M.D. UNIVERSITY, ROHTAK

SCHEME OF STUDIES AND EXAMINATION
(Under NEP-2020)

Bachelor of Technology 2nd Year

B. Tech. (Robotics & Artificial Intelligence)

'H' Scheme (Under NEP-2020)

Effective from:
Academic Session 2026-27 (for 2nd Year)

1. Definition of Credit:

1 Hr. Lecture (L) per week	1 credit
1 Hr. Tutorial (T) per week	1 credit
1 Hr. Practical (P) per week	0.5 credits
2 Hours Practical (Lab) per week	1 credit

2. Structure of the Undergraduate Engineering program:

Sr. No.	Category
1	Humanities and Social Sciences including Management courses
2	Basic Science Courses
3	Engineering Science courses
4	Program Core Courses (Branch specific)
5	Professional Elective courses relevant to chosen specialization/branch
6	Open Elective Courses (from Humanities, Technical Emerging or other Subjects)
7	Project work, Seminar and Internship in Industry or elsewhere
8	Mandatory Courses [Environmental Sciences, Induction Program, Indian Constitution, Essence of Indian Knowledge Tradition] etc. (non-credit)

3. Course code and definition:

Course Code	**Definitions**
L	Lecture
T	Tutorial
P	Practical
BSC	Basic Science Courses
ESC	Engineering Science Courses
HSMC	Humanities and Social Sciences including Management courses
PCC	Professional Core Courses
LC	Laboratory Courses
MC	Mandatory Courses
PT	Practical Training
PEC	Professional Elective courses
OEC	Open Elective courses
PRROJ/SEM	Seminar Employment Enhancement Courses (Project/Summer Internship/ Seminar)

PROGRAM OUTCOMES (PO)

Engineering Graduates will be able to:

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PSO (Program Specific Outcomes):

PSO1:Apply principles of robotics, electronics, mechanics, control systems, and embedded systems to design, develop, and deploy robotic solutions for industrial, healthcare, agricultural, and service applications.

PSO2:Develop intelligent systems using Artificial Intelligence, Machine Learning, Deep Learning, Computer Vision, and Natural Language Processing techniques to enable autonomous decision-making and smart automation.

PSO3:Integrate AI algorithms with robotic hardware and software platforms to build autonomous, adaptive, and human-centric robotic systems capable of operating in dynamic environments

Semester-3

Sr. No.	Course Code	Course Title	Hours per week		Total Contact Hrs. per week	Credit	Examination Scheme (Marks)				Duration of Exam (Hours)
			L	P			Internal awards	Theory	Practical	Total	
1	26PCC-CSE-203H	Python Programming	3	0	3	**3**	25	50		75	3
2	26PCC-CSE-201H	Data Structure & Algorithms	3	0	3	**3**	25	50		75	3
3	26PCC-RAI-205-H	Digital Logic and Computer Architecture	3	0	3	**3**	25	50		75	3
4	26PCC-RAI-207-H	Fundamentals of Robotics & AI	3	0	3	**3**	25	50		75	3
5	26PCC-AIML-221-H	Artificial Intelligence	3	0	3	**3**	25	50		75	3
6	26BSC-MATH-201H	Mathematics-III(Multivariable Calculus and Differential Equations)	3	0	3	**3**	30	70		100	3
7	26LC-CSE-213H	Python Programming Lab	0	2	2	**1**	5		20	25	3
8	26LC-CSE-211H	Data Structure & Algorithms Using C LAB	0	2	2	**1**	5		20	25	3
9	26LC-AIML-215-H	Artificial Intelligence Lab	0	2	2	**1**	5		20	25	3
10	26-LC-RAI-217-H	Digital Logic Design Lab	0	2	2	**1**	5		20	25	3
				Total	27	**22**				575	
				Foi Honors course							
1	26PCC-RAI-211-H	Drives for Robot System	3	0	3	3	25	50		75	3
2	26LC-RAI-213-H	Drives for Robot System Lab	0	2	2	1	5		20	25	3
				Total	5	4				100	

* Mathematics is mandatory for branches where eligibility for admission to B. Tech requires Mathematics as a compulsory Subject.

Course code	26PCC-CSE-203H				
Category	Professional Core Course				
Course title	**Python Programming**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-3**
	3	**0**	**0**	**3**	
Classwork	25Marks				
Exam	50Marks				
Total	75Marks				
Duration of Exam	03 Hours				

Note: The examiner will set a total of 9 questions. Question one will carry questions from all units, and the remaining eight questions will be set by taking two questions from each unit. The students have to attempt five questions in total, with the first being compulsory and selecting one from each unit. All questions will carry equal marks.

COURSE OBJECTIVES

- To impart the basic concepts of Python programming.
- To understand syntax of Python language
- To create dynamic applications in Python language.
- To implement object-oriented concepts using Python language

COURSE OUTCOMES

CO1: Develop scripts using primitive language constructs of Python.

CO2: Identify the methods to manipulate primitive Python data structures.

CO3: Make use of Python standard libraries for programming.

CO4: Build scripts for performing file operations.

CO5: Illustrate the concepts of Object-Oriented Programming as used in Python.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	-	2	-	-	-	-	-	-	1	-	-
CO2	3	3	2	-	2	-	-	-	-	-	-	1	1	-
CO3	2	2	2	1	3	-	-	-	1	-	-	2	2	1
CO4	2	2	2	2	3	-	-	-	1	1	-	2	1	1
CO5	3	3	3	1	3	-	-	1	1	1	1	2	2	2
WT. AVG	2.6	2.4	2	1.34	2.6			1	1	1	1	1.6	1.5	1.34
									Overall Mapping of Subject					1.61

UNIT-I

Introduction: Installing Python; basic syntax, interactive shell, editing, saving, and running a script; data types; variables, assignments; numerical types; arithmetic operators and expressions; Loops and selection statements, Control statements String manipulations: subscript operator, indexing, slicing a string; text files: reading/writing text and numbers from/to a file; creating and reading a formatted file

UNIT-II

Lists, dictionary and Design with functions: Basic list operators, replacing, inserting, removing an element; searching and sorting lists; dictionary literals, adding, and removing keys, accessing and replacing values; traversing dictionaries. Hiding redundancy, complexity; arguments and return values; Program structure and design. Recursive functions.

UNIT-III

Simple graphics and image processing: Simple graphics, Turtle operations, manipulating turtle screen, drawing two dimensional shapes, examining an object attribute, taking a random walk, Color and RGB scheme, Image processing: Image manipulation operations, properties of images, image module, copying, blurring and reducing image. Graphical User Interfaces: Terminal based and GUI based programs, Simple GUI-Based Programs, Windows and Window Components, Input and Output with Entry Fields, Defining and Using Instance Variables

UNIT-IV

Object Oriented concepts: Classes and OOP: classes, objects, attributes and methods; defining classes; design with classes, data modeling; Inheritance, polymorphism, operator overloading; abstract classes; exception handling, try block. Multithreading, Networks, And Client/Server programming

Alternative NPTEL/SWAYAM Course:

	Course Name	Instructor	Host Institute
1	The joy of computing using python	Prof. Sudarshan Iyengar	IIT, Ropar

Suggested Text Books/ Reference Books:

1. FundamentalsofPython:First Programs" Kenneth Lambert,CourseTechnology,Cengage Learning, 2012

2. Introduction to Computer Science Using Python: A Computational Problem-Solving Focus", By Charles Dierbach, John Wiley & Sons, December 2012,

Course code	26PCC-CSE-201H				
Category	Professional Core Course				
Course title	**Data Structure &Algorithms**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-3**
	3	**0**	**0**	**3**	
Classwork	25Marks				
Exam	50 Marks				
Total	75Marks				
Duration of Exam	03 Hours				

Note: The examiner will set a total of 9 questions. Question one will carry questions from all units, and the remaining eight questions will be set by taking two questions from each unit. The students have to attempt five questions in total, with the first being compulsory and selecting one from each unit. All questions will carry equal marks.

COURSE OBJECTIVES

- To impart the basic concepts of data structures and algorithms.
- To understand concepts about searching and sorting techniques
- To understand basic concepts about stacks, queues, lists trees and graphs.
- Toenablethemtowritealgorithmsforsolvingproblemswiththehelpoffundamentaldata structures

COURSE OUTCOMES

CO1: Understanding of abstract data types

CO2: Design, implement and analyze linear data structures, such as lists, queues, and stacks, according to the needs of different applications.

CO3: Implement and analyze the sorting and hashing techniques

CO4: Design, implement, and analyze efficient tree structures to meet requirements such as searching, indexing, and sorting

CO5: Model problems as graph problems and implement efficient graph algorithms to solve them

CO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PS O 1**	**PS O 2**	**PS O 3**
CO1	1	2	2	3	1	-	-	-	2	-	2	1	-	-
CO2	2	3	2	2	2	-	-	-	2	-	2	3	2	-
CO3	2	2	3	2	3	-	-	-	3	-	2	3	2	1
CO4	2	2	3	2	3	-	-	-	3	-	2	3	2	1
CO5	3	3	3	3	1	-	-	-	3	-	2	3	2	1
WT. AVG	2	2.4	2.6	2.4	2				2.6		2	2.6	2	3
							Overall Mapping of Subject						2.36	

UNIT I

Introduction: Basic Terminologies: Concept of Data Structures, Choice of right Data Structure. algorithms, how to design and develop algorithm, Complexity of algorithm. Operations: insertion, deletion, traversal etc.; Analysis of an Algorithm, Searching: Linear Search and Binary Search and their complexity analysis.

UNIT II

Stacks and Queues: Stack and its operations: Algorithms and their complexity analysis, Applications of Stacks: Expression Conversion and Evaluation -corresponding algorithms and complexity analysis. Queue and its operations: Algorithms and their complexity analysis, Types of Queues: Simple Queues, Circular Queues, and Priority Queues.

UNIT III

Linked Lists: Singly linked lists: Representation in memory, Algorithms of several operations: Traversing, Searching, Insertion, Deletion; Linked representation of Stack and Queue; Header linked list, doubly linked list, Circular Linked Lists: operations on it and algorithmic analysis and the complexity analysis.

Trees: Basic Tree Terminologies, Different types of Trees: Binary Tree, Binary Search Tree, AVL Tree; Tree operations on each of the trees and their algorithms with complexity analysis. Applications of Binary Trees. M-way Trees, B Trees, B+ Trees: definitions, algorithms and analysis.

UNIT IV

Sorting and Hashing: Objective and properties of different sorting algorithms: Selection Sort, Bubble Sort, Insertion Sort, Selection Sort Quick Sort, Merge Sort, Heap Sort; Analysis and Comparison of different sorting algorithms.

Graph: Basic Terminologies and Representations, Graph search and traversal algorithms and complexity analysis. Minimum Spanning Tree: Kruskal's Algorithm, Prim's Algorithm.

Alternative NPTEL/SWAYAM Course:

	Course Name	**Instructor**	**Host Institute**
1	Programming, Data structure and algorithms using python	Prof. Madhavan Mukund	Chennai Mathematical institute

Suggested Text Books/ Reference Books:

1. "Fundamentals of Data Structures", Illustrated Edition by Ellis Horowitz, Sartaj Sahni, and Computer Science Press

2. Algorithms,Data Structures,andProblemSolvingwithC++",IllustratedEditionbyMarkAllenWeiss,Addison-Wesley Publishing Company

3. "How to Solve it by Computer", 2nd Impression by R.G. Dromey, Pearson Education.

Course code	26PCC-RAI-205-H				
Category	Professional Core Course				
Course title	**Digital Logic and Computer Architecture**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-3**
	3	**0**	**0**	**3**	
Class work	25Marks				
Exam	50Marks				
Total	75Marks				
Duration of Exam	03 Hours				

Note: The examiner will set a total of 9 questions. Question one will carry questions from all units, and the remaining eight questions will be set by taking two questions from each unit. The students have to attempt five questions in total, with the first being compulsory and selecting one from each unit. All questions will carry equal marks.

COURSE OBJECTIVES

- To express real-life problems in logic design terminology.
- To use Boolean algebraic formulations to design digital systems.
- To design using combinational/sequential circuits
- To understand the Instruction execution stages and the functions of the various computer hardware components.

COURSE OUTCOMES

CO1: Describe the representation of data using binary, octal and hexadecimal numbering systems

CO2: Apply logic gates and universal logic gates to design and analyze combinational circuits

CO3: Analyze the operation and design of sequential circuits using flip-flops and registers

CO4: Evaluate the performance and design considerations of fast adders and multipliers in computer arithmetic.

CO5: Access the characteristics and functionalities of different types of memory systems, including cache memories and virtual memories.

CO6: Demonstrate proficiency in accessing and managing I/O devices, Interrupts, and standard I/O interfaces in computer system.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PS O 1	PS O 2	PS O 3
CO1	3	2	1	-	1	-	-	-	-	-	-	2	-	2
CO2	3	3	2	-	2	-	-	-	-	-	-	3	-	-
CO3	3	3	3	-	2	-	-	-	-	-	-	3	-	-
CO4	3	3	2	1	3	-	-	-	-	-	-	3	2	-
CO5	3	3	2	2	3	-	2	-	-	-	-	2	-	-
CO6	3	3	2	1	2	1	-	-	-	2	-	2	-	2
WT. AVG	3	2.8	2	1.34	2.1	1	2			2		2.5	2	2
							Overall Mapping of Subject						2.06	

UNIT-I

Number Systems & Digital Logic Circuits Overview: Data Representation, point ; Number base conversions, complements, codes, Logic Functions- Basic Logic Functions, Logic gates, universal logic gates, Boolean Algebra,Minimisation and realisation of switching circuits/logical expressions; Combinational circuits **;** Design of synchronous sequential circuits.

UNIT-II

Computer Arithmetic: Algorithms for fixed point and floating point addition, subtraction, multiplication and division operations. Hardware Implementation of arithmetic and logic operations, High performance arithmetic.

Instruction Set & Addressing: Memory Locations and Addresses, Machine addresses and sequencing, Various Addressing Modes, Instruction Formats, Basic Machine Instructions. IA-32 Pentium example.

UNIT-III

Processor Organization: CPU, ALU ,Register Transfers, Execution of Instructions, Multiple Bus Organization, Control unit design: hardwired and microprogrammed;Memory Organization: Concept of Memory, RAM, ROM memories, memory hierarchy, cache memories, virtual memory, secondary storage, memory management requirements.

UNIT-IV

Input / Output Organization: Introduction to I/O, Interrupts- Hardware, Enabling and disabling Interrupts, Device Control, Programmed I/O, Direct memory access, buses, interface circuits, standard I/O Interfaces.

Alternative NPTEL/SWAYAM Course:

	Course Name	Instructor	Host Institute
1	Advanced Computer architecture	Prof. Smruti R Sarangi	IIT, Delhi

Suggested Text Books/ Reference Books:

1. Digital Logic and Computer Design–Third Edition, M.Morris Mano, Pearson Education/PHI.
2. Computer Organization–Carl Hamacher, Zvonko Vranesic, Sawatzky, fifth edition, McGraw Hill.
3. Computer Architecture and Organisation: An Integrated Approach, Miles Murdocca, Vincent Heuring, Second Edition, Wiley India.
4. Computer Systems Architecture–M.Moris Mano, IIIEdition, Pearson.
5. Computer Organisation and Architecture–William Stallings, Sixth Edition,2010, Pearson
6. Computer Organisation and Design-David A.Paterson and JohnL. Hennessy, Elsevier.
7. Fundamentals or Computer Organization and Design, -SivaramaDandamudi SpringerInt.Edition.
8. Fundamentals of Logic Design, Roth,5thEdition, Thomson.

Course code	26PCC-RAI-207-H				
Category	Professional Core Course				
Course title	**FUNDAMENTALS OF ROBOTICS & AI**				
Scheme and Credits	L	**T**	**P**	**Credits**	**Semester-3**
	3	**0**	**0**	**3**	
Classwork	25Marks				
Exam	50Marks				
Total	75Marks				
Duration of Exam	03 Hours				

Note: The examiner will set a total of 9 questions. Question one will carry questions from all units, and the remaining eight questions will be set by taking two questions from each unit. The students have to attempt five questions in total, with the first being compulsory and selecting one from each unit. All questions will carry equal marks.

COURSE OBJECTIVES

At the end of the course, the students will be able to:

- Differentiate types of robots and robot grippers.
- Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation and learning.
- Understand AI, its current scope and limitations, and societal implications.

COURSE OUTCOMES

CO1: Understand the fundamentals of robots and their components.

CO2: Design and develop kinematic operation for a robotic manipulator.

CO3: Understand different algorithms for path planning and navigation.

CO4: Apply AI and Robotics technologies using basic programming and machine learning.

CO5: Understand societal and business impact of AI and Robotics technologies.

CO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	2	2	1	1	1	1	1	2	1	2	3	2
CO2	3	2	3	2	2	2	1	2	1	2	2	3	3	2
CO3	3	2	3	2	3	2	2	2	2	2	2	3	3	2
CO4	3	1	2	3	3	2	2	2	2	2	2	3	3	2
CO5	3	1	2	2	3	1	2	2	2	2	2	2	3	2
WT. AVG	3	1.6	2.4	2.2	2.4	1.6	1.6	1.8	1.6	2	1.8	2.6	3	2
								Overall Mapping of Subject						2.11

UNIT-I

Introduction: Introduction to Robotics-classification with respect to geometrical configuration (Anatomy), Industrial robots' specifications. Selection based on the Application. Controlled system& chain type: Serial manipulator & Parallel Manipulator. Components of Industrial robotics: precision of movement, resolution, accuracy & Repeatability-Dynamic characteristics- speed of motion, load carrying capacity & speed of response.

UNIT-II

Sensors, Drives and Grippers: Characteristics of sensing devices, Criterion for selections of sensors, Classification, & applications of sensors. Internal sensors: Position sensors, & Velocity sensors, External sensors: Proximity sensors, Tactile Sensors, & Force or Torque sensors.

Drives – Basic types of drives. Advantages and Disadvantages of each type. Selection / suitability of drives for Robotic application. Controllers, Types of Controllers and introduction to close loop controller Grippers, Mechanical Gripper-Grasping force, mechanisms for actuation, Magnetic gripper vacuum cup gripper considerations in gripper selection & design.

UNIT-III

Kinematics of Manipulators: Kinematics-Manipulators Kinematics, Rotation Matrix, Homogeneous Transformation Matrix, D-H transformation matrix, D-H method of assignment of frames. Direct and Inverse Kinematics for industrial robots. Differential Kinematics for planar serial robots

Robot Applications: Material transfer and machine loading/unloading, processing operations assembly and inspection. Programming and Languages: Methods of robot programming, Introduction to various languages such as RAIL and VAL II …etc., Features of each type and development of languages for recent robot systems.

UNIT-IV

Introduction to Artificial Intelligence: Overview: foundations, scope, problems, and approaches of AI. Intelligent agents: reactive, deliberative, goal driven, utility-driven, and learning agents, Artificial Intelligence programming techniques.

Alternative NPTEL/SWAYAM Course:

	Course Name	**Instructor**	**Host Institute**
1	Robotics: Basics and selected advances concepts	Prof. Astitva Ghosal	IISc Bangalore

Suggested Text Books/ Reference Books:

1. Sabrie Soloman, Advanced Robotics, Khanna Book Publishing Co., 2023.

2. John J. Craig, Introduction to Robotics, Pearson Education Inc., Asia, 3rd Edition, 2005.

3. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press, 2006.

4. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, 2019.

5. M.C. Trivedi, A Classical Approach to Artificial Intelligence, Khanna Book Publishing, 2023.

6. S. Mukherjee, Robotics Process Automation, Khanna Book Publishing, 2021.

7. Dr. Rajiv Chopra, Data Science with AI, ML, DL, Khanna Book Publishing, 2023

8. A. B. Bhattacharya, Debasish RoyExploring Tomorrow (The Comprehensive Guide to Robotics and Automation), Khanna Publishing House.

Course code	**26PCC-AIML-221 H**				
Category	Professional Core course				
Course title	**Artificial Intelligence**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-3**
	3	**0**	**0**	**3**	
Classwork	25 Marks				
Exam	50Marks				
Total	75Marks				
Duration of Exam	03 Hours				

Note: The examiner will set a total of 9 questions. Question one will carry questions from all units, and the remaining eight questions will be set by taking two questions from each unit. The students have to attempt five questions in total, with the first being compulsory and selecting one from each unit. All questions will carry equal marks.

COURSE OBJECTIVES

- To provide a historical perspective of AI and its foundation.
- To provide the most fundamental knowledge to the students so that they become familiar with basic principles of AI towards problem solving, inference, knowledge representation and learning.
- Explore the application of AI techniques in Expert systems, Neural Networks.
- Explore the current trends, potential, limitations, and implications of AI.

COURSE OUTCOMES

CO1: Display the understanding of the historical perspective of AI and its foundation.
CO2: Apply basic principles of AI in solutions that require problem solving, inference, knowledge representation and learning.
CO3: Demonstrate fundamental understanding of various applications of AI techniques in Expert systems, Neural Networks.
CO4: Demonstrate an ability to share in discussion of AI, it's the current trends, limitations, and implications of AI.

CO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**POS 2**	**POS 3**
CO1	3	2	1	-	1	-	-	-	-	-	-	-	2	-
CO2	3	3	3	2	3	-	-	-	1	-	-	1	3	2
CO3	3	2	2	2	3	-	-	-	1	1	-	1	3	2
CO4	2	2	1	1	2	2	1	2	2	3	1	-	2	1
WT. AVG	2.75	2.25	1.75	1.25	2.25	2	1	2	1	1	1	2	2.25	1.25
								Overall Mapping of Subject						1.58

UNIT I

Introduction: Definition of AI, History of AI, nature of AI problems, examples of AI problems. Problem solving by search: Uninformed Search: Depth First Search (DFS), Breadth First Search (BFS). Informed Search: Best First Search, A*. Local Search: Hill Climbing. Problem Reduction Search: AO*. Population-Based Search: Ant Colony Optimization, Genetic Algorithm. Game Playing: MinMax Algorithm, Alpha-Beta Pruning.

UNIT II

Knowledge Representation: Types of Knowledge, Knowledge Representation Techniques/schemes: Propositional Logic, Predicate Logic, Semantic nets, Frames. Knowledge representation issues. Rule-based systems

UNIT III

Reasoning under Uncertainty: Basics of Probability Theory, Probabilistic Reasoning, Bayesian Reasoning, Dempster-Shafer Theory. Planning: Introduction to Planning, Representation of Planning, Partial-order Planning.

UNIT IV

Learning: Introduction to Learning, Types of Learning: Learning by Induction, Rote Learning, Symbol Based Learning, Identification Trees, Explanation Based Learning, Transformational Analogy, Introduction to Neural Networks, Expert Systems, Current trends in Artificial Intelligence

Alternative NPTEL/SWAYAM Course:

	Course Name	**Instructor**	**Host Institute**
1	Artificial Intelligence: Knowledge Representation and reasoning	Prof. Deepak Khemani	IIT, madras

Suggested Text Books/ Reference Books:

1. Artificial Intelligence: A Modern Approach Third Edition Stuart Russell and Peter Norvig, 2010, Pearson Education.

Suggested reference books:

1. Elaine Rich, Kevin Knight, & Shivashankar B Nair, Artificial Intelligence, McGraw Hill, 3rd ed.,2009.
2. Introduction to Artificial Intelligence & Expert Systems, Dan W Patterson, PHI.,2010.
3. Artificial intelligence, Patrick Henry Winston, 1992, Addition Wesley 3 Ed.

Course code	26BSC-MATH-201 H				
Category	Basic Science Course				
Course title	**Mathematics-III (Multivariable Calculus and Differential Equations)**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-3**
	3	**0**		**3**	
Classwork	2 5 Marks				
Exam	50 Marks				
Total	75Marks				
Duration of Exam	03Hours				

Note: The examiner will set a total of 9 questions. Question one will carry questions from all units, and the remaining eight questions will be set by taking two questions from each unit. The students have to attempt five questions in total, with the first being compulsory and selecting one from each unit. All questions will carry equal marks.

COURSE OBJECTIVES

The studentswill learn:

- Todealwithfunctionsofseveralvariablesandevaluatepartialderivatives.
- Themathematicaltoolsneededinevaluatingmultipleintegralsandtheirusage.
- The effective mathematical tools for the solutions ofordinary differential equations that model physical processes.

COURSE OUTCOMES

CO1: Apply partial derivatives and Jacobians in multivariable functions

CO2: Evaluate multiple integrals and apply them to real-world problems

CO3: Use vector calculus concepts and integral theorems

CO4: Solve first-order differential equations in engineering applications

CO5: Solve higher-order differential equations and model physical systems

CO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	-	-	-	-	-	-	-	-	-	2	2	2
CO2	3	3	1	-	-	-	-	-	-	-	-	2	1	1
CO3	3	3	2	1	-	-	-	-	-	-	-	3	1	2
CO4	3	3	2	-	-	-	-	-	-	-	-	3	2	2
CO5	3	3	2	1	-	-	-	-	-	-	-	3	2	3
WT. AVD	3	2.8	1.4	1								2.6	1.6	2
									Overall Mapping of Subject					2.05

UNIT-I

Sequences and Series: Convergence of sequence and series, Tests for convergence: Comparison test, Cauchy's Root test, D' Alembert's Ratio test, Raabe's test, Logarithmic test, Gauss test, Cauchy's Integral test, Alternating series, Absolute and conditionally convergent series, Fourier series, Half range sine and cosine series

UNIT-II

Multivariable Differential Calculus: Functions of several variables: Limit and Continuity, Partial derivatives, Homogeneous functions, Euler's Theorem, Total derivative, Local maxima and minima for function of two variables, Lagrange's method of undetermined multipliers, Gradient of a scalar field and Directional derivative, Divergence and Curl of a vector field

UNIT-III

Multivariable Integral Calculus: Double integral, change of order of integration, Triple integral, Change of variable (Cartesian to polar coordinate) for double and (Cartesian to Spherical and Cylindrical polar coordinates) for triple integrals, Line integral, Surface integral, Volume integral, Green, Stokes and Gauss theorems (without proof) and their applications.

UNIT-IV

Differential Equations: First order linear equations, Bernoulli's equations, Exact differential equations, Equations reducible to exact differential equations, Linear differential equations of second and higher order, Complete solution, Complementary function and Particular integral, Method of variation of parameters to find particular integral, Cauchy's and Legendre's linear equations

Alternative NPTEL/SWAYAM Course:

	Course Name	**Instructor**	**Host Institute**
1	Multivariable calculus	Prof. S. K Gupta	IIT, Roorkee

Reference Books:

1. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, Pearson Education.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley &Sons.
3. B.V. Ramana, Higher Engineering Mathematics, Tata McGraw-Hill Publishing Company Limited.
4. N.P. Baliand Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications.
5. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers.
6. W.E. Boyce and R.C.DiPrima, Elementary Differential Equations and Boundary Value Problems, Wiley India.
7. S.L. Ross, Differential Equations, Wiley India.
8. E.A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India.
9. E.L. Ince, Ordinary Differential Equations, Dover Publications

Course code	26LC-CSE-213H				
Category	LaboratoryCourse				
Course title	**Python Programming Lab**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-3**
	0	**0**	**2**	**1**	
Classwork	05Marks				
Exam	20 Marks				
Total	25 Marks				
Duration of Exam	03Hours				

COURSE OBJECTIVES

- To write, test, and debug simple Python programs.
- To implement Python programs with conditionals and loops.
- Use functions for structuring Python programs.
- Represent compound data using Python lists, tuples, and dictionaries.
- Read and write data from/to files in Python.

LIST OF EXPERIMENTS: -

1. Write a program that calculates income tax.
2. Write a program that computes an investment report.
3. Write a program that computes square roots.
4. Write a program that computes the Flesch Index and grade level for text stored in a text file.
5. Write a program that generates sentences.
6. Write a program that emulates a nondirective psychotherapist.
7. Write a program that allows the user to obtain information about the file system.
8. Write a program that allows the user to draw a particular c-curve in varying degrees.
9. Write a program that allows the user to play and study the game of craps.
10. Write a program that simulates a simple ATM.
11. Replace the terminal-based interface of the ATM program with a GUI.
12. Write a program that supports an online chat room.

Suggested Books:

1. “Fundamentals of Python: First Programs” Kenneth Lambert, Course Technology, Cengage Learning, 2012

Note: Students must perform at least 10 experiments.

1). Each laboratory class/section shall not be more than about 20 students.

2). To allow fair opportunity of practical hands-on experience to each student, each experiment may either be done by each student individually or in group of not more than 3-4 students. Larger groups are strictly discouraged/disallowed.

3). Pre-experimental & post-experimental quiz /questions may be offered for each lab experiment to reinforce &aid comprehension of the experiment.

Course code	26LC-CSE-211H				
Category	Laboratory Course				
Course title	**Data Structures and Algorithms Lab Using C**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-3**
	0	**0**	**2**	**1**	
Branches (B.Tech.)	Computer Science and Engineering				
Classwork	05Marks				
Exam	20 Marks				
Total	25 Marks				
Duration ofExam	03Hours				

List of Experiments:

1. Write a menu driven program those implements following operations (using separate functions) on a linear array:
   - Insert a new element at end as well as at a given position
   - Delete an element from a given whose value is given or whose position is given
   - To find the location of a given element
   - To display the elements of the linear array
2. Write a menu driven program that maintains a linear linked list whose elements are stored in on ascending order and implements the following operations (using separate functions):
   - Insert a new element
   - Delete an existing element
   - Search an element
   - Display all the elements
3. Write a program to demonstrate the use of stack (implemented using linear array) in converting arithmetic expression from infix notation to postfix notation.
4. Program to demonstrate the use of stack (implemented using linear linked lists) in evaluating arithmetic expression in postfix notation.
5. Program to demonstration the implementation of various operations on a linear queue represented using a linear array.
6. Program to demonstration the implementation of various operations on a circular queue represented using a linear array.
7. Program to demonstration the implementation of various operations on a queue represented using a linear linked list (linked queue).
8. Program to illustrate the implementation of different operations on a binary search tree.
9. Program to illustrate the traversal of graph using breadth-first search
10. Program to illustrate the traversal of graph using depth-first search.
11. Program to sort an array of integers in ascending order using bubble sort.
12. Program to sort an array of integers in ascending order using selection sort.
13. Program to sort an array of integers in ascending order using insertion sort.
14. Program to sort an array of integers in ascending order using merge sort.

15. Program to sort an array of integers in ascending order using quick sort.
16. Program to sort an array of integers in ascending order using heap sort.
17. Program to sort an array of integers in ascending order using shell sort.
18. Program to demonstrate the use of linear search to search a given element in an array.
19. Program to demonstrate the use of binary search to search a given element in a sorted array in ascending order.

Suggested books

1. "Data Structures with C", by Lipschutz Seymour, McGraw Hill Education India.

Course code	26 LC-AIML-215-H				
Category	Laboratory Course				
Course title	**Artificial Intelligence Lab**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-3**
	0	**0**	**2**	**1**	
Classwork	05Marks				
Exam	20 Marks				
Total	25 Marks				
Duration of Exam	03Hours				

COURSE OBJECTIVES

1. To instill the basic principles of Applied Sciences to enable students learn technical subjects effectively.

2. To equip students with innovative skills that improve their practical understanding enabling them to solve real-world challenges effectively.

3.To enhance students' team-building skills and leadership qualities continuously through social, cultural, and environmental activities.

List of Programs

List of Program:

1. Write a Program to Implement Breadth First Search using Python.
2. Write a Program to Implement Depth First Search using Python.
3. Write a Program to Implement Tic-Tac-Toe game using Python.
4. Write a Program to implement 8-Puzzle problem using Python.
5. Write a Program to Implement Water-Jug problem using Python.
6. Write a Program to Implement Travelling Salesman Problem using Python.
7. Write a Program to Implement Tower of Hanoi using Python.
8. Write a Program to Implement Monkey Banana Problem using Python.
9. Write a Program to Implement Missionaries-Cannibals Problems using Python.
10. Write a Program to implement 8-Queens Problem using Python.

Note: At least 5 to 10 more exercises to be given by the teacher concerned.

Course code	26LC-RAI-217-H				
Category	LaboratoryCourse				
Course title	**Digital Logic Design Lab**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-3**
	0	**0**	**2**	**1**	
Classwork	05Marks				
Exam	20Marks				
Total	25Marks				
Duration of Exam	03Hours				

COURSE OBJECTIVES

- To understand and verify the operation of basic logic gates and Boolean algebra principles through practical implementation.
- To design and implement combinational logic circuits such as adders, subtractors, multiplexers, demultiplexers, encoders, and decoders.
- To design and analyse sequential circuits including flip-flops, counters, and shift registers using digital ICs.
- To develop skills in designing, simulating, and troubleshooting digital circuits using hardware components and simulation tools.
- To apply digital logic design concepts in solving real-world engineering problems and developing simple digital systems.

List of Experiments

1. Realization of Logic gates using discrete components, verification of truth table for logic gates, realization of basic gates using NAND and NOR gates
2. Implementation of Logic Circuits by verification of Boolean laws and verification of De Morgans.
3. Design of Decoder and Encoder
4. Design of Multiplexer and De multiplexer
5. Design of Magnitude Comparator
6. Design of Mealy and Moore circuit
7. Implementation of Shift registers
8. Design of 4-bit Counter
9. Design of Ring Counter.
10. Addition and Subtraction of 8/16-bit number
11. Multiplication of 8-bit number
12. Factorial of a given number
13. Design of Half Adder
14. Design of Full Adder
15. Square root of a number
16. Program to realize delay and stimulus in simple circuit
17. Design and implement code converters using logic gates simulation

18. Registers and Counters
19. Program to implementation of Flip-Flop
20. Implementation of different circuits to solve real world problems
21. Implementation of different circuits to solve real world problems

TEXT BOOKS:

1. Digital Logic & Computer Design – Third Edition, M.Morris Mano, Pearson Education/PHI.
2. Computer Organization – Carl Hamacher, Zvonko Vranesic, Safwat Zaky, fifth edition, McGraw Hill.
3. Computer Architecture and Organization- An Integrated Approach, Miles Murdocca, Vincent Heuring, Second Edition, Wiley India.
Computer Systems Architecture – M.Moris Mano, IIIrd Edition, Pearson.

Course code	26PCC-RAI-211-H				
Category	Professional Core Course				
Course title	**Drives for Robot Systems**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-3**
	3	**0**	**0**	**3**	
Classwork	25Marks				
Exam	50Marks				
Total	75Marks				
Duration of Exam	03 Hours				

Note: The examiner will set a total of 9 questions. Question one will carry questions from all units, and the remaining eight questions will be set by taking two questions from each unit. The students have to attempt five questions in total, with the first being compulsory and selecting one from each unit. All questions will carry equal marks.

COURSE OBJECTIVES

- Analyze DC drive, Induction and Synchronous Motors Drives.
- Evaluate the steady state behavior and basic operating characteristics of A.C Machine.
- Understand the basics of electric drives and fundamentals of drive dynamics.
- Demonstrate analytical skills to assess machine performance in steady state.
- Analyze the integration of the hydraulic drives & pneumatic drives in robotic systems

COURSE OUTCOMES:

CO1: Understand different types of robot drive systems and their characteristics

CO2: Analyze and select appropriate electrical drives for robotic applications

CO3: Apply power electronics and control techniques for motor drives

CO4: Understand and compare hydraulic and pneumatic drive systems

CO5: Design and implement advanced and intelligent drive systems for robots

CO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	1	-	1	-	-	-	-	-	-	3	1	2
CO2	3	3	2	1	2	-	-	-	-	-	-	3	1	2
CO3	3	3	3	2	3	-	-	-	1	-	-	3	2	3
CO4	2	2	2	1	2	1	1	-	-	-	-	3	1	2
CO5	3	3	3	2	3	-	-	1	2	1	1	3	3	3
WT. AVG	2.8	2.6	2.2	1.5	2.2	1	1	1	1.5	1	1	3	1.6	2.4
								Overall Mapping of Subject						1.77

UNIT I

D.C. Motors & Other Motors Principles of working, Significance of back emf, Torque Equation, Types, Characteristics and Selection of DC Motors, Starting of DC Motors, Speed Control, Losses and Efficiency, Condition for Maximum Efficiency, Braking of DC Motors, Effect of saturation and

armature reaction on losses; Applications, Permanent Magnet DC Motors, Type and Routine tests. PMAC and BLDC motor drives, Stepper motor drives, switched reluctance motor drives.

UNIT II

Synchronous Motors and Asynchronous Motor Construction, types, armature reaction, circuit model of synchronous machine, determination of synchronous reactance, pharos diagram, power angle characteristics, parallel operation of synchronous generators, synchronizing to infinite bus bars, two axis theory, synchronous motor operation, dynamics, modeling of synchronous machine, PM synchronous machines. Types of induction motor, flux and mmf waves, development of circuit model, power across air gap, torque and power output, starting methods, speed control, induction generator, induction machine dynamics, high efficiency

UNIT III

Electric Drives, Dynamics and Control Definition, Advantages of electrical drives, Components of Electric drive system, Selection Factors, speed control and drive classifications, Motor Load Dynamics, Speed Torque conventions and multi quadrant operation, Equivalent values of drive parameters. Load Torque Components, Nature and classification of Load Torques, Constant Torque and Constant Power operation of a Drive, Steady state stability, Load epilation and selection motors.

UNIT IV

Performance & Control of Induction and Synchronous Motor Drives Induction motor analysis, starting and speed control methods- voltage and frequency control, current control, closed loop control of induction motor drives, rotor resistance control, slip power recovery – Static Kramer and Scher Bius Drive, Single phase induction motor starting, braking and speed control. Synchronous motor operation with fixed frequency, variable speed drives

Suggested books:

1. D. P. Kothari, I. J. Nagrath, “Electric Machines”, Tata McGraw Hill Publication, Fourth edition, reprint 2012.

2. A.E. Fitzgerald, Charles Kingsley Jr., Stephen D. Umans, “Electric Machinery”, Tata McGraw Hill Publication, sixth edition, 2002.

Course code	26LC-RAI-213-H				
Category	Laboratory Course				
Course title	**Drives for Robot System Lab**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-3**
	0	**0**	**2**	**1**	
Branches (B.Tech.)	Robotics and AI				
Classwork	05Marks				
Exam	20 Marks				
Total	25 Marks				
Duration of Exam	03Hours				

NOTE:

1. Lab programs/activities can be designed and developed by the subject faculty using Robo Studio or any suitable Open-Source tools/ software.
2. Min 10 Lab activities will be carried out from the offered course contents of Drives for Robot System Course in the semester.
3. Study of various Data Sources

Listof Programs

1 To study PN junction diode and draw its characteristics?
2 Explain the working of half - wave and Full – wave rectifiers with waveforms?
3 Draw and explain characteristics of NPN transistors in CE configuration. Also explain working of CE configuration as an amplifier?
4 Draw and explain characteristics of Zener diode and also explain working of Zener diode as voltage regulator?
5 To design inverting and non – inverting amplifier?
6 Explain working of summing and difference amplifier with neat diagram?
7 Draw and explain working of integrator and differentiator?
8 Explain working of IC 555 as stable and mono-stable multivibrator?
9 Explain working of Universal gates with truth table?
10 Explain working of Half – subtractor and adder?
11 Explain working of Full - adder and subtractor?
12 Draw block diagram of microprocessor/microcontroller and also explain working of the same?
13 Explain working of Multiplexer and Demultiplexer with neat diagram?
14 Explain working of JK and RS flip flop with neat diagram?

Semester-4

Sr. No.	Course Code	Course Title	Hours per week		Total Contact Hrs. per week	Credit	Examination Scheme (Marks)				Duration of Exam (Hours)
			L	P			Internal awards	Theory	Practical	Total	
1	26PCC-CSE-206H	Database Management System	3	0	3	**3**	25	50		75	3
2	26PCC-RAI-204-H	Advances in Robotics and Artificial Intelligence	3	0	3	**3**	25	50		75	3
3	26PCC-CSE-205H	Operating System	3	0	3	**3**	25	50		75	3
4	26PCC-RAI-208-H	Programming for Data Science & AIML	3	0	3	**3**	25	50		75	3
5	26PCC-RAI-210-H	Sensors and Actuators for Robotics	3	0	3	**3**	25	50		75	3
6	26PCC-CSE-207-H	Software Engineering	3	0	3	**3**	25	50		75	3
7	PEC	Professional Elective courses —I Or Basic Science Course	3	0	3	**3**	25	50		75	3
8	26LC-CSE-215H	Operating System Lab	0	2	2	**1**	5		20	25	3
9	26LC-RAI-208-H	Programming for Data Science & AI Lab	0	2	2	**1**	5		20	25	3
10	26LC-CSE-212H	Database Management System Lab	0	2	2	**1**	5		20	25	3
11	26AU-ENV-202-H	Environmental Science [3rd/4th Sem]	2	1	3	**0**	Refer Note 1				
				Total	30	**24**				600	
				Foi Honors course							
1	26PCC-RAI-212-H	Robot Safety & Maintenance	3	0	3	3	25	50		75	3
2	26LC-RAI-214-H	Robot Safety & Maintenance Lab	0	2	2	1	5		20	25	3
				Total	5	4				100	

Professional Professional Elective courses —I or Basic Science Course

1. Elective Course-I (26 PEC-RAI-202-H) Mobile and Micro-robotics (Tract: Robotics)
2. Elective Course-I (26 PEC-RAI-204-H) Data Analytics (Tract: AI)
3. Elective Course-I (26 PEC-RAI-206-H) Intelligent Manufacturing (Tract: Mechatronics)
4. Elective Course-I (26 PEC-RAI-208-H) Microcontroller Architecture and Programming (Tract: Control Systems)

Note-1: AU/MC is a mandatory non–credit course in which students will be required to obtain passing marks in theory. The marks in this qualifying paper will not be included in determining the percentage of marks obtained for the award of degree. However, these marks will be shown in detailed marks certificate of student.

Marks Distribution:

- Internal Assessment: 30 marks
- Theory Examination: 70 marks

The institute will conduct the theory examination at its own level.

Note-2: At the end of the 4th semester, each student has to undergo Practical Training of 4/6 weeks in an Industry/ Institute/ Professional organization/ Research Laboratory/ training centre, etc., and submit a typed report along with a certificate from the organization& its evaluation shall be carried out in the 5th Semester.

Course code	26PCC-CSE-206H				
Category	Professional Core Course				
Course title	**Database Management System**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-4**

	3	**0**	**0**	**3**	
Classwork	25Marks				
Exam	50Marks				
Total	75Marks				
Duration of Exam	03 Hours				

Note: The examiner will set a total of 9 questions. Question one will carry questions from all units, and the remaining eight questions will be set by taking two questions from each unit. The students have to attempt five questions in total, with the first being compulsory and selecting one from each unit. All questions will carry equal marks.

COURSE OBJECTIVES

- To understand the different issues involved in the design and implementation of a database system.
- To study the physical and logical database designs, database modelling, relational, hierarchical, and network models
- To understand and use a manipulation language to query, update, and manage a database
- To develop an understanding of essential DBMS concepts such as: database security, integrity, concurrency, distributed database, intelligent database, Client/Server (Database Server), and Data Warehousing.
- To design and build a simple database system and demonstrate competence with the fundamental tasks involved with modelling, designing, and implementing a DBMS.

COURSE OUTCOMES

CO1: Construct SQL queries using relational algebra
CO2: Design a database using ER model and normalize the database
CO3: Construct queries to handle transaction processing and maintain the consistency of the database
CO4: Compare and contrast various indexing strategies and apply the knowledge to tune the performance of the database
CO5: Appraise how advanced databases differ from relational databases and find a suitable database for the given requirement.

CO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	2	3	2	1	-	-	-	2	1	1	1	2	1	3
CO2	3	1	1	1	1	-	-	-	2	3	3	3	3	1	2
CO3	3	2	3	2	1	-	-	-	2	1	1	2	2	3	3
CO4	1	2	3	2	-	-	-	-	3	2	3	3	1	2	3
CO5	1	1	3	3	2	-	-	-	1	3	3	1	2	2	2
Wt. AVG	2	1.6	2.6	2	1	-	-	-	1.8	2.2	2.2	2	2	1.8	2.6
									Overall Mapping of Subject						1.98

UNIT: I

Database system architecture: Data Abstraction, Data Independence, Data Definition Language (DDL), Data Manipulation Language (DML). Data models: Entity-relationship model, network model, relational and object-oriented data models, integrity constraints, data manipulation operations.

UNIT: II

Relational query languages: Relational algebra, Tuple and domain relational calculus, SQL3, DDL and DML constructs, Open source and Commercial DBMS - MYSQL, ORACLE, DB2, SQL server.

Relational database design: Domain and data dependency, Armstrong's axioms, Normal forms, Dependency preservation, Lossless design.

Query processing and optimization: Evaluation of relational algebra expressions, Query equivalence, Join strategies, Query optimization algorithms.

UNIT: III

Storage strategies: Indices, B-trees, hashing, Transaction processing: Concurrency control, ACID property, Serializability of scheduling, Locking and timestamp-based schedulers, multi-version and optimistic Concurrency Control schemes, Database recovery.

UNIT: IV

Database Security: Authentication, Authorization and access control, DAC, MAC and RBAC models, Intrusion detection, SQL injection.

Advanced topics: Object oriented and object relational databases, Logical databases, Web databases, Distributed databases, Data warehousing and data mining.

Alternative NPTEL/SWAYAM Course:

	Course Name	**Instructor**	**Host Institute**
1	Introduction to Database system	Prof. Sreenivasa Kumar	IIT, Madras

Suggested Text Books/ Reference Books:

1. DatabaseSystemConcepts,6thEditionbyAbrahamSilberschatz,HenryF. Korth,S.Sudarshan,McGraw- Hill.

2. Principles of Database and Knowledge-Base Systems, Volume 1 by J. D. Ullman, Computer Science Press.

3. Fundamentals of Database Systems, 5th Edition by R. Elmasri and S. Navathe, Pearson Education.

4. Foundations of Databases (Reprint Edition) by Serge Abiteboul, Richard Hull, and Victor Vianu, Addison-Wesley.

Course code	26PCC-RAI-204-H				
Category	Professional Core Course				
Course title	**ADVANCES IN ROBOTICS AND ARTIFICIAL INTELLIGENCE**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-4**
	3	**0**	**0**	**3**	
Classwork	25Marks				
Exam	50Marks				
Total	75Marks				
Duration of Exam	03 Hours				

Note: The examiner will set a total of 9 questions. Question one will carry questions from all units, and the remaining eight questions will be set by taking two questions from each unit. The students have to attempt five questions in total, with the first being compulsory and selecting one from each unit. All questions will carry equal marks.

COURSE OBJECTIVES

- To understand and the different issues involved in the design and implementation of a databases system.
- To study the physical and logical database designs, database modeling, relational, hierarchical, and network models
- To understand and used at a manipulation a language to query, update, and manage a database
- To develop an understanding of essential DBMS concepts such as: database security, integrity, concurrency, distributed database, and intelligent database, Client/Server (Database Server), Data Warehousing.
- To design and build a simple database system and demonstrate competence with the fundamental tasks involved with modelling, designing, and implementing a DBMS.

COURSE OUTCOMES

CO1: Understand and analyze humanoid robot design, components, and applications.

CO2: Apply principles of swarm robotics and multi-agent systems in real-world problems.

CO3: Evaluate human-robot interaction models and collaborative robotics technologies.

CO4: Analyze Industry 4.0 concepts and IoRT applications in modern automation

CO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	2	1	2	1	-	-	-	-	-	3	1	3
CO2	3	3	3	2	3	-	1	-	1	-	-	2	3	3
CO3	2	2	3	2	2	3	1	2	2	2	-	3	2	3
CO4	3	3	3	2	3	2	2	1	1	1	2	2	3	3
Wt. AVG	2.75	2.5	2.75	1.75	2.5	1.5	1	0.75	1	0.75	0.5	2.5	1.8	3
									Overall Mapping of Subject					1.78

UNIT I

Humanoid Robotics Technology and Social Robots: Sensors in Humanoid Robot, Control of Humanoid Robot, actuation types for humanoid Robot, System Integration in Humanoid Robot, Social Robot, Need of Social Robots, Assistive and Social Robots in the Healthcare Sector and other, Case study On Humanoid Robot.

UNITII

Swarm Robotics: Characteristics, Swarm Robotics and Multi-Robotic Systems, Experimental Platforms in Swarm Robotics, Tasks in Swarm Robotics, Swarm Robots used in Real world applications, Smart Robots, Smart Robots applications, Robotics for Warfare Applications.

UNITIII

Human Robot Interaction (HRI): Definition, History, Need of HRI, Ethical Issues for HRI, Multi-Modal Perception, Social, Service, and Assistive Robotics, HRI Architecture, Collaborative Robots, Definition, Types of Collaboration, Applications of collaborative robots, collaborative Robot Technology.

UNIT IV

Industry 4.0 and Internet of Robotic Things (IORT): Introduction, Internet of Things and Robotics, Applications and developments of the Internet of Robotic Things.

Alternative NPTEL/SWAYAM Course:

	Course Name	Instructor	Host Institute
1	Advanced Robotics	Prof. Ashish Dutta	IIT, Kanpur

Suggested books:

1. Sabrie Soloman, Advanced Robotics (Design & Applications), Khanna Book Publishing Co., 2023.
2. M.C. Trivedi, A Classical Approach to Artificial Intelligence, Khanna Book Publishing, 2023.
3. Luger " Artificial Intelligence", Edition 5, Pearson, 2008.
4. Ralf Herbrick, Thore Graepel, “A Handbook on Natural Language Processing”, Second Edition, CRC

Course code	26PCC-CSE-205H				
Category	Professional Core Course				
Course title	**Operating System**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-4**
	3	**0**	**0**	**3**	
Classwork	25 Marks				
Exam	50Marks				
Total	75Marks				
Duration of Exam	03 Hours				

Note: The examiner will set a total of 9 questions. Question one will carry questions from all units, and the remaining eight questions will be set by taking two questions from each unit. The students have to attempt five questions in total, with the first being compulsory and selecting one from each unit. All questions will carry equal marks.

COURSE OBJECTIVES:

- To understand the role and functions of an operating system and its impact on the overall performance of a computer system.
- To understand the concepts and techniques involved in process management, such as process creation, scheduling, inter-process communication, and synchronization.
- To understand the concepts and techniques involved in memory management, such as virtual memory, swapping, paging, and segmentation.
- To gain hands-on experience with the design and implementation of operating systems through programming projects and case studies.

COURSE OUTCOMES

CO1: Analyze various scheduling algorithms and process synchronization
CO2: Explain deadlock prevention and avoidence algorithms
CO3: Compare and contrast various memory management scgemes.
CO4: Explain the functionality of file system, I/O systems, and virtualization
CO5: Compare IoS and Android Operating system

CO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PS O 2**	**PS O 3**
CO1	2	1	3	2	-	-	-	-	2	1	2	3	2	1	1
CO2	2	1	1	1	1	-	-	-	1	3	3	3	2	3	3
CO3	1	3	3	3	1	-	-	-	1	2	1	2	2	1	2
CO4	1	2	2	3	-	-	-	-	2	3	3	1	3	1	3
CO5	1	2	3	2	3	-	-	-	3	1	3	3	1	3	3
	1.4	1.8	2.4	2.2	1	-	-	-	1.8	2	2.4	2.4	1.8	1.8	2.4
									Overall Mapping of Subject						1.95

UNIT I

Introduction: Concept of Operating Systems, Generations of Operating Systems, Types of Operating Systems, OS Functions and Objectives.

Processes: Definition, Process Relationship, Different states of a Process, Process State transitions, Process Control Block (PCB), Light Weight and Heavy Weight Processes.

Process Scheduling: Foundation and Scheduling objectives, Types of Schedulers- Long Term and Short-Term Schedulers, Dispatcher, Context Switching time, Scheduling criteria: CPU utilization, Throughput, Turnaround Time, Average Waiting Time, Response Time; Scheduling algorithms: Pre-emptive and Non-pre-emptive, FCFS (First Come First Serve), SJF (Shortest Job First), SRTF (Shortest Remaining Time First), RR (Round Robin)/Time Sharing Scheduling Algorithms.

UNIT II

Inter-process Communication: Critical Section, Race Conditions, Mutual Exclusion, Semaphores-Binary and Counting Semaphores, Busy-waiting (Spinning) and Wait and Signal operations for Synchronization, Classical IPC Problems: Reader's & Writer Problem, Producer-Consumer Problem, Dinning Philosopher Problem etc.

Deadlocks: Definition, Necessary and sufficient conditions for Deadlock, Deadlock Prevention, and Deadlock Avoidance: Banker's algorithm, Deadlock detection and Recovery.

UNIT III

Memory Management: Basic concept, Logical and Physical address map, Memory allocation: Contiguous Memory allocation – Fixed and variable partition–Internal and External fragmentation and Compaction; Paging: Principle of operation – Page allocation – Hardware support for paging, Protection and sharing, Disadvantages of paging.

Virtual Memory: Basics of Virtual Memory Management, Demand paging, Page Replacement algorithms: Optimal, First in First Out (FIFO), Optimal Page Replacement and Least Recently used (LRU).

UNIT IV

File Management: Concept of File, Access methods, File types, File operation, Directory structure, File System structure, Allocation methods (contiguous, linked, indexed), efficiency and performance.

Disk Management: Disk structure, Disk scheduling - FCFS, SSTF, SCAN, C-SCAN, Disk reliability, Disk formatting, Case study on UNIX and WINDOWS Operating Systems.

Alternative NPTEL/SWAYAM Course:

	Course Name	Instructor	Host Institute
1	Introduction to Operating Systems	Prof. CHESTER REBEIRO	IIT, Madras

Suggested Text Books/ Reference Books:

1. OperatingSystemConceptsEssentials,9thEdition by Avi Silberschatz, Peter Galvin, Greg Gagne, Wiley Asia Student Edition.
2. Operating Systems: Internals and Design Principles, 5th Edition, William Stallings, Prentice Hall of India.
3. Operating System: ADesign-orientedApproach,1stEditionbyCharlesCrowley, Irwin Publishing
4. Operating Systems: A Modern Perspective,2nd Edition by Gary J. Nutt, Addison-Wesley
5. Design of the Unix Operating Systems,8th Edition by Maurice Bach, Prentice-Hallof India
6. Understanding the LinuxKernel,3rd Edition, DanielP. Bovet, Marco Cesati, O'Reilly and Associate

Course code	26PCC-RAI-208-H				
Category	Professional Core Course				
Course title	**Programming for Data Science &AIML**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-4**
	3	**0**	**0**	**3**	
Classwork	25Marks				
Exam	50Marks				
Total	75Marks				
Duration of Exam	03 Hours				

Note: The examiner will set a total of 9 questions. Question one will carry questions from all units, and the remaining eight questions will be set by taking two questions from each unit. The students have to attempt five questions in total, with the first being compulsory and selecting one from each unit. All questions will carry equal marks.

COURSE OBJECTIVES

- To impart the basic concepts of Python programming.
- To understand concepts and usage of NumPy and Pandas packages for numerical data calculations inPython.
- To understand concepts and applications of various data visualization tools of Python on real-worlddata.
- To understand and implement the Machine Learning Concepts in Python.

COURSE OUTCOMES

CO1: Apply Python programming concepts to solve data science problems.

CO2: Perform numerical computations and data manipulation using NumPy and Pandas.

CO3: Visualize and interpret data using Python visualization tools.

CO4: Implement basic machine learning models and NLP techniques using Python libraries.

CO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	2	1	2	1	-	-	1	1	-	1	2	1
CO2	3	3	2	2	3	1	-	-	1	1	-	1	3	1
CO3	2	2	3	2	3	1	-	-	1	2	-	1	3	1
CO4	3	3	3	2	3	2	-	1	1	2	-	1	3	3
	2.2	2.5	2.5	1.4	2.2	1.25	-	0.25	1	1.5	-	1	2.75	1.25
								Overall Mapping of Subject						1.65

UNIT I

Overview of Python Programming Concepts: The concept of data types; variables, assignments; numerical types; operators and expressions; Control Structures; String manipulations; File Handling – creating, reading/writing text/number files; Dictionaries; Functions; OOPs Concepts

UNIT II

Introduction to Numpy - Creation on Array,Array generation from a uniform distribution, Random array generation, reshaping, maximum and minimum, reshaping, Arithmetic operations, Mathematical functions, Bracket Indexing and Selection, Broadcasting, Indexing a 2D array (matrices)

Data Manipulation with Pandas -Creating a Series - from lists, arrays and dictionaries, Storing data in series from intrinsic sources, Creating Data Frames, Imputation, Grouping and aggregation, Merging, Joining, Concatenation, Find Null Values or Check for Null Values, Reading data from csv, txt, excel, web.

UNIT III

Introduction to Visualization - Installing and setting up visualization libraries, Canvas and Axes, Subplots, Common plots – scatter, histogram, boxplot,Logarithmic scale, Placement of ticks and custom tick labels, Pandas Viz, Style Sheets, Plot type, Area, Barplots,Histograms,Line Plots, Scatter Plots, BoxPlots, Hexagonal Bin Plot, Kernel Density Estimation plot (KDE), Distribution Plots, Categorical Data Plots, Combining Categorical Plots, Matrix Plots, Regression Plots, Grids; Python Visualizations toolkits/libraries.

UNIT IV

Introduction to Machine Learning with SciKit-Learn & PyTorch– Data Representation and basic functions- Estimator, parameters & model validation, Model Selection, Curve, Grid search, Feature engineering, Naive Bayes Classification, Linear regression, SVM etc; Overview of other Python ML/Deep Learning toolkits/Libraries.

Introduction to NLP with NLTK and its functions, modules like speech tagging, tokenization, parsing, segmentation, recognition , cleaning & normalization of text etc; Overview of other Python NLP toolkits/Libraries.

Alternative NPTEL/SWAYAM Course:

	Course Name	Instructor	Host Institute
1	Data Science for engineers	Prof. Shankar Narsimhan	IIT, Madras

Suggested Text Books/ Reference Books:

1. Charles Dierbach.,Introduction to Python using Computer Science, Wiley Publications, Second Edition, 2015
2. Mark Lutz, Learning Python, O'Reilly publications, FifthEdition,2015
3. Jake Vandar Plas, Python Data Science Handbook, O'Reilly,2016
4. Paul Barry, *Head First Python*, Orielly Publications, Second Edition, 2010

Course code	**26PCC-RAI-210-H**				
Category	Professional Core Course				
Course title	**Sensors and Actuators for Robotics**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-4**
	3	**0**	**0**	**3**	
Classwork	25Marks				
Exam	50Marks				
Total	75Marks				
Duration of Exam	03 Hours				

Note: The examiner will set a total of 9 questions. Question one will carry questions from all units, and the remaining eight questions will be set by taking two questions from each unit. The students have to attempt five questions in total, with the first being compulsory and selecting one from each unit. All questions will carry equal marks.

COURSE OBJECTIVES

- Analyze sensory systems in robotics.
- Select the sensor for robotic applications and design the systems.
- Analyze actuators and configuring the parameters of Actuators.

COURSE OUTCOMES

CO1: Explain the structure of robotic systems, including joints, links, end effectors, and degrees of freedom.

CO2: Analyze and select appropriate sensors for measuring physical parameters in robotic applications.

CO3: Apply image processing and vision system techniques in robotics.

CO4: Evaluate smart sensors, MEMS technologies, and modern sensing innovations.

CO5: Analyze and select suitable actuators and transmission systems for robotic system design.

CO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	2	1	1	-	-	-	1	1	-	3	2	1
CO2	3	3	2	2	2	1	-	-	1	1	-	3	3	2
CO3	2	2	3	3	3	1	-	-	1	2	-	2	3	3
CO4	3	2	2	2	3	1	1	-	1	1	-	3	2	3
CO5	3	3	3	2	3	2	1	-	1	1	1	3	3	2
Wt. AVG	2.8	2.4	2.4	2	2.4	1	0.4	-	1	1.2	0.2	2.8	2.6	2.2
							Overall Mapping of Subject							1.8

UNIT I

Anatomy of Robotic system: links and joints in robots, types of joints, end effectors, concept of degrees of Freedom and its calculations.

UNIT II

Pressure/contact, Resistive position, Infrared. Light, Position Sensors, optical encoders, proximity sensors, Range sensors, Ultrasonic sensors, Touch and Slip sensors, Sensors for motion and position, Force, torque and tactile sensors, Flow sensors, Temperature sensing devices.

Vision System Devices, Image acquisition, Masking, Sampling and quantization, Image Processing Techniques, Noise reduction methods, Edge detection, Segmentation.

UNIT III

Smart sensors, MEMS based sensors, Innovations in sensor technology Actuators and its selection while designing a robot system, Types of transmission systems.

UNIT IV

Direct current motor, Permanent magnet stepper motor, Servo Control DC motors, Linear and latching linear actuators, Rotary actuators, Piezoelectric actuators, Actuator parameters and characteristics, Stepper motors, Specifications and characteristics of Stepper Motors Servo Motors.

Alternative NPTEL/SWAYAM Course:

	Course Name	**Instructor**	**Host Institute**
1	Sensors and actuators	Prof. Hardik Jeetendra Pandya	IISC Bangalore

Suggested Text Books/ Reference Books:

1. Sabrie Soloman,Advanced Robotics (Design & Applications), Khanna Book Publishing, 2023.
2.Sabrie Soloman, Sensors Technology Handbook, Khanna Publishing House.
3.D. Patranabis, Sensors and Transducers, PHI, 2nd Edition 2013.
4.Jon S. Wilson, Sensor Technology Handbook, Elsevier, 2005.
5.S. Mukherjee, Robotics Process Automation, Khanna Book Publishing, 2021.
6.Mc Comb, G. Robot builder's bonanza. 5th ed. New York: McGraw-Hill, 2019.
7.A. B. Bhattacharya, Debasish Roy, Foundations of Robotics & Automation (Theory & Practice), Khanna Book Publishing.

Course code	26PCC-CSE-207H				
Category	Professional Core Course				
Course title	**Software Engineering**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-4**
	3	**0**	**0**	**3**	
Classwork	25Marks				
Exam	50 Marks				
Total	75Marks				
Duration of Exam	03 Hours				

Note: The examiner will set a total of 9 questions. Question one will carry questions from all units, and the remaining eight questions will be set by taking two questions from each unit. The students have to attempt five questions in total, with the first being compulsory and selecting one from each unit. All questions will carry equal marks.

COURSE OBJECTIVES:

- Ability to translate end-user requirements into system and software requirements, using e.g. UML, and structure the user requirements in a Software Requirements Specification Document (SRS).
- Identify and apply appropriate software architectures and patterns to carry out high-level design of a system and be able to make critical comparisons of various choices.
- To gain exposure/or awareness of testing problems and to be able to develop a simple testing report.
- Application of quality management techniques to small size software projects.

COURSE OUTCOMES:

After successful completion of the course, the students will be able to:

CO1: Understand and explain fundamental concepts, principles, and processes of Software Engineering and Software Development Life Cycle (SDLC).

CO2: Apply appropriate software process models (Agile, Waterfall, Spiral, etc.) for developing quality software systems.

CO3: Analyze user requirements and prepare Software Requirement Specification (SRS) documents using standard practices.

CO4: Design software systems using structured and object-oriented design approaches, including UML diagrams. Implement testing strategies and quality assurance techniques to ensure reliable and maintainable software.

CO-PO Mapping

	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 2
CO 1	3	2	1	-	1	-	-	1	-	1	-	1	1	1
CO 2	3	3	3	2	2	1	-	1	2	1	1	1	2	2
CO 3	2	3	3	2	2	1	-	1	2	3	1	1	2	2
CO 4	3	3	3	2	3	1	-	2	2	2	1	1	3	2
Wt. AVG	2.75	2.75	2.5	1.5	2	0.75	-	1.25	1.5	1.75	0.75	1	2	1.75
								Overall Mapping of Subject						1.71

UNIT I

Introduction to Software Engineering: Basic Concepts & characteristics of Software, Types of software, Phases of Software development life cycle - feasibility study, planning, requirement analysis, designing, coding, testing & debugging, implementation & maintenance.

SDLC models: Waterfall, Prototype, Incremental Process, Spiral, Agile Model. Basic concepts of Software Engineering, David Hooker's Seven Principles Model of Software Engineering, 4 P's of Software Project Management, introduction to Software metrics, and risk management.

UNIT II

Requirement Engineering: Types of Software Requirements – functional and non-functional, Requirement analysis, Requirement elicitation techniques, documenting User Requirements- SRS, Static verification of user requirements, Requirement Management &Modeling.

Software Designing: Different levels of software design: Architectural Design, High level design (HLD), Detailed Design/ Low level Design (LLD), Coupling and Cohesion concepts. Software design approaches-Top down, bottom-up approach, Software designing tools.

UNIT III

Coding & Testing: Programming languages and coding styles, Software Testing Life Cycle-Test Case Planning, Test Case Designing, Test Environment Setup-Stubs and Drivers, Test Case Execution, Test Closure and test adequacy criteria.

Testing Strategies: Static and Dynamic Testing,Levels of Software Testing: Unit, Integration and System Testing. Types of Software Testing: Functional and Non-functional Testing. V Model for Software testing,alpha and beta testing; System testing: Recovery testing, security testing, stress testing, Regression Testing and its Types, Introduction to Software Bugs, Debugging approaches.

UNIT IV

Software Maintenance & Quality Assurance:Corrective, adaptive and Perfective maintenance. Software quality attributes and models- Mc Call's Model, Boehm's Model. CMM-Capability maturity model and Six Sigma Model for quality management, ISO 9001, Reverse Engineering & Reengineering, Reusability of software components.

Alternative NPTEL/SWAYAM Course:

	Course Name	Instructor	Host Institute
1	Introduction to Software Engg.	Prof. N.L SARDA, Prof. R. K. Joshi	IIT, Mumbai

Suggested Text Books/ Reference Books:

1. Software Engineering – A Practitioner's Approach, Roger S. Pressman, 1996, MGH.
2. Software Engineering- Sommerville, 7th edition, Pearson Education.

3. Fundamentals of software Engineering, Rajib Mall, PHI Software Engineering by Nasib Singh Gill, Khanna Book Publishing Co (p) Ltd

4.Software Engineering by Ian Somerville, Pearson Edu, 5 edition, 1999, AW,

5.Software Engineering – David Gustafson, 2002, T.M.H

6.Software Engineering Fundamentals Oxford University, Ali Behforooz and Frederick J. Hudson 1995 JW&S,

7. An Integrated Approach to software engineering by Pankaj jalote , 1991 Narosa,

Course code	26LC-CSE-215H			
Category	Laboratory Course			
Course title	**Operating System Lab**			
Scheme and Credits	**L**	**T**	**P**	**Credits**
	0	**0**	**2**	**1**
Classwork	05 Marks			
Exam	20Marks			
Total	25Marks			
Duration of Exam	03 Hours			

List of Experiments:

1 Introduction to Types of Shells and UNIX File System.

2. File and Directory Related Commands in UNIX.

3. Essential UNIX Commands for working in a UNIX environment.

4. I/O Redirection and Piping and Introduction to VI editor and Modes-Command Mode, Insert Mode etc.

5. Introduction of Processes and Communication in UNIX

6. Introduction of the concept of Shell Scripting.

7. Decision and Iterative Statements in Shell Scripting.

8. Writing the Shall Scripts for unknown problems. e.g. Fibonacci Series, Even/Odd number, Factorial of a number, Counting up to any number N, Arithmetic Operations

Suggested Books:

1. UNIX Shell Programming by YashavantKanetkar.

2. UNIX Concepts and Applications by SumitabhaDas

Course code	26LC-RAI-208-H				
Category	LaboratoryCourse				
Course title	**Programming for Data Science & AIMLLab**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-4**
	0	**0**	**2**	**1**	
Classwork	05Marks				
Exam	20 Marks				
Total	25 Marks				
Duration of Exam	03Hours				

List of Experiments:

1. Python program to display details about the operating system, working directory, files Anddirectoriesinthecurrentdirectory,liststhefilesandalldirectories,scanandclassifythemasdirectories and files
2. Python program to convert an array to an array of machine values and vice versa
3.Pythonprogramtogetinformationaboutthefilepertainingtothefilemodeandtogettimevalueswith components using local time and gm time.
4.Python program to connect to Google using socket programming.
5. Python program to perform array operations using the NumPy package.
6. Python program to perform data manipulation operations using the Pandas package.
7. Python program to display multiple types of charts using the Matplotlib package.
8. Python program to perform file operations on an Excel dataset.
9. Python program to implement machine learning tasks using Python, Scikit-learn, and NLTK.
10. Python program to implement natural language processing tasks using Python, NLTK, spaCy, and PyNLPI.

NOTE: More programs related to the course contents of Object Programming for Data Science& AIML can be designed and developed by the subject faculty.

Course code	26LC-CSE-212H			
Category	Laboratory Course			
Course title	**Database Management System Lab**			
Scheme and Credits	**L**	**T**	**P**	**Credits**
	0	**0**	**2**	**1**
Classwork	05Marks			
Exam	20Marks			
Total	25Marks			
Duration of Exam	03 Hours			

COURSE OBJECTIVES:

- To engage themselves in lifelong learning of Database management systems theories and technologies this enables them to purse higher studies.
- To interact professionally with colleagues or clients located abroad and the ability to overcome challenges that arises from geographic distance, cultural differences, and multiple languages in the context of computing.
- Develop team spirit, effective work habits, and professional attitude in written and oral forms, towards the development of database applications.

List of Practicals

1. Creation of a database and writing SQL queries to retrieve information from the database.
2. Performing Insertion, Deletion, Modifying, Altering, Updating and Viewing records based on conditions.
3. Creation of Views, Synonyms, Sequence, Indexes, Save point.
4. Creating an employee database to set various constraints.
5. Creating relationship between the databases.
6. Study of PL/SQL block.
7. Write a PL/SQL block to satisfy some conditions by accepting input from the user.
8. Write a PL/SQL block that handles all types of exceptions.
9. Creation of Procedures.
10. Creation of database triggers and functions
11. Mini project (Application Development using Oracle/ MySQL)
    i. Inventory Control System
    ii. Material Requirement Processing.
    iii. Hospital Management System.
    iv. Railway Reservation System.
    v. Personal Information System.
    vi. Web Based User Identification System.
    vii. Time Table Management System.
    viii. Hotel Management

Course code	26AU-ENV-202-H				
Category	Mandatory Course				
Course title	**Environmental Sciences**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-4**
	2	**0**	**1**	**0**	
Branches (B. Tech.)	Common For All Branches				

COURSE OBJECTIVES:

People working in industries or elsewhere essentially require the knowledge of environmental science so as to enable them to work and produce the most efficient, economical and eco-friendly finished product. It will guide the students living in a historic transitional period of burgeoning awareness of the conflict between human activities and environmental constraints to help and save the fragile and endangered planet with the natural resources already overexploited.

- Solve various engineering problems by applying an environmentally sustainable approach to produce eco-friendly products.
- Use relevant pollution control methods to solve domestic and industrial problems.
- To recognize eco-friendly and sustainable energy resources for combating global problems like climate change, acid rain and resource depletion etc.
- To solve local solid hazardous and e-waste problems.

COURSE OUTCOMES

CO1: Understand environmental concepts, ecosystems, and ecological relationships.

CO2: Analyze natural resources and their sustainable utilization.

CO3: Evaluate causes and control measures of environmental pollution.

CO4: Understand biodiversity conservation and environmental issues.

CO5: Apply environmental awareness, ethics, and sustainable practices in real-life situations.

CO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PS O 1**	**PS O 2**	**PS O 3**
CO1	2	2	1	1	-	1	3	1	1	1	-	2	1	1
CO2	2	3	2	1	-	2	3	1	1	1	-	3	2	1
CO3	2	3	1	2	1	2	3	1	1	1	-	3	3	2
CO4	2	2	1	1	-	2	3	2	1	1	-	2	2	1
CO5	1	2	2	1	-	3	3	3	2	2	1	3	3	2
Wt. AVG	1.8	2.4	1.4	1.2	0.2	2	3	1.6	1.2	1.2	0.2	2.6	2.2	1.4
								Overall Mapping of Subject						1.6

UNIT I

The Multidisciplinary nature of environmental studies, Definition, scope and importance.. Structure and composition of atmosphere, hydrosphere, lithosphere and biosphere. Interaction between earth, man, and environment (2lectures)

UNIT II

Natural Resources (8 Lectures): Renewable and non-renewable resources: Natural resources and associated problems.

a) Forest resources: Use and over-exploitation: deforestation, case studies. Timber extraction, mining dams and their effects on forests and tribal people.
b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.
c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.
d) Food resources: World food problems, changes, caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, Water logging, salinity, case studies.
e) Energy resources: Growing energy needs; renewable random-renewable energy sources use of alternate energy sources, case studies.
f) Land resources: Land as a resource, land degradation, noninduced and slides, soil erosion and desertification.
g) Role of an individual in conservation of natural resources.
h) Equitable use of resources for sustainable lifestyles.

UNIT III

Ecosystem and biodiversity conservation (8 Lectures)

* Structure of ecosystem, Biotic and Abiotic components
* Energy flow in the ecosystem.
* Ecological succession.
* Food chains, food webs and ecological pyramids.
* Aquatic and terrestrial ecosystems
* Different level of biodiversity: Genetic, Species and ecosystem diversity.
* Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values.
* Biodiversity at global, National and local levels.
* India as a mega-diversity nation.
* Hot-spots of biodiversity.
* Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts.
* Endangered and endemic species of India.
* Conservation of biodiversity: In-situ and ex-situ conservation of biodiversity

UNIT IV

Environmental Assessment and Management: (6 Lectures)

Aims and objectives of environmental impact assessment (EIA), Environmental Impact Statement (EIS) and environment management plan (EMP). Structure and role of the central and state pollution control board, ISO14000: implementation in industries for benefit.

* Environment Protection Act.
* Air (Prevention and Control of Pollution) Act.
* Water (Prevention and Control of Pollution) Act.
* Wildlife Protection Act.
* Forest Conservation Act.
* Issues involved in the enforcement of environmental legislation.
* Public awareness.

UNIT V

Environmentalpollution(8lectures): Definition, causes, effects and control measures of:

a) Air pollution.

b) Water pollution.

c) Soil pollution.

d) Marine pollution.

e) Noise pollution.

f) Thermal pollution.

g) Nuclear hazards.

- Solid waste management: causes, effects, and control measures of urban and industrial wastes.
- Role of an individual in the prevention of pollution.
- Pollution case studies.
- Disaster management: floods, earthquakes, cyclones, and landslides.

UNIT VI

Social issues and the Environment (7lectures):

- From unsustainable to sustainable development.
- Urban problems related to energy.
- Water conservation, rainwater harvesting, and watershed management.
- Resettlement and rehabilitation of people: its problems and concerns. Case studies.
- Environmental ethics: issues and possible solutions.
- Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents, and holocaust. Case studies.
- Wasteland reclamation.
- Consumerism and waste products.
- Environment Protection Act.
- Air (Prevention and Control of Pollution) Act.
- Water (Prevention and Control of Pollution) Act.
- Wildlife Protection Act.

- Forest Conservation Act.
- Issues involved in the enforcement of environmental legislation.
- Public awareness.

UNIT VII

(6lectures)
Human population and the Environment, Population growth, variation among nations, Population explosion- Family Welfare Programme, Environment and human health, Human Rights, Value Education, HIV/AIDS, Woman and Child Welfare, Role of Information Technology in Environment and human health, Case Studies.

UNIT VIII

Field Work (Fieldworkequalto15 lecturehours):

- Visit a local area to document environmental assets-river/forest/grassland/hill/mountain.
- Visit to a local polluted site-urban/Rural/Industrial/ Agricultural.
- Study of common plants, insects, birds.
- Study of simple ecosystems-pond, river, hillslopes, etc.

Alternative NPTEL/SWAYAM Course:

	Course Name	Instructor	Host Institute
1	Environmental Science	Prof. Sudha Goel	IIT, Kharagpur

References

1. Agarwal, K. C. (2001). Environmental Biology. Nidi Publications, Bikaner.
2. Bharucha, E. The Biodiversity of India. Mapin Publishing Pvt. Ltd., Ahmedabad – 380013, India. E-mail: mapin@icenet.net (R).
3. Brunner, R. C. (1989). Hazardous Waste Incineration. McGraw-Hill Inc., 480 p.
4. Clark, R. S. Marine Pollution. Sanderson Press, Oxford (TB).
5. Cunningham, W. P., Cooper, T. H., Gorhani, E., & Hepworth, M. T. (2001). Environmental Encyclopaedia. Jaico Publishing House, Mumbai, 1196 p.
6. De, A. K. Environmental Chemistry. Wiley Eastern Ltd.
7. Down to Earth. Centre for Science and Environment (R).
8. Gleick, H. P. (1993). Water in Crisis. Pacific Institute for Studies in Development, Environment & Security, Stockholm Environment Institute, Oxford University Press, 473 p.
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11. Jadhav, H., & Bhosale, V. M. (1995). Environmental Protection and Laws. Himalaya Publishing House, Delhi, 284 p.
12. Mackinney, M. L., & Schoch, R. M. (1996). Environmental Science: Systems and Solutions, Web Enhanced Edition, 639 p.
13. Mhaskar, A. K. Mayer Hazardous. Techno-Science Publications (TB).

14. Miller, T. G., Jr. Environmental Science. Wadsworth Publishing Co. (TB).
15. Odum, E. P. (1971). Fundamentals of Ecology. W. B. Saunders Co., USA, 574 p.
16. Rao, M. N., & Datta, A. K. (1987). Waste Water Treatment. Oxford & IBH Publishing Co. Pvt. Ltd., 345 p.
17. Sharma, B. K. (2001). Environmental Chemistry. Goal Publishing House, Meerut.
18. Survey of the Environment. The Hindu (M).
19. Townsend, C., Harper, J., &Begon, M. Essentials of Ecology. Blackwell Science (TB).
20. Trivedi, R. K. Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards, Volumes I and II. Enviro Media (R).
21. Trivedi, R. K., & P. K. Goel. Introduction to Air Pollution. Techno-Science Publications (TR).
22. Wagner, K. D. (1998). Environmental Management. W. B. Saunders Co., Philadelphia, USA, 499 p.
23. Dr. J. P. Yadav. A Textbook of Environmental Education. G.V.S. Publishers.

Note-1: AU/MC is a mandatory non–credit course in which students will be required to obtain passing marks in theory. The marks in this qualifying paper will not be included in determining the percentage of marks obtained for the award of degree. However, these marks will be shown in detailed marks certificate of student.

Marks Distribution:

- Internal Assessment: 30 marks
- Theory Examination: 70 marks

The institute will conduct the theory examination at its own level.

Course code	26PCC-RAI-212-H				
Category	Professional Core Course				
Course title	**Robot Safety and Maintenance**				
Scheme and Credits	L	**T**	**P**	**Credits**	**Semester-4**
	3	**0**	**0**	**3**	
Classwork	25Marks				
Exam	50 Marks				
Total	75Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have 6 parts of 2.5 marks each from all units and the remaining eight questions of 15 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, with the first being compulsory and selecting one from each unit.

COURSE OBJECTIVES

- Analyze sensory systems in robotics.
- Select the sensor for robotic application and design the systems.
- Analyze actuators and configuring the parameters of Actuators.

COURSE OUTCOMES

CO1: Understand robot safety concepts, hazards, and safety regulations.
CO2: Apply safety standards and procedures in robot operation and industrial environments.

CO3: Analyze and implement robot maintenance strategies for reliable operation.

CO4:Evaluate risks, hazards, and safety management systems in robotic applications.

CO5: Apply safety practices, ergonomics, and accident prevention techniques in real-world scenarios.

CO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	1	1	-	2	1	2	1	1	-	3	2	2
CO2	3	3	2	2	2	3	1	2	2	1	1	3	3	2
CO3	3	3	3	2	2	2	1	1	1	1	1	3	3	2
CO4	3	3	2	3	2	3	2	3	1	1	1	3	3	3
CO5	2	2	2	2	1	3	2	3	2	2	1	2	3	2
Wt. AVG	2.8	2.6	2	2	1.4	2.6	1.4	2.2	1.4	1.2	0.8	2.8	2.8	2.2
									Overall Mapping of Subject					2.01

UNIT I

Introduction to Robot Safety: Introduction, Safety-Related Terms and Definitions, Organizations Concerned with Safety, Introduction, Robotic Safety Problems and Hazards, Use of Robots to Promote Safety, Weak Points in Planning and Design, \Operations Causing Safety Problems, The Manufacturer's and User's Role in Robot Safety, Safety Considerations in Robot Design, Installation, Programming, and Operation and Maintenance, Robot Safeguard Methods

UNIT II

Introduction, Robot Safety Education, Safety Considerations in Robot Testing and Start-Up, Commissioning, and Acceptance, Safety Considerations in Robot Welding Operations, Robot Safety in the Automobile Industry, Stopping Grippers of Industrial Robots Not Dropping Throwing Work Items When Experiencing Energy Loss or Not Gripping on the Return of Energy , Robot Standardization and Safety Standards, , Safety Devices, STOP type of a Robot, Emergency Stop, Mode select switch, Deadman switch, Safeguards, Operation inside of the safety fence, Safety Procedures for entering the safety fence.

UNIT III

Introduction, General Maintenance Functions and Types of Maintenance, Robot Maintenance Needs and Types, Robot Parts and Special Tools for Maintenance and Repair, Robot Warranty Coverage and Preventive Maintenance Kits, Robot Inspection, Some Guidelines for Safeguarding Robot Maintenance Personnel, Some Models Useful in Performing Robot Maintenance.

UNITIV

BIS and ISO safety standards for Robots, Safety management system, Hazard identification, Risk analysis and Evaluation, Audit Programme, Preventive Maintenance of Robots, Accident Prevention Techniques, Ergonomics of robots handling, Safety management and management principles, Major accident control, Safety Training, Robotics Safety Requirements.

Alternative NPTEL/SWAYAM Course:

	Course Name	Instructor	Host Institute
1	Wheeled Mobile robots	Prof. Asokan Thondiyath	IIT, Madras

Suggested Text Books/ Reference Books:

1. Sabrie Soloman, Advanced Robotics (Design & Applications), Khanna Book Publishing, 2023.
2. B.S. Dhillon, “Robot Reliability and Safety”, CRC Press, 2015.
3. Paolo Barattini et. al., “Human Robot Interaction: Safety, Standardization and Benchmarking”, CRC Press, 2019. (iv) S. Mukherjee, Robotics Process Automation, Khanna Book Publishing, 2021.
4. A. B. Bhattacharya, Debasish Roy, Foundations of Robotics & Automation (Theory& Practice), Khanna Publishing House.
5. Nicholas Odrey, “Industrial Robotics -Technology, Programming and Applications”, 2017.
6. Mikell Groover, “Industrial Robotics, Tata McGraw Hill, 2008.
7.Tom Taulli, “The Robotic Process Automation Handbook: A Guide to Implementing RPA Systems”, Springer India, 31 December 2021.

Course code	26LC-RAI-214-H				
Category	Laboratory Course				
Course title	**Robot Safety & Maintenance Lab**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-4**
	0	**0**	**2**	**1**	
Classwork	05Marks				
Exam	20Marks				
Total	25 Marks				
Duration of Exam	03Hours				

NOTE:

1. Lab programs/activities can be designed and developed by the subject faculty using Robo Studio/ MATLAB or any suitable Open-Source tools/ software.
2. Min 10 Lab activities will be carried out from the offered course contents of Robot Safety & Maintenance Course in the semester.
3. Study of various Data Sources

ELECTIVE COURSE-I

Course code	26 PEC-RAI-202-H				
Category	Professional Elective Course				
Course title	**Mobile and Micro-Robotics**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-4**
	3	**0**	**0**	**3**	
Classwork	25Marks				
Exam	50 Marks				
Total	75Marks				
Duration of Exam	03 Hours				

COURSE OBJECTIVES

- Analyse various locomotion mechanisms, kinematics, and dynamics of mobile robots.
- Study the principles of sensors, actuators, and control techniques used in mobile and micro-robots.
- Understand navigation, localization, path planning, and autonomous decision-making techniques for mobile robots.
- Explore the design, fabrication methods, and applications of micro-robots in biomedical, industrial, and environmental domains.

COURSE OUTCOMES

CO1: Understand fundamentals, classifications, and applications of mobile robots and their operating environments.

CO2: Analyze kinematics and dynamics of different wheeled mobile robots and understand sensor technologies used for localization and navigation.

CO3: Apply localization, mapping, and motion control techniques for mobile robots and evaluate their real-world applications and limitations.

CO4: Understand principles of micro-robotics, fabrication methods, and actuator technologies for micro-robotic systems.

CO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	1	-	2	2	1	-	-	-	-	2	1	2
CO2	3	3	2	2	3	-	-	-	-	-	-	3	3	2
CO3	3	3	3	3	3	1	1	-	2	1	-	3	3	3
CO4	3	2	2	2	2	-	2	-	-	-	-	2	2	3
Wt. AVG	3	2.5	2	1.75	2.5	0.75	1	-	0.5	0.25	-	2.5	1.8	2.5
								Overall Mapping of Subject						1.75

UNIT I

Introduction to Mobile Robots - Tasks of mobile robots, robots' manufacturers, type of obstacles and challenges, tele-robotics, philosophy of robotics, service robotics, types of environment representation. Ground Robots: Wheeled and Legged Robots, Aerial Robots, Underwater Robots and Surface Robots.

UNIT II

Kinematics and Dynamics of Wheeled Mobile Robots (two, three, four - wheeled robots, omnidirectional and macanum wheeled robots). Sensors for localization: magnetic and optic position sensor, gyroscope, accelerometer, magnetic compass, inclinometer, GNSS and Sensors for navigation: tactile and proximity sensors, ultrasound rangefinder, laser scanner, infrared rangefinder, visual system.

UNIT III

Localization and Mapping in mobile robotics. Motion Control of Mobile Robots (Model and Motion based Controllers): Lyapunov-based Motion Control Designs and Case Studies. Understand the current application and limitations of Mobile Robots, Introduction to Mobile Manipulators and Cooperative Mobile Robots.

UNIT IV

Micro-robotics: Introduction, Task specific definition of micro-robots - Size and Fabrication Technology based definition of micro-robots - Mobility and Functional-based definition of microrobots - Applications for MEMS based micro-robots. Implementation of Micro-robots: Arrayed actuator principles for micro-robotic applications – Micro-robotic actuators.

Alternative NPTEL/SWAYAM Course:

	Course Name	Instructor	Host Institute
1	Wheeled Mobile robots	Prof. Asokan Thondiyath	IIT, Madras

Suggested Text Books/ Reference Books:

1. Sabrie Soloman, Advanced Robotics (Design & Applications), Khanna Book Publishing, 2023.
2. Roland Siegwart, Illah Reza Nourbakhsh, Davide Sacramuzza, Introduction to Autonomous Mobile Robots, MIT press, 2nd edition, 2011.
3. Howie Choset, Kevin Lynch Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, ―Principles of Robot Motion-Theory, Algorithms, and Implementation, MIT Press, Cambridge, 2005.
4.Atnaik, Srikanta, "Robot Cognition and Navigation: An Experiment with Mobile Robots", Springer-Verlag Berlin and Heidelberg, 2007.
5. Spyros G. Tzafestas, "Introduction to Mobile Robot Control", Elsevier, 2021.
6. Margaret E. Jefferies and Wai-Kiang Yeap, "Robotics and Cognitive Approaches to Spatial Mapping", Springer-Verlag Berlin Heidelberg, 2008.
7. Santosh Mukherjee, Essentials of Robotics Process Automation, Khanna Publishing House, 2023.

Course code	26 PEC-RAI-204-H				
Category	Professional Elective Course				
Course title	**Data Analytics**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-4**
	3	**0**	**0**	**3**	
Classwork	25Marks				
Exam	50Marks				
Total	75Marks				
Duration of Exam	03 Hours				

COURSE OBJECTIVES

- Understand the fundamental concepts, processes, and applications of data analytics and data-driven decision-making.
- Analyse and preprocess structured and unstructured data using appropriate statistical and analytical techniques.
- Apply data mining, machine learning, and predictive analytics methods to extract meaningful patterns and insights from datasets.
- Use data visualization and business intelligence tools to interpret analytical results and support decision-making.

COURSE OUTCOMES

CO1: Understand fundamental concepts of data analytics, data types, and analytics processes using modern tools.

CO2: Perform data pre-processing techniques including cleaning, transformation, normalization, and handling missing data using Python.

CO3: Apply data visualization techniques to represent and interpret data effectively.

CO4: Analyze data using statistical methods including probability distributions, hypothesis testing, ANOVA, and regression

CO5: Apply basic machine learning algorithms for classification, clustering, and prediction tasks.

CO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PS O 2**	**PSO 3**
CO1	3	2	1	-	3	-	-	-	-	-	-	2	1	2
CO2	3	3	2	2	3	-	-	-	-	-	-	3	3	2
CO3	2	2	2	2	3	-	-	-	1	2	-	2	3	2
CO4	3	3	2	3	2	-	-	-	-	-	-	3	2	3
CO5	3	3	3	3	3	1	-	-	1	1	-	3	3	3
Wt. AVG	2.8	2.6	2	2	2.8	0.2	-	-	0.4	0.6	-	2.6	2.4	2.4
								Overall Mapping of Subject						1.89

UNIT I

Fundamentals of Data Analytics Descriptive, Predictive, and Prescriptive Analytics, Data Types, Analytics Types, Data Analytics Steps: Data Pre-Processing, Data Cleaning, Data Transformation, and Data Visualization.

Data Analytics Tools Data Analytics using Python, Statistical Procedures, NumPy, Pandas, SciPy, Matplotlib.

UNIT II

Data Pre-Processing Understanding the Data, Dealing with Missing Values, Data Formatting, Data Normalization, Data Binning, Importing and Exporting Data in Python, turning categorical variables into quantitative variables in Python, Accessing Databases with Python.

UNIT III

Data Visualization Graphic representation of data, Characteristics and charts for effective graphical displays, Chart types- Single variable: Dot plot, Jitter plot, Error bar plot, Box-and whisker plot, Histogram, Twovariable: Bar chart, Scatter plot, Line plot, Log-log plot, More than two variables: Stacked plots, Parallel coordinate plot.

UNIT IV

Descriptive and Inferential Statistics Probability distributions, Hypothesis testing, ANOVA, Regression.

Machine Learning Concepts Classification and Clustering, Bayes‟ classifier, Decision Tree, Apriori algorithm, K-Means Algorithm, Logistics regression, Support Vector Machines, Introduction to recommendation system.

Alternative NPTEL/SWAYAM Course:

	Course Name	Instructor	Host Institute
1	Data Analytics with python	Prof. A. Ramesh	IIT, Roorkee

Suggested Text Books/ Reference Books:

1. V.K. Jain, Data Science and Analytics (with Pyton, R, SPSS Programming), Khanna Book Publishing, 2023.
2. Dr. Jeeva Jose, Beginner's Guide for Data Analysis using R Programming, Khanna Book Publishing, 2023.
3. Anil Maheshwari, "Data Analytics made accessible," Amazon Digital Publication, 2014.
4. James R. Evans, "Business Analytics: Methods, Models, and Decisions", Pearson 2012.
5. Song, Peter X. K, "Correlated Data Analysis: Modeling, Analytics, and Applications", Springer-Verlag New York 2007.
6. V.K. Jain, Big Data and Hadoop, Khanna Book Publishing Co., 2023.
7. Glenn J. Myatt, Wayne P. Johnson, "Making Sense of Data I: A Practical Guide to Exploratory Data Analysis and Data Mining", Wiley 2009.
8. Thomas H. Davenport, Jeanne G. Harris and Robert Morison, "Analytics at Work: Smarter Decisions, Better Results", Harvard Business Press, 2010.
9. Rachel Schutt, Cathy O'Neil, "Doing Data Science", O'REILLY, 2006. Shamanth Kumar Fred Morstatter Huan Liu "Twitter Data Analytics", Springer-Verlag, 2014.

Course code	26 PEC-RAI-206-H				
Category	Professional ElectiveCourse				
Course title	**Intelligent Manufacturing**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-4**
	3	**0**	**0**	**3**	
Classwork	25Marks				
Exam	50Marks				
Total	75Marks				
Duration of Exam	03 Hours				

COURSE OBJECTIVES

- Analyse manufacturing processes using automation, cyber-physical systems, and data-driven approaches to improve productivity and efficiency.
- Apply technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and Industrial Robotics in manufacturing systems.
- Design and integrate intelligent manufacturing systems for process optimization, quality control, and predictive maintenance.
- Develop smart manufacturing solutions to address real-world industrial challenges and support Industry 4.0 initiatives.

COURSE OUTCOMES

CO1: Understand the structure, components, and communication systems of Computer Integrated Manufacturing (CIM).

CO2: Explain knowledge-based systems, knowledge representation techniques, and inference mechanisms used in manufacturing.

CO3: Apply automated process planning approaches and expert systems in manufacturing applications.

CO4: Analyze feature recognition and equipment selection problems using knowledge-based system approaches.

CO5: Apply group technology models, algorithms, and knowledge-based systems in intelligent manufacturing environments.

CO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	1	-	3	1	1	-	-	-	-	3	2	2
CO2	3	2	2	2	3	-	-	-	-	-	-	3	3	2
CO3	3	3	3	2	3	-	-	-	1	-	-	3	3	2
CO4	3	3	3	3	2		-	-	1	-	-	3	3	3
CO5	3	3	3	2	2	1	1	-	1	-	-	3	2	3
Wt. AVG	3	2.6	2.4	1.8	2.6	0.4	0.4	-	0.6	-	-	3	2.6	2.4
								Overall Mapping of Subject						1.98

UNIT I

Computer Integrated Manufacturing Systems Structure and functional areas of CIM system, - CAD, CAPP, CAM, CAQC, ASRS. Advantages of CIM. Manufacturing Communication Systems - MAP/TOP, OSI Model, Data Redundancy, Top- down and Bottom-up Approach, Volume of Information. Intelligent Manufacturing System Components, System Architecture and Data Flow, System Operation.

UNIT II

Basic Components of Knowledge Based Systems, Knowledge Representation, Comparison of Knowledge Representation Schemes, Interference Engine, Knowledge Acquisition. Automated Process Planning - Variant Approach, Generative Approach, Expert Systems for Process Planning.

UNIT III

Feature Recognition, Phases of Process planning. Knowledge Based System for Equipment Selection (KBSES) - Manufacturing system design. Equipment Selection Problem, Modeling the Manufacturing Equipment Selection Problem, Problem Solving approach in KBSES, Structure of the KRSES.

UNIT IV

Group Technology: Models and Algorithms Visual Method, Coding Method, Cluster Analysis Method, Matrix Formation - Similarity Coefficient Method, Sorting-based Algorithms, Bond Energy Algorithm, Cost Based method, Cluster Identification Method, Extended CI Method. Knowledge Based Group Technology - Group Technology in Automated Manufacturing System. Structure of Knowledge based system for group technology (KBSC IT) — Data Base, Knowledge Base, Clustering Algorithm.

Alternative NPTEL/SWAYAM Course:

	Course Name	Instructor	Host Institute
1	Product Design and manufacturing	Prof. Amandeep Singh	IIT, Kanpur

Suggested Text Books/ Reference Books:

1. Andrew Kusiak, “Intelligent Manufacturing Systems”, Prentice Hall, 1990.
2. Pat Langley, “Computational Intelligence and Intelligent Systems”, 2006.
3. Mohammad Jamshidi, “Design and Implementation of Intelligent Manufacturing Systems: From Expert Systems, Neural Networks to Fuzzy Logic”, 1st Edition, 1995.
4. Lucia Knapčíková, Michal Balog, “Industry 4.0: Trends in Management of Intelligent Manufacturing Systems”, Springer, 2019.

Course code	26 PEC-RAI-208-H				
Category	Professional ElectiveCourse				
Course title	**Microcontrollers Architecture and Programming**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester-4**
	3	**0**	**0**	**3**	
Classwork	25Marks				
Exam	50Marks				
Total	75Marks				
Duration of Exam	03 Hours				

COURSE OBJECTIVE

- Understand the architecture, organization, and instruction set of microcontrollers and their applications in embedded systems.
- Analyze the operation of memory, I/O ports, timers, interrupts, and serial communication interfaces of microcontrollers.
- Develop assembly language and embedded C programs for microcontroller-based applications.

COURSE OUTCOMES

CO1: Understand fundamental concepts of microprocessors, memory organization, and instruction execution.

CO2: Analyze the architecture and instruction set of 8085 microprocessor and PIC16F877 microcontroller.

CO3: Develop programs using assembly language and Embedded C in MPLAB IDE for microcontroller-based systems.

CO4: Apply interrupt handling, stack operations, and peripheral interfacing in embedded systems.

CO5: Design and implement microcontroller-based applications using peripherals and interfacing techniques.

CO-PO Mapping

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	1	-	2	-	-	-	-	-	-	2	1	2
CO2	3	3	2	2	2	-	-	-	-	-	-	3	2	2
CO3	3	3	3	2	3	-	-	-	1	1	-	3	3	2
CO4	3	3	3	3	3	1	-	-	1	-	-	3	3	3
CO5	3	3	3	3	3	1	1	-	2	1	-	3	3	3
Wt. AVG	3	2.8	2.4	2	2.6	0.4	0.2	-	0.8	0.4	-	2.8	2.2	2.4
							Overall Mapping of Subject							1.83

UNIT-I

Introduction to Microprocessors: Registers - File registers - Memory Organization - Tristate logic – Buses - Memory Address register – Read/Write operations. ROM, RAM, PROM, EPROM, E2PROM. Introduction to elementary processor – Organization - Data Transfer Unit (DTU)operation - Enhanced Data Transfer Unit (EDTU) – opcode - machine language - assembly language - pipeline and system clock.

UNIT II

Architecture of 8085 – Addressing modes - Data transfer, data processing and program flow control instructions - Simple assembly language programs, Introduction to Microcontrollers: PIC16F877 Architecture - Program and Data memory organization - Special Function Registers - Addressing modes, Instruction set.

UNIT III

MPLAB Integrated Development Environment – Introduction to Assembly language and Embedded C programming – Stack – Subroutines - Interrupt structure – Peripherals – Input/ Output Ports.

UNIT IV

PIC Peripherals: Timers/Counters - Watchdog Timer – Capture/Compare/PWM (CCP) - Analog to Digital Converter (ADC) – EEPROM - Serial Communication – USART - Development of Application Programs and interfacing - LED, LCD, Keyboard, DC and Stepper motor interface. Introduction to 8051 Microcontroller: Architecture – Ports – Timers

Alternative NPTEL/SWAYAM Course:

	Course Name	Instructor	Host Institute
1	Microprocessors and microcontrollers	Prof. Santanu Chattopadhyay	IIT, Kharagpur

Suggested Text Books/ Reference Books:

1. Rajkamal, “Microcontrollers - Architecture, Programming, Interfacing and System Design”, Pearson India, January 2011.
2. Valdes Perez, “The 8051 and MSP430 Microcontrollers: Architecture, Program”, T and F India, Jan 2013.
3. Kenneth J Ayala the 8051 Microcontroller Architecture, Programming and Architecture, 1996.
4. Raj Kamal, Embedded systems Architecture, Programming and design, Tata McGraw hill Education, 2008.