Predict future stock prices based on historical price and volume data. **Dataset:** Historical stock prices data, which includes daily opening, closing, highest, and lowest prices, and volume of stocks traded.
Week– 9	**Sentiment Analysis of Text** **Objective:** Determine the sentiment (positive, negative, neutral) of

	a piece of text, such as a tweet or a product review. **Dataset:** This involves datasets containing text data with corresponding sentiment labels.
Week– 10	**Fashion-MNIST Classification** **Objective:** Classify images of clothing items into 10 categories (e.g., T-shirts, trousers, shoes). **Dataset:** Fashion-MNIST is a dataset comprising 70,000 grayscale images of 10 fashion categories, with each image being 28 × 28 pixels

Text Books:

1. AurelienGeron, Hands-On Machine Learning with Scikit-Learn and TensorFlow, Oreilly, March 2017.

Reference Books:

1. Dr. M Gopal, Applied Machine Learning, 1st Edition, McGraw-Hill,2018.
2. AurelienGeron, Hands-On Machine Learning with Scikit-Learn and TensorFlow, Oreilly,March 2017.

II Semester	GENERATIVE AI	L	T	P	C
		3	1	0	4

Course Objectives:

The main objective of this course is to

1. Understand the fundamentals of generative models and their evolution, differentiating between generative and discriminative models.
2. Explore the application of generative models in text generation, including language models like GPT, BERT, and techniques like prompt engineering and reinforcement learning from human feedback (RLHF).
3. Study generative models for image creation, including GANs, VAEs, and transformer-based models, and understand challenges like mode collapse and stability.
4. Investigate the use of generative models in creative domains (painting, music, storytelling), exploring architectures such as Cyclic GAN, MuseGAN, and autonomous agents.

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Analyze and explain the core principles and different types of generative models (e.g., GANs, VAEs, autoregressive models) and their applications.	K2
CO2	Evaluate and apply generative models to generate text, leveraging state-of-the-art architectures like GPT and BERT.	K2
CO3	Design and implement effective prompt engineering techniques, including RLHF, for improved language generation tasks.	K3
CO4	Develop and evaluate generative models for image generation, with an understanding of GANs, VAEs, and transformer-based models like DALL-E.	K3
CO5	Apply generative models for creative tasks such as generating music, paintings, and stories using architectures like Cyclic GAN and MuseGAN.	K4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	L	L	M	L
CO2	H	M	L	L	M	L
CO3	M	H	H	M	H	L
CO4	M	H	H	M	H	L
CO5	M	M	H	H	H	M

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	**Introduction To Gen AI:** Historical Overview of Generative modelling, Difference between Gen AI and Discriminative Modeling, Importance of generative models in AI and Machine Learning, Types of Generative models, GANs, VAEs, autoregressive models and Vector quantized Diffusion models, understanding if probabilistic modeling and generative process, Challenges of Generative Modeling, Future of Gen AI, Ethical Aspects of AI, Responsible AI, Use Cases.	12
UNIT – 2	**Generative Models for Text:** Language Models Basics, building blocks of Language models, Transformer Architecture, Encoder and Decoder, Attention mechanisms, Generation of Text, Models like BERT and GPT models, Generation of Text, Autoencoding, Regression Models, Exploring ChatGPT, Prompt Engineering: Designing Prompts, Revising Prompts using Reinforcement Learning from Human Feedback (RLHF), Retrieval Augmented Generation, Multimodal LLM, Issues of LLM like hallucination.	12
UNIT – 3	**Generation of Images:** Introduction to Generative Adversarial Networks, Adversarial Training Process, Nash Equilibrium, VariationalAutoencoders, Encoder-Decoder Architectures, Stable Diffusion Models, Introduction to Transformer-based Image Generation, CLIP, Visual Transformers ViT- Dall-E2 and Dall-E3, GPT-4V, Issues of Image Generation models like Mode Collapse and Stability.	12
UNIT – 4	**Generation of Painting, Music, and Play:** Variants of GAN, Types of GAN, Cyclic GAN, Using Cyclic GAN to Generate Paintings, Neural Style Transfer, Style Transfer, Music Generating RNN, MuseGAN, Autonomous agents, Deep Q Algorithm, Actor-critic Network.	12
UNIT – 5	**Open-Source Models and Programming Frameworks:** Training and Fine tuning of Generative models, GPT4All, Transfer learning and Pretrained models, Training vision models, Google Copilot, Programming LLM,LangChain, Open-Source Models, Llama, Programming for TimeSformer, Deployment, Hugging Face	12
	Total	60

Text Books:

1. Denis Rothman, "Transformers for Natural Language Processing and Computer Vision", Third Edition,Packt Books, 2024

Reference Books:

1. David Foster," Generative Deep Learning", O'Reily Books, 2024.
2. Altaf Rehmani, "Generative AI for Everyone", BlueRose One, 2024.

II Semester	NATURAL LANGUAGE PROCESSING	L	T	P	C
		3	1	0	4

Course Objectives:

The main objective of this course is to

1. Provide a foundational understanding of Natural Language Processing (NLP), its components, and different levels of language analysis.
2. Study and implement different grammatical structures and parsing techniques such as top-down, bottom-up parsing, and augmented grammars.
3. Explore the semantic interpretation of natural language, including logical forms, word senses, and the role of ambiguity in NLP tasks.
4. Understand and implement various language modeling techniques and apply them in real-world tasks, such as machine translation, multilingual retrieval, and automatic summarization.

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Identify and explain the basic concepts and techniques used in NLP, including different levels of language analysis (e.g., syntax, semantics, pragmatics).	K2
CO2	Evaluate the organization and structure of NLP systems, and identify their key components and functionalities.	K3
CO3	Implement parsing algorithms such as top-down and bottom-up parsers and analyze augmented grammars for language processing tasks.	K3
CO4	Analyze and perform semantic interpretation, resolving ambiguities and mapping language into logical forms for deeper understanding.	K4
CO5	Apply language models, including n-gram models, and implement multilingual information retrieval and automatic summarization systems.	K3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	L	L	M	M
CO2	M	M	H	M	H	M
CO3	M	H	H	M	H	M
CO4	M	H	M	H	M	M
CO5	M	H	H	M	H	M

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	**Introduction to Natural language** The Study of Language, Applications of NLP, Evaluating Language Understanding Systems, Different Levels of Language Analysis, Representations and Understanding, Organization of Natural language Understanding Systems, Linguistic Background: An outline of English Syntax.	12
UNIT – 2	**Grammars and Parsing** Grammars and Parsing- Top- Down and Bottom-Up Parsers, Transition Network Grammars, Feature Systems and Augmented Grammars, Morphological Analysis and the Lexicon, Parsing with Features, Augmented Transition Networks.	12
UNIT – 3	**Grammars for Natural Language** Grammars for Natural Language, Movement Phenomenon in Language, Handling questions in Context Free Grammars, Hold Mechanisms in ATNs, Gap Threading, Human Preferences in Parsing, Shift Reduce Parsers, Deterministic Parsers.	12
UNIT – 4	**Semantic Interpretation** Semantic & Logical form, Word senses & ambiguity, The basic logical form language, Encoding ambiguity in the logical Form, Verbs & States in logical form, Thematic roles, Speech acts & embedded sentences, Defining semantics structure model theory. **Language Modeling** Introduction, n-Gram Models, Language model Evaluation, Parameter Estimation, Language Model Adaption, Types of Language Models, Language-Specific Modeling Problems, Multilingual and Cross lingual Language Modeling.	12
UNIT – 5	**Machine Translation** Survey: Introduction, Problems of Machine Translation, Is Machine Translation Possible, Brief History, Possible Approaches, Current Status. Anusaraka or Language Accessor: Background, Cutting the Gordian Knot, The Problem, Structure of Anusaraka System, User Interface, Linguistic Area, Giving up Agreement in Anusarsaka Output, Language Bridges. **Multilingual Information Retrieval** Introduction, Document Preprocessing, Monolingual Information Retrieval, CLIR, MLIR, Evaluation in Information Retrieval, Tools, Software and Resources. **Multilingual Automatic Summarization** Introduction, Approaches to Summarization, Evaluation, How to Build a Summarizer, Competitions and Datasets.	12
	Total	60

Text Books:

1. James Allen, Natural Language Understanding, 2nd Edition, 2003, Pearson Education.
2. Multilingual Natural Language Processing Applications : From Theory To Practice-Daniel M.Bikel and ImedZitouni , Pearson Publications.
3. Natural Language Processing, A paninian perspective, Akshar Bharathi, Vineetchaitanya, Prentice –Hall of India.

References Books:

1. Charniack, Eugene, Statistical Language Learning, MIT Press, 1993.
2. Jurafsky, Dan and Martin, James, Speech and Language Processing, 2nd Edition, PrenticeHall, 2008.
3. Manning, Christopher and Henrich, Schutze, Foundations of Statistical Natural Language Processing, MIT Press, 1999.

II Semester	DEEP LEARNING	L	T	P	C
		3	1	0	4

Course Objectives:

The main objective of this course is to

1. Introduce the fundamental concepts of deep learning, including its history, foundational models (e.g., McCulloch-Pitts Neuron, Perceptrons), and the evolution of deep learning architectures.
2. Study optimization algorithms, activation functions, and regularization techniques used in deep learning models, ensuring effective training and generalization.
3. Understand and implement Convolutional Neural Networks (CNNs) and explore their applications in image processing tasks such as object detection and segmentation.
4. Dive into Recurrent Neural Networks (RNNs), sequence learning problems, LSTMs, GRUs, and explore advanced models such as attention mechanisms and graph neural networks (GNNs).

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Explain the history and evolution of deep learning models, including McCulloch-Pitts Neuron, Perceptrons, and Multi-layer Perceptrons (MLPs).	K2
CO2	Understand and implement key neural network architectures, including Feedforward Neural Networks (FFNs), Backpropagation, and the representation power of MLPs.	K3
CO3	Implement and apply various optimization algorithms such as Gradient Descent, Adam, and techniques like Xavier and He initialization for neural networks.	K3
CO4	Apply Convolutional Neural Networks (CNNs) for image-related tasks, including object detection, image segmentation, and advanced architectures like ResNet and GoogleNet.	K3
CO5	Design and implement Recurrent Neural Networks (RNNs) and advanced architectures like LSTMs, GRUs, and Encoder-Decoder models for sequence learning tasks.	K3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	L	L	M	M
CO2	H	M	H	M	H	M
CO3	H	H	H	M	H	M
CO4	H	H	H	M	H	M
CO5	H	H	H	M	H	M

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	History of Deep Learning, McCulloch Pitts Neuron, Perceptrons, Perceptron Learning Algorithm, Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent, Feedforward Neural Networks (FFNs), Representation Power of FFNs, Backpropagation	12
UNIT – 2	Optimization algorithms and activation functions: Gradient Descent (GD), Momentum based GD, stochastic GD, mini-batch GD, Adagrad, RMSProp, Adam. Initialization techniques: Xavier and He initialization. Regularization: Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Dropout, Batch Normalization	12
UNIT – 3	Convolutional Neural Networks (CNN): Convolution operation, filters, Padding and Stride, Sparse Connectivity and Weight Sharing, Max Pooling and NonLinearities. Transfer Learning and pretrained CNN architectures: AlexNet, ZFNet, VGGNet, GoogleNet, ResNet. Batch Normalization, Dropout.	12
UNIT – 4	Basic Concepts in Object Detection: Bounding box and annotation techniques, Non-maximum suppression (NMS), R-CNN and its evolution (Fast R-CNN, Faster R-CNN), You Only Look Once (YOLO) series, Single Shot MultiBox Detector (SSD) Semantic Segmentation, U-Net and its variants image segmentation, SegNet and its architecture, Instance and Panoptic Segmentation, Mask R-CNN for instance segmentation, Metrics for performance evaluation (mAP for detection, IoU for segmentation)	12
UNIT – 5	Recurrent Neural Networks (RNN): Sequence Learning problems, Intuition behind RNN, sequence classification, sequence labeling, Model, Loss function, Learning algorithm, Evaluation. Vanishing and Exploding gradient. LSTMs and GRUs, Encoder Decoder models, Attention mechanism, Graph Neural Networks (GNNs).	12
	Total	60

Text Books:

1. Bengio, Yoshua, Ian J. Goodfellow, and Aaron Courville. "Deep learning.", MIT Press(2015) .

Reference Books:

1. Bengio, Yoshua. "Learning deep architectures for AI." Foundations and trends in Machine Learning 2.1 (2009): 1127.
2. Géron, A. (2022). Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow. "O'Reilly Media, Inc.".
3. Trask, A. W. (2019). Groking deep learning. Simon and Schuster.

II Semester	DEEP REINFORCEMENT LEARNING	L	T	P	C
		3	0	0	3

Course Objectives:

The main objective of this course is to

1. Introduce the foundational concepts of Reinforcement Learning (RL), including its comparison with supervised and unsupervised learning, and its key components such as agent, environment, state, action, reward, and transitions.
2. Understand and apply Markov Decision Processes (MDPs), policies, value functions, and the Bellman equation to formulate RL problems and solve them using dynamic programming techniques.
3. Explore and implement exploration-exploitation strategies and Monte Carlo methods, including various techniques like epsilon-greedy, softmax, and UCB.
4. Understand and implement Temporal Difference (TD) learning, including advanced methods such as Q-learning, SARSA, and deep RL algorithms like DQN, DDQN, and policy gradient methods.

Course Outcomes: At the end of the course, student will be able to (Four to Six)

		Knowledge Level (K)#
CO1	Define and differentiate between supervised, unsupervised, and reinforcement learning, and explain the components of a reinforcement learning system.	K2
CO2	Formulate RL problems using Markov Decision Processes (MDPs), including defining policies, state-value functions, and action-value functions.	K3
CO3	Apply dynamic programming techniques such as policy iteration and value iteration to solve MDPs and evaluate policies.	K3
CO4	Implement exploration-exploitation strategies (e.g., epsilon-greedy, UCB) and Monte Carlo methods for policy evaluation and improvement.	K4
CO5	Apply Temporal Difference (TD) learning methods, Q-learning, SARSA, and deep reinforcement learning techniques (DQN, DDQN, and Policy Gradient methods).	K3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	L	L	M	M
CO2	H	H	M	M	H	M
CO3	H	H	M	M	H	M
CO4	M	M	H	M	H	M
CO5	H	H	H	M	H	M

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	Overview of reinforcement learning, Difference between supervised, unsupervised, and reinforcement learning, Components of reinforcement learning (agent, environment, state, action, reward, transaction function, Discount, episode), Bandit problem.	12
UNIT – 2	Understanding Markov Decision Processes (MDPs), Policy, State value function, Action value function, Bellman equation, Dynamic Programming—Policy iteration, Policy Improvement, Value iteration, and Limitations of dynamic programming.	12
UNIT – 3	Exploration and exploitation strategies- Random, Greedy, Epsilon-Greedy, Softmax, UCB. Monte Carlo Methods: First-Visit Monte Carlo, Every-Visit Monte Carlo, Monte Carlo simulation for policy evaluation.	12
UNIT – 4	Temporal Difference Learning (TD), n-step TD, Q-learning, SARSA, bootstrapping.	12
UNIT – 5	Function Approximation, linear function approximation, Deep Q-networks (DQN), Double Deep Q-networks (DDQN), Dueling Q-networks (Dueling DQN), Policy gradient methods, and Actor Critic methods.	12
	Total	60

Text Books:

1. "Reinforcement Learning: An Introduction" by Richard S. Sutton and Andrew G. Barto.

Reference Books:

1. "Grokking Deep Reinforcement Learning" by Miguel Morales, 2020.
2. Alexander Zai , Brandon Brown, Deep Reinforcement Learning in Action, 2020, 1st Edition,Manning Publications.
3. Mohit Sewak, Deep Reinforcement Learning: Frontiers of Artificial Intelligence, 2019,Springer.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

DEPARTMENT OF COMPUTER SCIENCE ENGINEERING

R25 M.TECH ARTIFICIAL INTELLIGENCE SYLLABUS

II Semester	BIG DATA ANALYTICS	L	T	P	C
		3	0	0	3

Course Objectives:

The main objective of this course is to

1. Introduce the fundamental concepts of Big Data, its importance, and the Hadoop ecosystem. Students will gain familiarity with the components and architecture of Hadoop, including its history, design, and role in data storage and processing.
2. Provide a deep understanding of Hadoop Distributed File System (HDFS), its architecture, and key concepts like file reading, writing, replication, and managing an HDFS cluster for efficient data storage and retrieval.
3. Explain the core concepts of the MapReduce programming model, including job submission, execution, and data processing. Students will learn how to write and execute distributed MapReduce jobs using Java and the Hadoop environment.
4. Familiarize students with Hive, its services, and the Hive Query Language (HQL). Students will understand how to analyze big data using Hive and compare it with traditional database systems.

Course Outcomes: At the end of the course, student will be able to (Four to Six)

		Knowledge Level (K)#
CO1	Explain the concept of Big Data, its significance, and the role of Hadoop in processing large-scale data sets.	K2
CO2	Understand the components of the Hadoop ecosystem, including Hadoop Distributed File System (HDFS), and be able to navigate the command line interface for Hadoop file management.	K3
CO3	Implement data storage and analysis tasks using HDFS, manage data replication, and perform file operations like reading, writing, and balancing the HDFS cluster.	K3
CO4	Write and execute MapReduce jobs, apply data flow principles, and configure and tune jobs for distributed processing using Hadoop.	K4
CO5	Understand the basics of Hive, execute queries in Hive QL, and compare Hive with traditional relational databases for big data processing	K3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	L	L	M	L
CO2	H	M	H	L	H	L
CO3	H	H	H	M	H	L
CO4	H	H	H	M	H	L
CO5	H	M	H	M	M	L

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	Introduction to Big Data. What is Big Data, Why Big Data is Important. Meet Hadoop Data, Data Storage and Analysis, Comparison with other systems, Grid Computing. A brief history of Hadoop. Apache hadoop and the Hadoop Ecosystem. Linux refresher, VMWare Installation of Hadoop.	12
UNIT – 2	The design of HDFS. HDFS concepts. Command line interface to HDFS.HadoopFile systems.Interfaces. Java Interface to Hadoop. Anatomy of a file read. Anatomy of a file writes. Replica placement and Coherency Model. Parallel copying with distcp, keeping an HDFS cluster balanced.	12
UNIT – 3	Introduction. Analyzing data with unix tools. Analyzing data with hadoop. Java MapReduce classes (new API). Data flow, combiner functions, Running a distributed MapReduce Job. Configuration API. Setting up the development environment. Managing configuration. Writing a unit test with MRUnit. Running a job in local job runner. Running on a cluster, Launching a job.TheMapReduceWebUl.	12
UNIT – 4	Classic Mapreduce. Job submission. Job Initialization. Task Assignment. Task execution.Progress and status updates. Job Completion. Shuffle and sort on Map and reducer side.Configuration tuning. Map Reduce Types. Input formats. Output cormats. Sorting. Map side andReduce side joins.	12
UNIT – 5	The Hive Shell. Hive services. Hive clients. The meta store. Comparison with traditional databases. Hive QI. Hbasics. Concepts. Implementation. Java and MapReduce clients. Loading data, web queries.	12
	Total	60

Text Books:

1. Tom White, Hadoop,"The Definitive Guide", 3rd Edition, O'Reilly Publications, 2012.
2. Dirk deRoos, Chris Eaton, George Lapis, Paul Zikopoulos, Tom Deutsch ,"Understanding Big
Data Analytics for Enterprise Class Hadoop and Streaming Data", 1st Edition, TMH,2012.

Reference Books:

1. Big Data and Health Analytics Hardcover Katherine Marconi (Editor), Harold Lehmann (Editor).
2. Analytics in a Big Data World: The Essential Guide to Data Science and its Applications by bartbaesens, Wiley publications.

II Semester	COMPUTATIONAL INTELLIGENCE	L	T	P	C
		3	0	0	3

Course Objectives:
The main objective of this course is to

1. Introduce the foundational concepts of Computational Intelligence (CI), including its history, evolution, the key differences between soft computing, fuzzy logic, and AI vs. hard computing.
2. Provide an in-depth understanding of evolutionary computation techniques such as genetic algorithms, evolutionary programming, and particle swarm optimization, including their applications.
3. Explore the theory, structure, and application of Neural Networks, their components, and how they are utilized in various problem-solving tasks.
4. Explain the concepts, theory, and applications of Fuzzy Systems, including fuzzy sets, fuzzy logic, and the implementation of fuzzy rule systems for computational intelligence applications.

Course Outcomes: At the end of the course, student will be able to (Four to Six)

		Knowledge Level (K)#
CO1	Define and explain the foundational concepts of Computational Intelligence and its applications in various fields such as data mining, adaptive systems, and soft computing.	K2
CO2	Understand the history and development of evolutionary computation techniques, including Genetic Algorithms, Evolutionary Programming, and Particle Swarm Optimization.	K2
CO3	Implement and evaluate evolutionary computation methods such as genetic algorithms and particle swarm optimization for optimization problems.	K4
CO4	Analyze and design neural network architectures, including their components, topologies, and applications for classification, prediction, and optimization.	K4
CO5	Implement fuzzy logic systems and fuzzy rule-based systems to solve real-world problems, and evaluate their performance in comparison to traditional methods.	K3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	L	L	M	M
CO2	M	H	M	M	H	L
CO3	H	H	H	M	H	L
CO4	H	H	H	M	H	L
CO5	M	H	H	M	H	M

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	**Introduction:** Background and history of evolutionary computation, Behavioral Motivations for Fuzzy Logic, Myths and Applications areas of Computational Intelligence. Adaption, Self organization and Evolution, Historical Views of Computational Intelligence, Adaption and Self organization for Computational Intelligence, Ability to Generalize, Computational Intelligence and Soft Computing Vs Artificial Intelligence and Hard Computing.	12
UNIT – 2	**Review of evolutionary computation theory and concepts:** History of Evolutionary Computation, Evolution Computation Overview, Genetic algorithms, Evolutionary programming, Evolution strategies, genetic programming, and particle swarm optimization.	12
UNIT – 3	**Review of basic neural network theory and concepts:** Neural Network History, What Neural Networks are and Why they are useful, Neural Networks Components and Terminology, Neural Networks Topology, Neural Network Adaption, Comparing Neural Networks and Other information Processing Methods, Preprocessing and Post Processing.	12
UNIT – 4	**Fuzzy Systems Concepts and Paradigms:** Fuzzy sets and Fuzzy Logic, Theory of Fuzzy sets, Approximate Reasoning , Fuzzy Systems Implementations , Fuzzy Rule System Implementation.	12
UNIT – 5	**Computational Intelligence Implementations:** Implementation Issues, Fuzzy Evolutionary Fuzzy Rule System Implementation, Best tools, Applying Computational Intelligence to Data Mining. **Performance Metrics:** General Issues, Percent Correct, Average Sum-squared Error.	12
	Total	60

Text Books:

1. Computational Intelligence - Concepts to Implementations, Eberhart& Shi.

Reference Books:

1. Introduction to Genetic Algorithms, Melanie Mitchell.
2. Handbook of Genetic Algorithms, Davis.
3. Machine Learning, Tom Mitchell.

II Semester	TEXT PROCESSING	L	T	P	C
		3	0	0	3

Course Objectives:

The main objective of this course is to

1. Introduce the fundamental concepts and components of the Information Environment, including types of information, automated office systems, and file management techniques.
2. Provide an in-depth understanding of text processing, including text editing, formatting, compression, encryption, and the underlying principles of statistical and cryptographic methods.
3. Explore text retrieval systems, with a focus on traditional and advanced models, indexing techniques, and automatic indexing methods to improve information retrieval efficiency.
4. Investigate advanced information retrieval models, language analysis and understanding, automatic text transformations, and the integration of paperless information systems in modern office environments.

Course Outcomes: At the end of the course, student will be able to (Four to Six)

		Knowledge Level (K)#
CO1	Understand and explain the role of automated information systems in the modern office environment, including file management systems, display systems, and information retrieval techniques.	K2
CO2	Implement text processing techniques, including text editing, formatting, compression, and encryption, using appropriate software tools and algorithms.	K3
CO3	Develop text retrieval systems using advanced indexing techniques, including inverted indexing, term-phrase formation, and multi-key access methods.	K3
CO4	Apply advanced information retrieval models (such as Vector Space Model, Probabilistic Retrieval Model) for efficient document classification, search, and retrieval.	K4
CO5	Investigate and implement automatic text transformation techniques such as automatic abstracting, automatic text generation, and automatic translation, integrating them into modern paperless systems.	K5

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	L	L	L	M	M
CO2	M	H	H	M	H	L
CO3	M	H	M	M	H	L
CO4	M	H	H	M	H	L
CO5	M	M	H	M	H	M

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	The Information Environment- Automatic information processing, Types of information. The Automated Office - The Office Environment, Analyzing Office Systems, File Management Systems, Office Display Systems, Office-Information Retrieval. Text Editing and Formatting- Introduction, Approaches to word Processing, Text Editing & Formatting, Typical processing systems, Automatic typesetting systems.	12
UNIT – 2	Text Compression-Statistical language characteristics, rationale for text compression, Text compression methods. Text Encryption- Basic cryptographic concepts, Conventional cryptographic systems, DES. File Accessing Systems- Basic concepts, Sequential search, single key Indexed searches, Tree searching, Balanced Search Trees, Multiway Search Trees, Hash-Table Access, Indexed Searches for Multikey Access, Bitmap Encoding for Multikey Access.	12
UNIT – 3	Conventional Text-Retrieval Systems- Database Management and Information Retrieval, Text Retrieval Using Inverted Indexing Methods, Typical File Organization, Text-scanning systems, Hardware aids to text searching. Automatic Indexing - Indexing Environment, Indexing Aims,Single – term Indexing Theories, Term Relationships in Indexing, Term-phrase Formation,Thesaurus-Group Generation, A blue print for Automatic indexing.	12
UNIT – 4	Advanced Information-Retrieval Models- The Vector Space Model, Automatic Document Classification, Probabilistic Retrieval Model, Extended Boolean Retrieval Model, Integrated System for Processing Text and Data, Advanced Interface Systems. Language Analysis and Understanding- The Linguistic Approach, Dictionary Operations, Syntactic Analysis, Knowledge-based Processing, Specialized Language Processing.	12
UNIT – 5	Automatic Text Transformations- Text transformations, Automatic writing Aids, Automatic abstracting systems, Automatic Text Generation, Automatic Translation. Paperless Information Systems- Paperless Processing, Processing Complex Documents, Graphics	12

	Processing, SpeechProcessing, Electronic Mail and Messages, Electronic Information Services, Electronic Publications and the Electronic Library.	
	Total	60

Text Books:

1. Gerald Salton, "Automatic Text Processing", Addison-Wesley, 1989.

Reference Books:

1. Bran Boguraev, Ted Briscoe (Eds), "Computational Lexicography for Natural Language Processing", Longman, 1989.
2. A V Aho, Ravi Sethi, J D Ullman, "Compilers: Principles, Techniques and Tools",Addison-Wesley.
3. Robert Sedgewick, "Algorithms in C", Addison Wesley, 1990.

II Semester	GENETIC ALGORITHMS & APPLICATIONS	L	T	P	C
		3	0	0	3

Course Objectives:

The main objective of this course is to

1. Introduce students to the foundations of Genetic Algorithms (GA), including their working principles, mathematical foundations, and comparison with traditional optimization methods.
2. Explain the working of GA operators, such as selection, crossover, mutation, and fitness scaling, and their role in optimizing solutions for complex problems.
3. Explore real-world applications of Genetic Algorithms, including function optimization, multi-objective optimization, and parallel processes, with a focus on practical use cases.
4. Provide an understanding of Genetics-Based Machine Learning (GBML), including classifier systems, rule-based systems, and the bucket brigade algorithm, and their current and historical applications.

Course Outcomes: At the end of the course, student will be able to (Four to Six)

		Knowledge Level (K)#
CO1	Understand and explain the fundamental concepts of Genetic Algorithms, including their comparison to traditional optimization methods and the role of schemata in GA.	K2
CO2	Implement and experiment with GA operators such as selection, crossover, and mutation, and apply them to various optimization problems.	K3
CO3	Solve real-world optimization problems using Genetic Algorithms, including multi-objective optimization and parallel processing techniques.	K3
CO4	Design and implement Genetics-Based Machine Learning systems using classifier systems and rule-based approaches.	K4
CO5	Critically evaluate and apply advanced GA techniques such as dominance, diploidy, niche & speciation, and knowledge-based techniques to improve problem-solving in machine learning and optimization.	K4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	L	L	L	M	L
CO2	M	M	H	M	M	L
CO3	M	H	H	M	M	M
CO4	M	M	H	M	M	M
CO5	M	H	H	M	M	L

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	**INTRODUCTION TO GENETIC ALGORITHM** **Introduction to Genetic Algorithm:** Robustness of Traditional Optimization and Search methods, Goals of optimization, GA versus Traditional methods, Simple GA, GA at work, Similarity templates (Schemata), Learning the lingo **Mathematical foundations:** The fundamental theorem, Schema processing at work. 2-armed & k-armed Bandit problem. Building Block Hypothesis. Minimal deceptive problem.	12
UNIT – 2	**GA OPERATORS** Data structures, Reproduction, Roulette-wheel Selection, Boltzman Selection, Tournament Selection, Rank Selection, Steady state selection, Crossover mutation, A time to reproduce, a time to cross. Get with the Main program. How well does it work. Mapping objective functions to fitness forum. Fitness scaling. Coding, A Multi parameter, Mapped, Fixed point coding, Discretization, constraints	12
UNIT – 3	**APPLICATIONS OF GA** The rise of GA, GA application of Historical Interaction. Dejung& Function optimization, Current applications of GA **Advanced operators & techniques in genetic search :** Dominance, Diploidy& abeyance, Inversion& other reordering operators. other mine-operators, Niche & Speciation, Multi objective optimization, Knowledge-Based Techniques.GA & parallel processes, Real life problem	12
UNIT – 4	**INTRODUCTION TO GENETICS-BASED MACHINE LEARNING** Genetics Based Machine learning, Classifier system, Rule & Message system, Apportionment of credit: The bucket brigade, Genetic Algorithm, A simple classifier system in Pascal. Results using the simple classifier system.	12
UNIT – 5	**APPLICATIONS OF GENETICS-BASED MACHINE LEARNING** The Rise of GBMC, Development of CS-1, the first classifier system. Smitch's Poker player, Other Early GBMC efforts. Current Applications.	12
	Total	60

Text Books:

1. David E. Gold Berg, "Genetic Algorithms in Search, Optimization & Machine Learning",Pearson Education, 2001.
2. S.Rajasekaran, G.A.VijayalakshmiPai, " Neural Networks, Fuzzy Logic and GeneticAlgorithms ", PHI , 2003 (Chapters 8 and 9).

Reference Books:

1. Kalyanmoy Deb, "Optimization for Engineering Design, algorithms and examples", PHI 1995
2. An Introduction to Genetic Algorithm by Melanie Mitchell.
3. The Simple Genetic Algorithm Foundation &Theories by Michael P. Vosk.

II Semester	BIO-INSPIRED COMPUTING	L	T	P	C
		3	0	0	3

Course Objectives:

The main objective of this course is to

1. Introduce the fundamentals of evolutionary algorithms and their components, including representation, evaluation, selection, variation, initialization, and termination conditions, using case studies from cellular systems and artificial life.
2. Provide an understanding of neural systems, focusing on biological and artificial neural networks, their architecture, and learning methods (supervised, unsupervised, reinforcement learning), and their applications in artificial intelligence and hybrid systems.
3. Explore the concepts of developmental and immune systems, emphasizing evolutionary developmental programs, biological immune systems, and their application to artificial immune algorithms, including case studies on algorithms like the Negative Selection and Clonal Selection algorithms.
4. Study behavioral systems with a focus on cognition, behavior-based robotics, the co-evolution of body and control, and the evolution of self-replicating robots, integrating real-world applications and simulations for intelligent robotic behavior.

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Understand the core principles of evolutionary algorithms, including key components such as representation, fitness functions, and selection mechanisms.	K2
CO2	Apply neural network architectures and learning algorithms, including supervised, unsupervised, and reinforcement learning, to solve AI problems in various domains.	K3
CO3	Implement and evaluate evolutionary developmental and immune systems, including algorithms like Negative Selection and Clonal Selection, for solving optimization and classification problems.	K3
CO4	Design and simulate behavior-based robotic systems, exploring the co-evolution of body and control, and applying AI techniques for self-replication and learning in robots.	K4
CO5	Apply hybridization techniques, such as memetic algorithms, in combination with evolutionary algorithms to optimize complex problems, including job shop scheduling and other AI applications.	K4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	L	L	L	M	L
CO2	M	M	H	M	M	M
CO3	M	M	H	M	M	L
CO4	M	H	H	M	M	M
CO5	M	H	H	M	M	L

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	Introduction To Evolutionary Algorithm: Evolutionary algorithm, components of evolutionary algorithm representation (definition of individuals), Evaluation function (Fitness function), Population, parent selection Mechanism, Variation Operators, Survivor Selection Mechanism (Replacement), Initialization, Termination Condition, evolutionary algorithm case study: Cellular systems, cellular automata, modeling with cellular systems, other cellular systems, computation with cellular systems, artificial life: analysis and synthesis of cellular systems.	12
UNIT – 2	Neural Systems: Biological nervous systems, artificial neural networks, neuron models, architecture, signal encoding, synaptic plasticity, unsupervised learning, supervised learning, reinforcement learning, evolution of neural networks, hybrid neural systems, case study. Developmental And Immune Systems: Rewriting system, synthesis of developmental system, evolutionary rewriting systems, evolutionary developmental programs, biological immune systems, lessons for artificial immune systems, algorithms and applications, shape space, negative selection algorithm, clonal selection algorithm.	12
UNIT – 3	Behavioral Systems: Behavior is cognitive science, behavior in AI, behavior-based robotics, biological inspiration for robots, robots as biological models, robot learning, evolution of behavioral systems, learning in behavioral systems, co-evolution of body and control, towards self-reproduction, simulation and reality.	12
UNIT – 4	Genetic Algorithms: Representation of Individuals, Mutation, Recombination, Population Models, Parent Selection, Survivor Selection, Example Application: Solving a Job Shop Scheduling Problem HYBRIDIZATION WITH OTHER TECHNIQUES: MEMETIC ALGORITHMS: Introduction to Local Search, Lamarckianism and the Baldwin Effect, Structure of a Memetic Algorithm, Heuristic or Intelligent Initialization, Hybridization within Variation Operators: Intelligent Crossover and Mutation, Local Search Acting on the output from Variation Operators, Hybridization During	12

	the Genotype to Phenotype Mapping, Design Issues for Memetic Algorithms.	
UNIT – 5	Collective Systems: Biological self-organization, Particle Swarm Optimization (PSO), antcolony optimization (ACO), swarm robotics, co-evolutionary dynamics, artificial evolution of competing systems, artificial evolution of cooperation, case study.	12
	Total	12

Text Books:

1. D. Floreano and C. Mattiussi, "Bio-Inspired Artificial Intelligence", MIT Press, 2008.
2. Tao Song, Pan Zheng, Mou Ling Dennis Wong, Xun Wang, "Bio-Inspired ComputingModels and Algorithms", ISBN: 978-981-3143-19-7, world scientific, 2019 F.
3. Neumann and C. Witt, "Bioinspired Computation in combinatorial optimization: Algorithmsand their computational complexity", Springer, 2010.

Reference Books:

1. D. E. Goldberg, "Genetic algorithms in search, optimization, and machine learning",Addison- Wesley, 1989.
2. Simon O. Haykin, "Neural Networks and Learning Machines", Third Edition, Prentice Hall,2008.

II Semester	GENERATIVE AI LAB	L	T	P	C
		0	1	2	2

Course Objectives:
The main objective of this course is to
1. Understand and implement basic operations in TensorFlow 2 for deep learning tasks, including tensor manipulations, gradients, and optimizations.
2. Design and implement Generative Adversarial Networks (GANs) and related advanced techniques (e.g., Wasserstein GANs, StyleGANs) for image generation, applying best practices in model training, evaluation, and hyperparameter tuning.
3. Apply Generative AI techniques to various domains such as text, music, and video generation, using deep learning architectures like LSTMs, Transformers, and pre-trained models for specific applications.
4. Experiment with model fine-tuning, transfer learning, and the evaluation of generative models for real-world applications like story generation, art creation, and music composition.

Course Outcomes: At the end of the course, student will be able to (Four to Six)

		Knowledge Level (K)#
CO1	Implement basic TensorFlow 2 operations and tensor manipulations for building deep learning models.	K2, K3
CO2	Design, train, and evaluate Generative Adversarial Networks (GANs) for image generation tasks using various datasets like MNIST and CIFAR-10.	K3, K4
CO3	Experiment with advanced GAN techniques, such as Wasserstein GANs, Progressive GANs, and StyleGANs, to generate high-quality images.	K4, K5
CO4	Develop and fine-tune language models for text generation tasks using LSTMs and Transformer-based architectures (e.g., GPT, BERT).	K3, K4
CO5	Apply Generative AI models for music and video generation tasks, exploring novel representations and training methodologies to create artistic or synthetic content.	K4, K5

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	L	M	L	M
CO2	M	H	H	H	M	L
CO3	M	H	H	M	M	L
CO4	M	H	M	H	L	M
CO5	L	M	M	L	H	M

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS
Week 1	Write Python scripts to implement basic operations and TensorFlow 2 tensors
Week– 2	Implement a Generative Adversarial Network (GAN) architecture using TensorFlow 2. Train the GAN model on a dataset such as MNIST or CIFAR-10 for image generation tasks.
Week– 3	Train a GAN model on a custom dataset for image generation. Experiment with hyper parameters, loss functions, and optimization techniques to optimize GAN training.
Week– 4	Explore advanced techniques such as Wasserstein GANs, Progressive GANs, or Style GANs for image generation. Implement and compare these techniques for generating high-quality images.
Week– 5	Develop applications for image and video generation using trained Generative AI models. Use the models to generate art, create deep fakes, or synthesize video content.
Week-6	**Text Generation:** Implement a Long Short-Term Memory (LSTM) network using Tensor Flow 2 for text generation tasks. Train the LSTM model on a dataset of text sequences and generate new text samples.
Week 7	**Text generation:** Implement a Transformer-based language model (e.g., GPT) using TensorFlow 2for text generation. Fine-tune the model on a text corpus and generate coherent and contextually relevant text.
Week– 8	**Text generation:** Fine-tune a pre-trained language model (e.g., GPT, BERT) using transfer learning techniques. Fine-tune the model on a domain-specific dataset and evaluate its performance for text generation tasks.
Week– 9	**Text generation:** Develop applications for text generation tasks such as story generation, dialogue generation, or code generation using trained Generative AI models.
Week– 10	**Music Generation:** Preprocess music data and represent it in a suitable format for music generation tasks. Explore MIDI or audio representations for training Generative AI models.
Week– 11	**Music Generation:** Implement a Long Short-Term Memory (LSTM) network using TensorFlow 2 for music generation. Train the LSTM model on a dataset of music sequences and generate new musical compositions.
Week-12	**Generate Novel Music Compositions:** Transformer-based Music Generation: Implement a Transformer-based architecture (e.g.,Music BERT, Music GPT) using Tensor Flow 2 for music generation. Fine-tune the model on a musicdata set and generate novel music compositions.

Text Books:

1. Responsible AI: Implementing Ethical and Unbiased Algorithms, Shashin Mishra, SrayAgarwal

2. Generative AI in Practice: 100+ Amazing Ways Generative Artificial Intelligence is Changing Business andSociety, Bernard Marr

Reference Books:

1. “Generative AI with Python and TensorFlow 2: Create images, text, and music with VAEs, GANs, LSTMs,Transformer models”, Joseph Babcock, Raghav Bali
2. "Generative Adversarial Networks: An Overview", Vinod Nair, Geoffrey E. Hinton.
3. "Hands-On Generative Adversarial Networks with PyTorch 1.x", StefanoBosisi, Vijayabhaskar

II Semester	DEEP LEARNING LAB	L	T	P	C
		0	1	2	2

Course Objectives:

The main objective of this course is to

1. Learn how to implement and optimize basic machine learning models like gradient descent and neural networks from scratch to minimize a cost function.
2. Gain practical experience in building and training Convolutional Neural Networks (CNNs) for image classification and Recurrent Neural Networks (RNNs) for sequential data analysis.
3. Learn how to use pre-trained models and fine-tune them for new tasks, and understand how advanced deep learning architectures (like GANs and GNNs) work.
4. Implement deep learning solutions for tasks such as sentiment analysis, stock price prediction, and language detection, applying data augmentation and advanced techniques for improving model performance.

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Implement basic machine learning algorithms, including gradient descent and neural network optimization, from scratch to minimize cost functions.	K3
CO2	Build and train Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) using Tensor Flow and PyTorch for image classification and sequential data prediction tasks.	K3
CO3	Apply transfer learning with pre-trained models such as VGG16, ResNet, and Mobile Net to solve image classification problems.	K4
CO4	Develop Generative Adversarial Networks (GANs) to generate synthetic data and solve image generation tasks.	K5
CO5	Solve real-world problems in NLP (Sentiment Analysis), time-series forecasting (Stock Prediction), and language detection using neural networks and advanced deep learning techniques.	K3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	H	M	L	L	L
CO2	H	M	M	H	M	M
CO3	M	M	H	M	M	M
CO4	M	H	L	H	L	L
CO5	M	M	H	H	H	H

Experiments	CONTENTS
Week 1	**Implementing Gradient Descent Algorithm from Scratch** **Objective:** Understand and implement the gradient descent optimization algorithm to minimize a simple cost function.
Week– 2	**Data Preprocessing** **Objective:** Load, reshape, normalize, and preprocess data for a neural network model. This includes converting labels to one-hot encoding
Week– 3	**Building and Training Neural Networks using Tensorflow** **Objective:** Build, train, validate, and infer with a neural network using Keras, and learn to save and reload the model
Week– 4	**Building and Training Neural Networks using PyTorch** **Objective:** Build, train, validate, and infer with a neural network using PyTorch, and learn to save and reload the model
Week– 5	**Binary Classification of Images** **Objective:** Create a CNN that can differentiate between cat and dog images. **Dataset:** Cats vs. Dogs Dataset (commonly found on Kaggle)
Week-6	**Multiclass Classification of Images** **Objective:** Build a simple convolutional neural network (CNN) to classify images Datasets: MNIST, Fashion-MNIST and CIFAR-10
Week 7	**Implementing Data Augmentation** **Objective:** Apply data augmentation techniques to enhance the training dataset for a neural network, improving model robustness and helping prevent overfitting.
Week– 8	**Transfer Learning for Image Classification** **Objective:** Utilize a pre-trained model (like VGG16, ResNet, or MobileNet) as a feature extractor and fine-tune it to classify a new set of images. **Dataset:** Use the Oxford 102 Flowers dataset for flower classification or the Stanford Cars dataset for car classification.
Week– 9	**Sentiment Analysis** **Objective:** Train a neural network to classify movie reviews from the IMDB dataset as positive or negative. **Dataset:** IMDB Movie Reviews
Week– 10	**Stock Prices Prediction** **Objective:** Build a model using RNNs to predict future stock prices based on historical price data. **Dataset:** Any stock price historical data
Week– 11	**Language Detection** **Objective:** Train a neural network to detect the language of a given text snippet. **Dataset:** WiLI-2018, a benchmark dataset for language identification

Week-12	**Generative Adversarial Network (GAN)** **Objective:** Generate digits by training a GAN on Identify the Digits (MNIST) dataset
Week-13	**Graph Neural Network (GNN)** **Objective:** Implement and explore basic Graph Neural Network (GNN) architectures to solve problems related to molecular data **Dataset:** Molecule Net (Tox-21)

Text Books:

1. Chollet, François. "Deep Learning with Python," Manning Publications, 2017.

Reference Books:

1. Deep Learning by Ian Goodfellow, Yoshua Bengio and Aaron Courville, MIT Press.
2. The Elements of Statistical Learning by T. Hastie, R. Tibshirani, J. Friedman, Springer.
3. Probabilistic Graphical Models. Koller, N. Friedman, MIT Press.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

DEPARTMENT OF COMPUTER SCIENCE ENGINEERING

R25 M.TECH ARTIFICIAL INTELLIGENCE SYLLABUS

II Semester	**RESEARCH METHODOLOGY AND IPR**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Outcomes: On completion of this course, the student will be able to:

		Knowledge Level (K)#
CO1	Identify and formulate research problems, design investigative approaches, and apply appropriate data collection and analysis methods.	K3,K4
CO2	Conduct effective literature reviews, maintain research ethics, and prepare structured technical reports and research proposals.	K2,K6
CO3	Explain the nature and types of Intellectual Property Rights and processes for patenting innovations nationally and internationally.	K2
CO4	Analyze patent rights, licensing processes, technology transfer, and the use of patent databases.	K4
CO5	Evaluate recent developments in IPR, including biological systems, software, and traditional knowledge through case studies.	K5

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	H		H	M		M
CO2	H	H	H			M
CO3	M		H			M
CO4	M		H			M
CO5	M		H			M
CO6						

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations	12

UNIT – 2	Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee	12
UNIT – 3	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	12
UNIT – 4	Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.	12
UNIT – 5	New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	12
	Total	60

REFERENCES:

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’”
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
3. Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners”
4. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
5. Mayall, “Industrial Design”, McGraw Hill, 1992.
6. Niebel, “Product Design”, McGraw Hill, 1974.
7. Asimov, “Introduction to Design”, Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, 2016.T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008.