DEPARTMENT OF ROBOTICS ENGINEERING

LIST OF NEW COURSES (2020)

S. No.	Course Code	Course Title	L:T:P	Credits
1.	19RO2018	Industrial Internet of Things	3:0:0	3
2.	19RO2019	Python Programming for Robotics	2:0:2	3
3.	19RO2020	Data Analytics for Robotics and Automation	3:0:0	3
4.	19RO2021	Augmented Reality/Virtual Reality for Robotics	3:0:0	3
5.	19RO2022	Block Chain Technology for Robotic Applications	3:0:0	3
6.	20RO1001	Engineering Practices	0:0:2	1
7.	20RO1002	Basic Course in Embedded C	3:0:3	4.5
8.	20RO1003	Fundamentals of Python Programming for Robotics	3:0:3	4.5
9.	20RO1004	Introduction to Robotics and Automation	3:0:0	3
10.	20RO1005	Basic Robotics Laboratory	0:0:2	1
11.	20RO2001	Digital Electronics and Microprocessors	3:0:0	3
12.	20RO2002	Mechanics of Solids	3:0:0	3
13.	20RO2003	Sensors and Protocols for Instrumentation	3:0:0	3
14.	20RO2004	AI and ML Laboratory for Robotics	0:0:4	2
15.	20RO2005	Robot Process Automation Laboratory	0:0:2	1
16.	20RO2006	Mobile Robots	3:0:0	3
17.	20RO2007	Smart Sensors for IoT Applications	3:0:0	3
18.	20RO2008	Basics of PLC Programming	3:0:0	3
19.	20RO2009	Design Approach for Robotic Systems	3:0:0	3
20.	20RO3001	Robotics : System and Analysis	3:0:0	3
21.	20RO3002	Industrial Automation	3:0:0	3
22.	20RO3003	Computer Aided Modeling and Design	3:0:0	3
23.	20RO3004	Drives and control systems for automation	3:0:0	3
24.	20RO3005	Embedded Systems for Automation	3:0:0	3
25.	20RO3006	Advanced Automation Laboratory	0:0:4	2
26.	20RO3007	Advanced Robotic Process Automation Laboratory	0:0:4	2
27.	20RO3008	Embedded and IOT Laboratory	0:0:4	2
28.	20RO3009	Advanced AI and ML laboratory	0:0:4	2
29.	20RO3010	Computer Aided Production and Operation Management	3:0:0	3
30.	20RO3011	Rapid-Prototyping	3:0:0	3
31.	20RO3012	Mobile Robotics	3:0:0	3
32.	20RO3013	Advanced Embedded Processors	3:0:0	3
33.	20RO3014	Industrial Internet of Things and its Applications	3:0:0	3
34.	20RO3015	Optimization Techniques	3:0:0	3
35.	20RO3016	Product Design & Development	3:0:0	3
36.	20RO3017	Image Processing and Machine Vision	3:0:0	3
37.	20RO3018	Artificial Intelligence in Robotics and Automation	3:0:0	3
38.	20RO3019	Advanced Machine learning	3:0:0	3
39.	20RO3020	Design of Mechatronics System	3:0:0	3
40.	20RO3021	Deep Learning for Computer Vision	3:0:0	3
41.	20RO3022	Robot Programming	3:0:0	3
42.	20RO3023	Virtual Reality and Augmented Reality	3:0:0	3
43.	20RO3024	Real Time Operating System	3:0:0	3
44.	20RO3025	Entrepreneurship Development for Robotics and Automation	3:0:0	0

19RO2018	INDUSTRIAL INTERNET OF THINGS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To introduce the fundamental concepts of IoT Architecture and its components.
2. To provide an overview about the sensors and interfacing concepts
3. Gain knowledge on the IoT protocols and its applications.

Course Outcomes:

The Student will be able to

1. Identify the role of IIOT in industrial applications.
2. Specify the functions of various IoT components
3. Discuss about the sensors and interfacing concepts related to IoT
4. Compare the features of various IoT protocols and cloud platforms
5. Describe the architecture of IoT
6. Analyze the applications of IoT with case studies.

Module 1: Introduction (8 hrs)

Introduction to IOT & IIOT, IOT Vs. IIOT, Components of IIOT - Sensors, Actuator , Proximity and IR sensors, Interface, Networks, People &Process, Hype cycle, IOT Market, Computer Vision. Trends & future Real life examples, Key terms – IOT Platform, Interfaces, API, clouds, Data Management Analytics, Mining &Manipulation; Role of IIOT in Manufacturing Processes Use of IIOT in plant maintenance practices, Sustainability through Business excellence tools Challenges & Benefits in implementing IIOT

Module 2: Overview of IOT components (7 hrs)

Various Architectures of IOT and IIOT, Advantages & disadvantages, Industrial Internet - Reference Architecture; IIOT System components: Sensors, Gateways, Routers, Modem, Cloud brokers, servers and its integration, WSN, WSN network design for IOT

Module 3: Sensors and Interfacing (7 hrs)

Introduction to sensors, Transducers, Classification, Roles of sensors in IIOT , Various types of sensors , Design of sensors, sensor architecture, special requirements for IIOT sensors, Role of actuators, types of actuators. Hardwire the sensors with different protocols such as HART, MODBUS-Serial & Parallel, Ethernet, BACNet , Current, M2M etc

Module 4: Protocols and cloud (8 hrs)

Different protocols: RF: Wi-Fi, Wi-Fi direct, ZigBee, Blue Tooth, BLE, Zwave, Mesh network. Communication Channels: GSM/GPRS, 2G, 3G, LTE, WiFi, PLC. IoT protocols and architecture: MQTT/MQTTS, CoAP, 6LoWPAN, 6lowpan, lwm2m, AMPQ like TCP, UDP, HTTP/S. Application issues with RF protocol – power consumption, LOS, reliability. Security aspects. Comparison of various LPWAN protocols like Sigfox, LoRA and LoRAWAN, Weightless, NB-IoT, LTE-M.

IIOT cloud platforms : Overview of cots cloud platforms, predix, thingworks, azure etc. Data analytics, cloud services, Business models: Saas, Paas, Iaas.

Module 5: Industry 4.0 Architecture (8 hrs) OLE for Process Control (OPC), OPC and DCOM Diagnostics, OPC Security, OPC Unified Architecture (OPC UA). Introduction to web security, Conventional web technology and relationship with IIOT, Vulnerabilities of IoT, Privacy, Security requirements, Threat analysis, Trust, IoT security tomography and layered attacker model, Identity establishment, Access control, Message integrity, Non-repudiation and availability, Security model for IoT, Network security techniques Management aspects of cyber security

Module 6: IoT Analytics and Applications (7 hrs)

IOT Analytics : Role of Analytics in IOT, Data visualization Techniques, Introduction to R Programming, Statistical Methods.

Internet of Things

Applications : Smart Metering, e-Health Body Area Networks, City Automation, Automotive Applications, Home Automation, Smart Cards, Plant Automation, Real life examples of IIOT in Manufacturing Sector

Text Books:

1. Daniel Minoli, "Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications", ISBN: 978-1-118-47347-4, Willy Publications 2. Bernd Scholz-Reiter, Florian
2. Michahelles, "Architecting the Internet of Things", ISBN 978-3- 642-19156-5 e-ISBN 978-3-642-19157-2, Springer

Reference Books:

1. Hakima Chaouchi, " The Internet of Things Connecting Objects to the Web" ISBN : 978-1-84821-140-7, Wiley Publications,
2. Olivier Hersent, David Boswarthick, Omar Elloumi, The Internet of Things: Key Applications and Protocols, ISBN: 978-1-119-99435-0, 2 nd Edition, Willy Publications
3. Inside the Internet of Things (IoT), Deloitte University Press
4. Ovidiu & Peter, "Internet of Things- From Research and Innovation to Market Deployment" By River Publishers Series
5. Phil Wainewright - Kevin Ashton, "Five thoughts from the Father of the Internet of Things"
6. How Protocol Conversion Addresses IIoT Challenges: White Paper By RedLion.

19RO2019	PYTHON PROGRAMMING FOR ROBOTICS	L	T	P	C
		2	0	2	3

Course Objectives:

1. Understand the most important libraries of Python, and its recommended programming styles and idioms.
2. Learn core Python scripting elements such as variables and flow control structures.
3. Develop applications using Python for robotics.

Course Outcomes:

The Student will be able to

1. Outline the structure and components of a Python program.
2. Explain loops and decision statements in Python.
3. Illustrate class inheritance in Python for reusability
4. Choose lists, tuples, and dictionaries in Python programs.
5. Assess object-oriented programs with Python classes.
6. Develop simple code for robotics applications.

Module 1 - Introduction to Python, Data Types, Expressions (8 hrs)

Introduction to Python Programming - Running Code in the Interactive Shell, Input, Processing and Output, Editing, Saving and Running a Script - Data Types, String Literals, Escape Sequences, String Concatenation, Variables and the Assignment Statement - Numeric Data Types Module, The Main Module, Program Format and Structure and Running a Script from a Terminal Command Prompt –

Module 2: Loops and Expressions (8 hrs)

Iteration - for loop - Selection - Boolean Type, Comparisons, and Boolean Expressions, if-else Statements, One-Way Selection Statements, Multi-way if Statements, Logical Operators and Compound Boolean Expressions, Short-Circuit Evaluation and Testing Selection Statements - Conditional Iteration - while loop.

Module 3: Strings and Text Files (8 hrs)

Strings - Accessing Characters and Substrings in Strings, Data Encryption, Strings and Number Systems and String Methods - Text Files - Text Files and Their Format, Writing Text to a File, Writing Numbers to a File, Reading Text from a File, Reading Numbers from a File and Accessing and Manipulating Files and Directories on Disk.

Module 4: Lists and Dictionaries (7 hrs)

Lists - List Literals and Basic Operators, Replacing an Element in a List, List Methods for Inserting and Removing Elements, Searching and Sorting a List, Mutator Methods and the Value None, Aliasing and Side Effects, Equality and Tuples - Defining Simple Functions - Syntax , Parameters and Arguments, return Statement, Boolean Functions and main function, DICTIONARIES - Dictionary Literals, Adding Keys and Replacing Values, Accessing Values, Removing Keys and Traversing a Dictionary.

Module 5: Design with Functions and Design with Classes (7 hrs)

Design with Functions and Design with Classes - Functions as Abstraction Mechanisms, Problem Solving with Top-Down Design, Design with Recursive Functions and Managing a Program's Namespace - DESIGN WITH CLASSES - Objects and Classes, Data Modeling and Structuring Classes with Inheritance and Polymorphism.

Module 6: Case Studies in Robotics (7 hrs)

Object sensing and detection - Pick and Place Robot – Path planning - Unmanned vehicle - Control Robots - Depalletizing Operation - Joints and Degrees of Freedom.

Experiments:

The list of experiments will be notified by the HoD at the beginning of each semester.

Text Books:

1. Paul Barry, Head First Python 2e, O'Reilly, 2nd Revised edition, 2016, ISBN-13: 978-1491919538.
2. Kenneth A. Lambert, Martin Osborne, Fundamentals of Python: From First Programs Through Data Structures, Course Technology, Cengage Learning, 2010, ISBN-13: 978-1-4239-0218-8.

Reference Books:

1. Zed A. Shaw, Learn Python The Hard Way, Addison-Wesley, Third Edition, 2014, ISBN-13: 978-0-321-88491-6.
2. Dave Kuhlman, A Python Book: Beginning Python, Advanced Python, and Python Exercises, 2013, ISBN: 9780984221233.
3. Kent D Lee, Python Programming Fundamentals, Springer-Verlag London Limited, 2011, ISBN 978-1-84996-536-1.
4. Diwakar Vaish, Python Robotics Projects, Packtpub, 2018, ISBN 978-1-78883-292-2

19RO2020	DATA ANALYTICS FOR ROBOTICS AND AUTOMATION	L	T	P	C
		3	0	0	3

Credits: 3:0:0

Course Objectives

1. To learn architecture components of data analytics
2. To understand the basics of big data analytics
3. To know different types of analytics

Course Outcomes:

The Student will be able to

1. Recall the basics behind data analytics
2. Describe the architecture components of data analytics
3. Elaborate advanced analytics platform
4. Summarize Map-Reduce and the New Software Stack
5. Compare and contrast issues in Mining Data Streams
6. Summarize the concept of Link Analysis

Module 1. Introduction (7 hrs)

Velocity, Variety, Veracity; Drivers for Big Data, Sophisticated Consumers, Automation, Monetization, Big Data Analytics Applications: Social Media Command Center, Product Knowledge Hub, Infrastructure and Operations Studies, Product Selection, Design and Engineering, Location-Based Services, Online Advertising, Risk Management

Module 2. Architecture Components (7 hrs)

Massively Parallel Processing (MPP) Platforms, Unstructured Data Analytics and Reporting: Search and Count, Context-Sensitive and Domain-Specific Searches, Categories and Ontology, Qualitative Comparisons, Data Privacy Protection, Real-Time Adaptive Analytics and Decision Engines

Module 3. Advanced Analytics Platform (8 hrs)

Real-Time Architecture for Conversations, Orchestration and Synthesis Using Analytics Engines, Entity Resolution, Model Management, Discovery Using Data at Rest, Integration Strategies Implementation of Big Data Analytics: Revolutionary, Evolutionary, or Hybrid, Big Data Governance, Integrating Big Data with MDM, Evolving Maturity Levels

Module 4. Map-Reduce and the New Software Stack (8 hrs)

Distributed File Systems, Physical Organization of Compute Nodes, Large-Scale File-System Organization, Map-Reduce features: Map Tasks, Grouping by Key, Reduce Tasks, Combiners, Map-Reduce Execution, Coping With Node Failures, Algorithms Using Map-Reduce for Matrix multiplication, Relational Algebra operations, Workflow Systems, Recursive Extensions to Map-Reduce,

Module 5: Mining Data Streams and Link Analysis (7 hrs)

Stream Data Mode l and Management Stream Source, Stream Queries, and issues, Sampling Data in a Stream , Filtering Streams, Counting Distinct Elements in a Stream, Estimating Moments, Counting Ones in a Window, Decaying Windows .

Link Analysis: Page Ranking in web search engines, Efficient Computation of PageRank using Map-Reduce and other approaches, Topic-Sensitive Page Rank , Link Spam, Hubs and Authorities.

Module 6. Data Analytics and Robotic Process Automation (RPA) (8 hrs)

Data Robotics – Robotic Process Automation (RPA) and Intelligent Process Automation (IPA), Role of RPA in Big Data Analytics, Predictive Data Analytics for Industrial Robots – Behavioural and Maintenance Analytics.

Text Books:

1. Big Data Analytics: Disruptive Technologies for Changing the Game, Dr. Arvind Sathi,, First Edition October 2012, IBM Corporation
2. Mining of Massive Datasets, Anand Rajarama, Jure Leskovec, Jeffrey D. Ullman.E-book, 2013

Reference Books:

1. Big Data Imperatives, Soumendra Mohanty, Madhu Jagadeesh, Harsha Srivatsa, Apress, ebook of 2012

19RO2021	AUGUMENTED REALITY AND VIRTUAL REALITY FOR ROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives

1. Learn the concepts and principles of virtual and augmented reality
2. Understand VR and AR environment and software
3. Gain knowledge about the applications for Robotic Engineering.

Course Outcomes:

The Student will be able to:

1. Recall basic concepts of virtual and augmented reality
2. Describe the geometric modelling and Virtual environment.
3. Work with Virtual Environment and Augmented Reality systems
4. Perform experiments with the Hardware and Software tools
5. Develop Virtual Reality applications.
6. Summarize the applications of Block Chain Technology for Robotics

Module 1: - Introduction to Augmented Reality and Virtual Reality (8 hrs)

Virtual Reality and Virtual Environment: Introduction, Computer graphics, Real time computer graphics, Flight Simulation, Virtual environment requirement, benefits of virtual reality, Historical development of VR, Scientific Landmark. Augmented Reality Concepts: History of Augmented Reality, Multimodal displays: Haptic, Tactile and Tangible Displays, Visual Perception

Module 2: Geometric Modelling (7 hrs)

Geometric Modelling: Introduction, From 2D to 3D, 3D space curves, 3D boundary representation. Geometrical Transformations: Introduction, Frames of reference, Modelling transformations, Instances, Picking, Flying, Scaling the VE, Collision detection

Module 3: Virtual Environment and Augmented Reality Systems (8 hrs)

Animating the Virtual Environment: Introduction, The dynamics of numbers, Linear and Nonlinear interpolation, the animation of objects, linear and non-linear translation, shape & object inbetweening, free from deformation, particle system. Augmented Reality Systems – Types, Taxonomy of Augmented Reality, Helmet, Headup display, Smart Glasses, Projection

Module 4: VR Hardware and Software (8 hrs)

Human Factors: Introduction, the eye, the ear, the somatic senses. VR Hardware: Introduction, sensor hardware, Head-coupled displays, Acoustic hardware, Integrated VR systems. VR Software: Introduction, Modelling virtual world, Physical simulation, VR toolkits, Introduction to VRML, Khronos Group – AR Toolkit – Augmented Reality Operating System – Role of Augmented Reality interfaces – Players and Platforms

Module 5: AV/VR Applications (7 hrs)

Introduction, Engineering, Entertainment, Science, Training. The Future: Virtual environment, modes of interaction. Physical Simulation: Introduction, Objects falling in a gravitational field, Rotating wheels, Elastic collisions, projectiles, simple pendulum, springs, Flight dynamics of an aircraft.

Module 6: AR/VR for Robotic Applications (7 hrs)

AR assisted Robot Programming System for Industrial Applications, AR based Mobile Robot Tele operation, AR for human robot communication.AR and Cobots.

Text Books

1. John Vince, "Virtual Reality Systems ", Pearson Education Asia, 2007.
2. Dieter Schmalstieg, Tobias Hollerer, "Augmented Reality: Principles and Practice", Addison-Wesley Professional, 2016.

Reference Books:

1. Anand R., "Augmented and Virtual Reality", Khanna Publishing House, Delhi.
2. Adams, "Visualizations of Virtual Reality", Tata McGraw Hill, 2000.
3. Grigore C. Burdea, Philippe Coiffet , "Virtual Reality Technology", Wiley Inter Science, 2nd Edition, 2006.
4. William R. Sherman, Alan B. Craig, "Understanding Virtual Reality: Interface, Application and Design", Morgan Kaufmann, 2008.
5. Jon Peddie, "Augmented Reality – Where We Will All Live", Springer International Publishing AG, 2017.

19RO2022	BLOCK CHAIN TECHNOLOGY FOR ROBOTIC APPLICATIONS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Provide conceptual understanding of block chain
2. Understand the applications of Block chain technology
3. Cover the technological underpinning of Block Chain operations in both theoretical and practical implementation of solution.

Course Outcomes:

The Student will be able to

1. Understand the fundamentals of Block Chain Technology.
2. Describe the concept of Crypto Currency
3. Develop Block Chain based solutions and write smart contract.
4. Build and deploy Block Chain application for on premise and cloud based architecture.
5. Integrate ideas from various domains and implement them using block chain technology in different perspectives.
6. Develop Block chain applications pertaining to biomedical engineering.

Module 1: Introduction (7 hrs)

Overview of Block chain, Public Ledgers, Bitcoin, Smart Contracts, Block in a Block chain, Transactions, Distributed Consensus, Public vs Private Block chain, Understanding Crypto currency to Block chain, Permissioned Model of Block chain, Overview of Security aspects of Block chain .

Module 2: Understanding Block chain with Crypto currency (8 hrs)

Basic Crypto Primitives: Cryptographic Hash Function, Properties of a hash function, Hash pointer and Merkle tree, Digital Signature, Public Key Cryptography, A basic cryptocurrency. Bitcoin and Block chain: Creation of coins, Payments and double spending, Bitcoin Scripts, Bitcoin P2P Network, Transaction in Bitcoin Network, Block Mining, Block propagation and block relay.

Module 3: Working with Consensus in Bitcoin (8 hrs)
Distributed consensus in open environments, Consensus in a Bitcoin network, Proof of Work (PoW) – basic introduction, Hashcash PoW, Bitcoin PoW, Attacks on PoW and the monopoly problem, Proof of Stake, Proof of Burn and Proof of Elapsed Time, life of a Bitcoin Miner, Mining Difficulty, Mining Pool.

Module 4: Understanding Block chain for Enterprises (8 hrs)
Permissioned Block chain: Permissioned model and use cases, Design issues for Permissioned block chains, Execute contracts, State machine replication, Overview of Consensus models for permissioned block chain- Distributed consensus in closed environment, Paxos, RAFT Consensus, Byzantine general problem, Byzantine fault tolerant system, Lamport-Shostak-Pease BFT Algorithm, BFT over Asynchronous systems.

Module 5: Enterprise application of Block chain (7 hrs)
Cross border payments, Know Your Customer (KYC), Food Security, Mortgage over Block chain, Block chain enabled Trade, We Trade – Trade Finance Network, Supply Chain Financing, Identity on Block chain

Module 6: Block chain application development (7 hrs)
Hyperledger Fabric- Architecture, Identities and Policies, Membership and Access Control, Channels, Transaction Validation, Writing smart contract using Hyperledger Fabric, Writing smart contract using Ethereum, Overview of Ripple and Corda. Frame work of Robotic swarm systems, Blockchain-based Multi-Robot Path Planning, Distributed Computing, Multi-robot system, robotic Path Planning.

Text Books:

1. Melanie Swan, "Block Chain: Blueprint for a New Economy", O'Reilly, 2015
2. Josh Thompsons, "Block Chain: The Block Chain for Beginners- Guide to Block chain Technology and Leveraging Block Chain Programming",2015

Reference Books:

1. Daniel Drescher, "Block Chain Basics", Apress; 1stedition, 2017
2. Anshul Kaushik, "Block Chain and Crypto Currencies", Khanna Publishing House, Delhi.
3. Imran Bashir, "Mastering Block Chain: Distributed Ledger Technology, Decentralization and Smart Contracts Explained", Packt Publishing,2018
4. Ritesh Modi, "Solidity Programming Essentials: A Beginner's Guide to Build Smart Contracts for Ethereum and Block Chain", Packt Publishing,2018
5. Salman Baset, Luc Desrosiers, Nitin Gaur, Petr Novotny, Anthony O'Dowd, Venkatraman Ramakrishna, "Hands-On Block Chain with Hyperledger: Building Decentralized Applications with Hyperledger Fabric and Composer", Import, 2018

Course code	ENGINEERING PRACTICES	L	T	P	C
20RO1001		0	0	2	1

Course Objective

Impart knowledge on
1. Carpentry Joints, Fitting, Welding Practices and motor selection
2. Basics of Measuring and Analyzing the Electronic Circuits
3. PCB design and fabrication

Course Outcome

The student will be able to
1. Assemble mechanical devices and equipment by applying carpentry, welding and fitting practices.
2. Design simple electric circuits and apply different types of wiring.
3. Identify the operation and handling of measuring instruments.
4. Perform the selection of suitable motors
5. Fabricate PCB boards for specific applications
6. Compare the functions of various electronics components.

List of Experiments

1.	Basic Carpentry experiments
2.	Drilling Practice on Mild Steel plates

3.	Welding of Mild Steel plates
4.	Household Wiring Practice
5.	Handling Digital Storage Oscilloscope (DSO)
6.	Basics of Measurement using Voltmeter, Ammeter and Multimeter
7.	Basics of Measurement using Wattmeter and Energy meter
8.	Study of Motor Characteristics and Selection of Motors
9.	Study of Electronic Components and its characteristics
10.	Design and Implementation of simple electronic circuits
11.	PCB layout design using software.
12.	PCB fabrication, Components soldering and Trouble shooting
	Total Lectures **30 Hours**

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	**BASIC COURSE IN EMBEDDED C**	**L**	**T**	**P**	**C**
20RO1002		3	0	3	4.5

Course Objective

To impart knowledge on

1. To develop programming skills in Embedded C
2. To understand array, pointer and structures in Embedded C programming
3. To acquire the concepts of file handling in C programming.

Course Outcome

The student will be able to

1. Develop program in Embedded C using operators, data types and flow control loops
2. Elaborate the concepts of arrays and functions.
3. Compare the basic concepts of Structures and Unions in C programming
4. Develop programming using pointers.
5. Write structures in Embedded C
6. Create simple examples with embedded programming

Module: 1	**C Overview and Program Structure**	**7 Hours**

Fundamentals of C – Data types and Constants -Simple & Formatted I/O - Memory Usage - Operators & Expressions -Flow Control- Loops

Module: 2	**Functions, Arrays for Embedded Programming**	**8 Hours**

Functions: Role of Functions - Pass by value / reference - Returning values from Functions - Recursive Functions - Call Back Functions -Implications on Stack -Library Vs User defined function -Passing variable number of arguments

Arrays: Defining, initializing and using arrays -Multi Dimensional Arrays -Arrays of Characters and Strings -Arrays and Pointers -Passing arrays to functions -String handling with and without library functions.

Module: 3	**Structures and Unions for Embedded Programming**	**7 Hours**

Declaration, initialization-Accessing like objects -Nested Structures -Array of Structures-Passing structures through functions

Module: 4	**Embedded Pointers**	**8 Hours**

Pointers : Embedded Pointers-The & and * operators -Pointer Assignment -Pointer Arithmetic -Multiple indirections-Advanced pointer types -Generic and Null Pointer- Function Pointers- Pointers to Arrays and Strings -Array of Pointers -Pointers to Structure and Union		
Module: 5	**Embedded C programming structure**	**8 Hours**
Embedded C programming structure Distinguish C and Embedded C, Embedded C programming structure- Embedded software development process: build process- compiling -linking- locating- downloading- debugging- remote debuggers- emulators and simulators-declaration of ports and registers- simple examples using embedded C		
Module: 6	**Embedded Programming for Robotics**	**7 Hours**
Embedded Programming for Robotics Introduction to IDE, Programming with Controller, Input /output interfacing, interfacing sensor for robots, IoT applications		
	Total Lectures	**45 Hours**

Text Books	
1.	Richard Barnett, Sarah Cox, Larry O'Cull, Mark Siegesmund,"Embedded C Programming: Techniques and Applications of C and PIC MCUS", Elsevier Inc., 2014,
2.	Michael Barr, "Programming Embedded Systems in C and C++", O'Reilly, 1999
Reference Books	
1.	Richard H. Barnett, Sarah Cox, Larry O'Cull , Embedded C Programming and the Atmel AVR, Delmar Cengage learning 2007.
2.	Ashok K. Pathak, Advanced Test in C and Embedded System Programming**,** BPB Publications, 2003
3.	Michael Barr, Embedded C Coding Standard, CreateSpace Independent Publishing Platform, 2018
4.	Michael J Pont, Embedded C , Pearson Education, 2008
5.	Delmar **,"**Embedded C Programming and the Microchip PIC",Cengage Learning. 2003
Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	FUNDAMENTALS OF PYTHON PROGRAMMING FOR ROBOTICS	L	T	P	C
20RO1003		**3**	**0**	**3**	**4.5**

Course Objective

To impart knowledge on

1. Understand the important libraries of Python, and its recommended programming styles and idioms.
2. Learn core Python scripting elements such as variables and flow control structures.
3. Develop applications using Python for robotics.

Course Outcome

The student will be able to

1. Outline the structure and components of a Python program.
2. Explain loops and decision statements in Python.
3. Illustrate class inheritance in Python for reusability
4. Choose lists, tuples, and dictionaries in Python programs.
5. Assess object-oriented programs with Python classes.
6. Develop simple code for robotics applications.

Module: 1	Introduction to Python, Data Types, Expressions	7 Hours
Introduction to Python, Data Types, Expressions: Introduction to Python Programming - Running Code in the Interactive Shell, Input, Processing and Output, Editing, Saving and Running a Script - Data Types, String Literals, Escape Sequences, String Concatenation, Variables and the Assignment Statement - Numeric Data Types Module, The Main Module, Program Format and Structure and Running a Script from a Terminal Command Prompt –		
Module: 2	**Loops and Expressions**	**8 Hours**
Loops and Expressions: Iteration - for loop - Selection - Boolean Type, Comparisons, and Boolean Expressions, if-else Statements, One-Way Selection Statements, Multi-way if Statements, Logical Operators and Compound Boolean Expressions, Short-Circuit Evaluation and Testing Selection Statements - Conditional Iteration - while loop.		
Module: 3	**Strings and Text Files**	**7 Hours**
Strings and Text Files: Strings - Accessing Characters and Substrings in Strings, Data Encryption, Strings and Number Systems and String Methods - Text Files - Text Files and Their Format, Writing Text to a File, Writing Numbers to a File, Reading Text from a File, Reading Numbers from a File and Accessing and Manipulating Files and Directories on Disk		
Module: 4	**Lists and Dictionaries**	**8 Hours**
Lists - List Literals and Basic Operators, Replacing an Element in a List, List Methods for Inserting and Removing Elements, Searching and Sorting a List, Mutator Methods and the Value None, Aliasing and Side Effects, Equality and Tuples - Defining Simple Functions - Syntax , Parameters and Arguments, return Statement, Boolean Functions and main function, **Dictionaries** - Dictionary Literals, Adding Keys and Replacing Values, Accessing Values, Removing Keys and Traversing a Dictionary.		
Module: 5	**Design with Functions and Design with Classes**	**8 Hours**
Design with Functions - Functions as Abstraction Mechanisms, Problem Solving with Top-Down Design, Design with Recursive Functions and Managing a Program's Namespace – **Design With Classes**- Objects and Classes, Data Modeling and Structuring Classes with Inheritance and Polymorphism.		
Module: 6	**Micro Python**	**7 Hours**
Micro Python: Micro Python Hardware- Workflow-setting up MicroPython on Board- Creating and Deploying code. Case studies: Object sensing and detection - Pick and Place Robot – Path planning - Unmanned vehicle - Control Robots - Joints and Degrees of Freedom.		
	Total Lectures	**45 Hours**

Text Books

1.	Paul Barry, Head First Python 2e, O′Reilly, 2nd Revised edition, 2016, ISBN-13: 978-1491919538.
2.	Kenneth A. Lambert, Martin Osborne, Fundamentals of Python: From First Programs Through Data Structures, Course Technology, Cengage Learning, 2010, ISBN-13: 978-1-4239-0218-8.

Reference Books

1.	Zed A. Shaw, Learn Python The Hard Way, Addison-Wesley, Third Edition, 2014, ISBN-13: 978-0-321-88491-6.
2.	Dave Kuhlman, A Python Book: Beginning Python, Advanced Python, and Python Exercises, 2013, ISBN: 9780984221233.

3.	Kent D Lee, Python Programming Fundamentals, Springer-Verlag London Limited, 2011, ISBN 978-1-84996-536-1.
4.	Diwakar Vaish, Python Robotics Projects, Packtpub, 2018, ISBN 978-1-78883-292-2
5.	Nicholas H.Tollervey, Programming with MicroPython- Embedded Programming with Micrcontrollers& Python, O'Reilly, 2018.

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	INTRODUCTION TO ROBOTICS AND AUTOMATION	L	T	P	C
20RO1004		**3**	**0**	**0**	**3**

Course Objectives

To impart knowledge on

1. To introduce the fundamentals of robotics and automation
2. To provide knowledge about the components of robotics
3. To deal with the applications of robotics and automation

Course Outcomes

The student will be able to

1. Recall the evolution of robots and their classification
2. Analyse the applications of sensors and actuators in robotics.
3. Describe the kinematics and dynamic behaviour of robots and its programming.
4. Appraise the emerging technologies in the field of robotics
5. Compare different concepts of automation
6. Apply knowledge of automation in various fields

Module: 1	**Introduction**	**7 Hours**

History of Robots, Definition, Robot anatomy, Asimov's laws, Co-ordinate systems, work envelope, Classification, Specifications, Degrees of Freedom, Need for robots, Applications.

Module: 2	**Robot Components**	**7 Hours**

Robot Components : Sensors: Range Sensors, Proximity Sensors, Position Sensors, Touch Sensors, Vision Systems (Qualitative Approach). Drives: Pneumatic, Hydraulic, Electric actuators, Comparison. End Effectors: Grippers, tools, selection of grippers and tools.

Module: 3	**Transformations and Robot Programming**	**7 Hours**

Transformations: Robot Kinematics and Dynamics – Qualitative Study, Homogeneous Transformation, Rotational Transformation, Jacobians,
Robot Programming Techniques: Teach Pendant Method, Lead-through Programming, Intelligent Robots, Robot Programming Languages, Introduction to ROS.

Module: 4	**Robot Applications**	**8 Hours**

Industrial Applications: Manufacturing, Assembly Automation, Machining, Drilling, Welding, Painting. Consumer Applications.
Emerging Applications: Mobile Robots, Medical Robots, Soft Robots, Collaborative Robots, Cloud Robots, Micro robots, Tele Robots, AGVs, Underwater Robots, Robotics and AI, RPA, Economic and Social Aspects of Robots.

Module: 5	**Introduction to Automation**	**8 Hours**

Definition, Types of Automation, Advantages, Goals and Issues in Automation, Industry 4.0, Components of an automatic system, Trends in Automation – PLC, DCS, SCADA, AI based Automation.		
Module: 6	**Applications of Automation**	**8 Hours**
Case Studies in Industrial Automation, Home Automation, Building Automation, Smart Cities, Future of Robotics and Automation		
	Total Lectures	**45 Hours**

Text Books

1.	Mikell P Groover, "Industrial Robotics", Mc GrawHill, 2012.
2.	Gupta.A.K, Arora. S. K., Industrial Automation and Robotics, Mercury Learning and Information, 2017.

Reference Books

1.	Thomas. K. Rufuss, "Robotics and Automation Handbook", CRC Press, 2018
2.	Ghoyal.K., Deepak Bhandari, "Automation and Robotics", S.K.Kataria& Sons Publishers, 2012.
3.	John.J. Craig, "Introduction to Robotics: Mechanics and Control", Pearson, 2018.
4.	Gonzalez, Fu Lee, Robotics: Control, Sensing, Vision and Intelligence, Wiley, 1998
5.	Mehta.B.R, Reddy.Y.J, "Industrial Process Automation Systems", Elsevier, 2015

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	**BASIC ROBOTICS LABORATORY**	**L**	**T**	**P**	**C**
20RO1005		0	0	2	1

Course Objective

Impart knowledge on

1. Carpentry Joints, Fitting, Welding Practices and Motor Selection
2. Basics of Measuring and Analyzing the Electronic Circuits
3. PCB Design and Fabrication

Course Outcome

The student will be able to

1. Work with simple Simulation Software for Developing Robots
2. Simulate the Robot features in various Simulation Softwares
3. Visualize the configurations of various types of robots using Lego Bots
4. Perform Programming and Analysis of Simple Robots using Software
5. Develop simple circuits for Robot Navigation.
6. Identify and implement simple sensor circuitry for Robot

List of Experiments

1.	Simulation of Robot Environment.
2.	Simulation of Robot Features.
3.	Simulation of Robot Motion Control.
4.	Simulation of Robot for Simple Applications.
5.	Design of Lego Bot – Pick and Place.
6.	Design of Lego Bot – Conveyer .
7.	Design of Lego Bot – Color sorter.
8.	Design of Lego Bot – Robo dog.
9.	Simple circuit control for robot.
10.	Simple circuit for Navigation of Robot.
11.	Design of Line following Robot using Electronics Circuits
12.	Design of Navigating and Obstacle Avoiding Robots using Electronics Circuit.
	Total Lectures **30 Hours**
Recommended by Board of Studies	

Approved by Academic Council	

Course code	DIGITAL ELECTRONICS AND MICROPROCESSORS	L	T	P	C
20RO2001		3	0	0	3

Course Objectives

To impart knowledge on

1. Basics of Logic families, Sequential and Combinational Logic Circuits
2. Fundamentals of Programmable Logic Devices
3. Concept of Semiconductor Memories and their application in Microprocessor Architecture

Course Outcomes

The student will be able to

1. Recall the concepts of logic gates and tri state logic
2. Design Combinational Circuits using Boolean Logic
3. Implement Sequential Circuits using logic gates.
4. Outline the process of Analog to Digital conversion and Digital to Analog conversion.
5. Apply PLDs to implement the given logical problem.
6. Relate the concepts of Digital Systems to Microprocessor Architecture

Module: 1	Fundamentals of Digital Systems and Logic Families	7 Hours

Digital signals, digital circuits, AND, OR, NOT, NAND, NOR and Exclusive-OR operations, Boolean algebra, examples of IC gates, number systems-binary, signed binary, octal hexadecimal number, binary arithmetic, one's and two's complements arithmetic, codes, error detecting and correcting codes, characteristics of digital logic families, TTL, Schottky TTL and CMOS logic, interfacing CMOS and TTL, Tri-state logic.

Module: 2	Combinational Digital Circuits	7 Hours

Standard representation for logic functions, K-map representation, simplification of logic functions using K-map, minimization of logical functions. Don't care conditions, Q-M method of function realization.

Multiplexer, DeMultiplexer/Decoders, Adders, Subtractors, BCD arithmetic, carry look ahead adder, serialadder, ALU, elementary ALU design, popular MSI chips, digital comparator, paritychecker/generator, code converters, priority encoders, decoders/drivers for display devices.

Module: 3	Sequential Circuits and Systems	7 Hours

Sequential circuits and systems :A 1-bit memory, the circuit properties of Bistable latch, the clocked SR flip flop, J- K-T and D- type flipflops, applications of flipflops, shift registers, applications of shift registers, serial to parallel converter, parallel to serial converter, ring counter, sequence generator, ripple(Asynchronous) counters, synchronous counters, counters design using flip flops, applications of counters.

Module: 4	A/D and D/A Converters	8 Hours

Digital to Analog converters: Weighted Resistor, R-2R Ladder, D/A converter, Specifications for D/A converters, Sample and Hold circuit, Analog to Digital converters: Quantization and Encoding, Parallel comparator A/D converter, Successive Approximation A/D converter, Counting A/D Converter, Dualslope A/D converter, A/D converter using voltage to frequency and voltage to time conversion, Specifications of A/D converters

Module: 5	Semiconductor memories and Programmable Logic Devices	8 Hours

Memory organization and operation, expanding memory size, classification and characteristics of memories, sequential memory, read only memory (ROM), read and write memory(RAM), ROM as

a PLD, Programmable logic array, Programmable array logic, Complex Programmable Logic Devices (CPLDS), Field Programmable Gate Array (FPGA).		
Module: 6	**Fundamentals of Microprocessors**	**8 Hours**
Fundamentals of Microprocessors : Basic blocks of a microcomputer, Functional block diagram of 8 bit Microprocessor, Registers, ALU, Bus Systems, Memory, Input Output Devices, Programming Concepts.		
	Total Lectures	**45 Hours**

Text Books

1.	R. P. Jain, "Modern Digital Electronics", McGraw Hill Education, 2010.
2.	M. M. Mano, "Digital logic and Computer design", Pearson Education India, 2016.

Reference Books

1.	Kumar, "Fundamentals of Digital Circuits", Prentice Hall India, 2016.
2.	M. Rafiquzman, Fundamentals of Digital Logic and Microcomputer Design, WileyInterscience, 2005.
3.	Bob Dukish, “Digital Electronics with Arduino”, BPB Publications, 2020.
4.	M. A.Mazidi, J. G. Mazidi and R. D. McKinlay, “The8051Microcontroller and Embedded Systems: Using Assembly and C”,Pearson Education, 2007.
5.	R. S. Gaonkar, “, Microprocessor Architecture: Programming and Applications with the 8085”, Penram International Publishing, 1996

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	**MECHANICS OF SOLIDS**	**L**	**T**	**P**	**C**
20RO2002		**3**	**0**	**0**	**3**

Course Objectives

To impart knowledge on

1. Nature of stresses developed in simple geometries
2. Elastic deformation occurring in various simple geometries for different types of loading.

3.Stresses action on shafts, springs and cylinders

Course Outcomes

The student will be able to

1. Describe the concepts of stress-strain relationships for homogenous, isotropic materials.
2. Calculate stresses and strains in members subjected to axial structural loads and thermal loads.
3. Determine the volumetric strain of the components and also derive the relationship between the elastic constants.
4. Calculate the shear force and bending moment of beams.
5. Compute the stresses and strains in members subject to flexural and torsional loadings.
6. Illustrate principal stresses, maximum shearing stress, and the stresses acting on a structural member.

Module: 1	**Stresses And Strains**	**7 Hours**
Stress and Strain Fundamentals, Axial load, Stress and Strain due to Axial Load, Stresses on Inclined Planes, Generalized Hooke’s Laws , Tension Test and Stress-Strain Diagram (Ductile and Brittle Materials), Shear Stress and Strain, Factor of Safety, Deformation of simple, stepped bars and compound bars due to axial force, uniformly varying sections, Strain energy, Resilience, Gradual, sudden, impact and shock loadings and thermal stresses.		

Module: 2	Changes In Dimensions And Volume	7 Hours
Lateral strain - Poisson's ratio, volumetric strain, changes in dimensions and volume, relationship between elastic constants		
Module: 3	**Bending Moment And Shear Force**	**7 Hours**
Definition of beam, Types of beams, Concept of shear force and bending moment, Relationship between load, shear force and bending moment, shear force and bending moment diagrams for cantilever, simply supported and overhanging beams under concentrated loads, uniformly distributed loads, uniformly varying loads, concentrated moments, maximum bending moment and point of contra flexure.		
Module: 4	**Flexure In Beams**	**8 Hours**
Theory of simple bending and assumptions - derivation of equation, section modulus, normal stresses due to flexure.		
Module: 5	**Torsion**	**8 Hours**
Theory of torsion and assumptions-derivation of the equation, polar modulus, stresses in solid and hollow circular shafts, power transmitted by a shaft, close coiled helical spring with axial load.		
Module: 6	**Principal Stresses And Strains (2D)**	**8 Hours**
State of stress at a point - normal and tangential stresses on a given plane, principal stresses and their planes, plane of maximum shear stress, analytical method, Mohr's circle method, application to simple problems.		
	Total Lectures	**45 Hours**

Text Books

1.	Punmia B C., Ashok Kumar Jain and Arun Kumar Jain, "Mechanics of materials", Laxmi Publications, New Delhi, 2005.
2.	Egor P Popov, “Engineering Mechanics of Solids”, Prentice Hall of India Learning Ltd., New Delhi, 2010.

Reference Books

1.	Hibbeler RC., "Mechanics of Materials", Pearson Education, Low Price Edition, 2007.
2.	Ramamrutham S and Narayan R., "Strength of Materials", Dhanpat Rai and Sons, New Delhi, 2008.
3.	Crandall, S. H., Dahl, N. C. and Lardner, T. J, An Introduction of the Mechanics of Solids, 3rd ed., Tata McGraw Hill, 2012.
4.	Shames, I. H, Engineering Mechanics: Statics and Dynamics, 4th ed., Prentice Hall of India, 2004.
5.	Meriam, J. L. and Kraige, L. G, Engineering Mechanics Statics, 5h ed., John Wiley and Sons, 2004

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	SENSORS AND PROTOCOLS FOR INSTRUMENTATION	L	T	P	C
20RO2003		3	0	0	3

Course Objectives

To impart knowledge on

1. The basics of measuring system and classify the types of error

2. Selection of the appropriate sensor for measuring various physical quantities
3. Different communication protocols

Course Outcomes

The student will be able to

1. Classify the types of errors in measurement system and identify the types of sensors
2. Compare the principle and working of temperature, pressure and flow sensors.
3. Identify and apply appropriate sensor for measurement of displacement and velocity.
4. Apply various sensors for designing and building robots
5. Describe the functions of different communication protocols
6. Apply the various wireless communication protocols in Sensor Interfacing

Module: 1	**Measuring System**	**7 Hours**

Sensor Systems – Classification of sensors: Factors in making the measurements-accuracy, precision, resolution, repeatability, reproducibility, hysteresis, sensitivity, range, selection and standard of sensors – Generalized Instrumentation System, SI Units – Base units of SI - Errors in Measurement – Types of errors – Calibration techniques.

Module: 2	**Temperature, Pressure Measurement**	**7 Hours**

Temperature Measurement: Terminology, Bimetallic thermometer, Resistance Temperature Detectors, Thermistors, Thermocouples, Integrated circuit temperature transducers. Pressure Measurement: Resistive, Capacitance, Piezoelectric transducer.

Module: 3	**Displacement & Velocity Measurement**	**7 Hours**

Linear and Angular measurement systems – Resistance potentiometer, strain gauge, capacitive transducers and variable inductance transducers, resolvers, LVDT, proximity sensors, ultrasonic and photo-electric sensors - linear scales, Laser Interferometers, tacho-generator, Encoders: absolute and incremental.

Module: 4	**Flow Measurement and Miscellaneous Sensors**	**8 Hours**

Flow and Level Measurement: Venturi flow meters, Electro-Magnetic flow meter- Level Measurement Techniques, Measurement of vibration, tactile sensors: force, torque, Gyroscope.

Module: 5	**Industrial Communication Interface Protocols**	**8 Hours**

Diagnostic Protocols – KWP2000,Serial Data Interfaces – RS-232, RS-485, CAN, I2C, SPI, I2S,Field Bus Protocols – Modbus, Profibus, Ethernet.

Module: 6	**Wireless Communication**	**8 Hours**

Electromagnetic spectrum – Frequency allocation – Radio modem – Data Communications , Wireless Local Area Networks (WLAN): Wireless Fidelity (Wi-Fi) ,Wireless Personal Area Networks (WPAN): Bluetooth, ANT, ZigBee Wireless Sensor Area Networks (WSAN): BLE (Bluetooth Low Energy), ZigBee, 6LoWPAN .

	Total Lectures	**45 Hours**

Text Books

1. Peter Elgar, ”Sensors for Measurement and Control”, Addison-Wesley Longman Ltd, 1998.
2. Patranabis D, “Sensors and Transducers”, Prentice-Hall of India Private Limited, New Delhi, 2003.

Reference Books

1. Richard D Klafter, Thomas A Chmielewski, Michael Negin, “Robotics Engineering: An Integrated Approach”, PHI Learning, New Delhi, 2009.
2. Ernest O Doebelin, “Measurement systems Application and Design”, Tata McGraw-Hill Book Company, 2010

3.	A. K. Sawhney, "Electrical & Electronic Measurement & Instruments", Dhanpat Rai& Co., 2010.
4.	Practical Field bus, Device Net and Ethernet for Industry, IDC Technology, 2006
5.	Dominique Paret, "Multiplexed Networks for Embedded Systems", John Wiley & Sons, 2007.
Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	**AI AND ML LABORATORY FOR ROBOTICS**	**L**	**T**	**P**	**C**
20RO2004		0	0	4	2

Course Objectives

Impart knowledge on

1. Fundamental techniques of AI and ML
2. Development of Algorithm using AI and ML
3. Significance of AI and ML for Robotic Applications

Course Outcomes

The student will be able to

1. Apply the fundamentals of AI.
2. Develop simple applications using ML.
3. Work with standard AI and ML Algorithms.
4. Perform experiments in the simulation environment for AI
5. Identify suitable Algorithm for Robotic Applications
6. Design and Implement Robotic Applicationsusing AI

List of Experiments

1.	Demonstration of Pre-processing
2.	Demonstration of Association rule
3.	Demonstration of Classification rule
4.	Demonstration of Clustering Rule using Simple K-Means
5.	Linear Regression Models
6.	Single Layer Perceptron Algorithm
7.	Multiple Layer Perceptron Training
8.	Back Propagation Algorithm
9.	Primitive Operations On Fuzzy Sets
10.	Particle Swarm Optimization Technique
11.	Simple Robotic Application using Depth First Search.
12.	Simple Robotic Application using Best First Search
	Total Lectures **45 Hours**
Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	**ROBOT PROCESS AUTOMATION LABORATORY**	**L**	**T**	**P**	**C**
20RO2005		0	0	2	1

Course Objectives

Impart knowledge on

1. To enable the students to understand the programming techniques of RPA
2. To design suitable Robotic Enterprise Framework Overview.
3. To understand the concepts of RPA Design & Development

Course Outcomes

The student will be able to

1. Apply the fundamentals of RPA

2. Work with standard Error and Exception Handling. 3. Generate signals with Excel and Data Tables 4. Perform Interactions using RPA. 5. Develop a PDF Automation. 6. Design RPA interfacing with E-mail Automation	
List of Experiments	
1.	Introduction to RPA
2.	Variables, Data Types, Control Flow
3.	Excel and Data Tables
4.	Selectors
5.	UI Interactions
6.	PDF Automation
7.	E-mail Automation
8.	Error and Exception Handling
9.	Debugging
10.	Project Organization
11.	Orchestrator for Developers
12.	Robotic Enterprise Framework Overview
Total Lectures	**30 Hours**
Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	**MOBILE ROBOTS**	**L**	**T**	**P**	**C**
20RO2006		3	0	0	3

Course Objectives

To impart knowledge on

1. Learn the concepts of various mobile robots and its kinematics
2. Understand the fundamentals of Sensors in the Mobile Robots
3. Gain knowledge about the control aspects for various types of mobile robots .

Course Outcomes

The student will be able to

1. Classify the various types of Mobile Robots
2. Describe the Kinematics in the Mobile Robots
3. Apply the concepts of sensing elements to Mobile Robot Applications
4. Explain the various dynamic models of Mobile Robots
5. Summarize the control aspects involved in Mobile Robotics
6. Apply the fundamentals of Mobile Robotics to develop Practical Applications.

Module: 1	**Types of Mobile Robots**	**7 Hours**

Robot History - Locomotion: Introduction - Key issues for locomotion - Types of Robots: Legged Mobile Robots - Wheeled Mobile Robots - Driving Robots - Omnidirectional Robots - Balancing Robots - Walking Robots - Autonomous Planes - Autonomous Vessels & Underwater Vehicles.

Module: 2	**Mobile Robot Kinematics**	**7 Hours**

Introduction – Background Concepts: Direct and Inverse Robot Kinematics, Homogeneous Transformations, Nonholonomic Constraints – Nonholonomic Mobile Robots: Unicycle, Differential Drive WMR, Tricycle, Car-like WMR, Chain and Brockett – Integral Models, Car Pulling Trailer WMR

Module: 3	**Mobile Robot Dynamics**	**7 Hours**

General Robot Dynamic Modeling: Newton-Euler Dynamic Model, Lagrange Dynamic Model, Lagrange Model of Multilink Robot, Dynamic Modeling of Nonholonomic Robots – Differential Drive WMR: Newton-Euler Dynamic Model, Lagrange Dynamic Model, Dynamics of WMR with Slip – Car like WMR Dynamic Model – 3 Wheel Omnidirectional Mobile Robot		
Module: 4	**Mobile Robot Sensors**	**8 Hours**
Mobile Robot Sensors Sensor Classification and Characteristics – Position & Velocity Sensors – Distance Sensors: Sonar, Laser, Infrared Sensors – Robot Vision – Gyroscope – Compass – Force and Tactile Sensors – Global Positioning System		
Module: 5	**Mobile Robot Controls**	**8 Hours**
General Robot Controllers: Proportional plus Derivative Position Control, Computed Torque Control, Robot Control in Cartesian Space – Control of Differential Drive Mobile Robot: Nonlinear Kinematic Tracking Control, Dynamic Tracking Control – Computed Torque Control of Differential Drive Mobile Robot		
Module: 6	**Mobile Robot Applications**	**8 Hours**
Mobile Robots in the Society – Assistive Mobile Robots – Mobile Telerobots and Web Robots – War Robots – Entertainment Robots – Research Robots – Mobile Robot Safety.		
	Total Lectures	**45 Hours**

Text Books

1.	Spyros G Tzafestas, "Introduction to Mobile Robot Control", First Edition, Elsevier Insights, 2014.
2.	Roland Siegwart, Illah Reza Nourbakhsh and Davide Scaramuzza, "Introduction to Autonomous Mobile Robots", Second Edition, MIT Press, 2011.

Reference Books

1.	Thomas Braunl, "Embedded Robotics", Third Edition, Springer, 2008.
2.	Witold Jacak, "Intelligent Robotic Systems: Design Planning and Control", Kluwer Academic Publishers, 1999.
3.	Luc Jaulin ,Mobile Robotics,Wiley,2019
4.	Gregory Dudek, Michael Jenkin ,Computational Principles of Mobile Robotics,Cambridge University Press,2010
5.	Frank L. Lewis ,Autonomous Mobile Robots Sensing, Control, Decision Making and Applications,CRC Press,2018

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	**SMART SENSORS FOR IOT APPLICATIONS**	**L**	**T**	**P**	**C**
20RO2007		3	0	0	3

Course Objectives

To impart knowledge on

1. Properties and working of sensors
2. Signal conditioning for sensors
3. Smart Sensor and IoT Application

Course Outcomes

The student will be able to

1. Describe the various sensors and their applications

2. Identify an appropriate signal condition circuit for the sensor
3. Implement an efficient amplifier circuit for the sensor
4. Explain the use of wireless network
5. Apply the skills to develop smart sensors.
6. Analyse the use of Smart Sensors and IOT

Module: 1	**Sensors Fundamental**	**7 Hours**
Sensor classification, Thermal sensors, Humidity sensors, Capacitive sensors, Electromagnetic sensors, Light sensing technology, Moisture sensing technology, Carbon dioxide (CO2) sensing technology, Sensors parameters, Selection of sensors.		
Module: 2	**Interfacing of Sensors and Signal Conditioning**	**7 Hours**
Change of bios and level of signals, loading effects on Sensor's output, Potential divider, Low-Pass RC filter, High-Pass RC filter, practical issues of designing passive filters		
Module: 3	**Circuits with Resistive Feedback**	**7 Hours**
OPAMPS, I/V and V/I converters, Current amplifiers, Difference amplifiers, Triple and dual op amp Instrumentation amplifiers, Instrumentation applications, Transducer bridge amplifiers.		
Module: 4	**Wireless sensors and Sensor Network**	**8 Hours**
Introduction, Frequency of wireless communication, Development of wireless sensor network-based project, Wireless sensor network based on only wifi.		
Module: 5	**Smart Sensors**	**8 Hours**
Smart Sensors, Components of Smart Sensors, General Architecture of Smart Sensors, Evolution of Smart Sensors, Advantages, Application area of Smart Sensors,		
Module: 6	**Introduction to IoT Components**	**8 Hours**
Characteristics IoT sensor nodes, Edge computer, cloud and peripheral cloud, single board computers, open source hardware's, Examples of IoT Applications		
	Total Lectures	**45 Hours**

Text Books

1. Subhas Chandra Mukhopadhyay ,"Smart Sensors, Measurement, and Instrumentation", Springer publication , 2017
2. Alan S Morris, Reza Langari , "Measurement and Instrumentation: Theory and Applications", Academic Press, Elsevier, 2015

Reference Books

1. Randy Frank ,"Understanding Smart Sensors" Artech House Sensors Library
2. Alessandro Bassi, Martin Bauer, Martin Fiedler, Thorsten Kramp, Rob van Kranenburg, Sebastian Lange, Stefan Meissner, "Enabling things to talk – Designing IoT solutions with the IoT Architecture Reference Model", Springer Open, 2016
3. Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand, David Boyle, "From Machine to Machine to Internet of Things", Elsevier Publications, 2014.
4. Franco S ,"Operational Amplifiers and Analog Integrated Circuits", McGraw Hill International Edition, 1988
5. Subhas C. Mukhopadhyay "Internet of Things Challenges and Opportunities" Springer International Publishing,2014

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	BASICS OF PLC PROGRAMMING	L	T	P	C
20RO2008		3	0	0	3

Course Objectives

To impart knowledge on

1. The fundamentals of PLC
2. The concept of PLC and its Programming using Ladder Diagram.
3. The basics of Installations in PLC.

Course Outcomes:

The student will be able to

1. Identify and understand the concepts of PLC.
2. Apply PLC architecture knowledge to select PLC for specific problems.
3. Use PLC Ladder diagram for simple applications
4. Design real time application using PLC. 5. Create prototype for the real time application Using PLC.
6. Recognize the faults and identify a proper solution for the PLC Hardware.

Module: 1	Introduction	8 Hours

Programmable Logic Controllers (PLCs): Introduction; definition & history of the PLC; Principles of Operation; PLC Architecture . PLC advantage & disadvantage; PLC versus Computers, PLC Application. Programming equipment; proper construction of PLC ladder diagrams; process scanning consideration; PLC operational faults., Programming Devices, Selection of wire types and size.

Module: 2	Input /Output Device	8 Hours

Input Devices : Switches: Push button Switches, Toggle Switches, Proximity switches, Photo switches, Temperature Switch, Pressure Switch, and Level Switch, Flow Switches, manually operated switches, Motor starters, Transducers and sensors, Transmitters.
Output Devices : Electromagnetic Control Relays, Latching relays, Contactors, Motors, Pumps, Solenoid Valves.

Module: 3	Basics of PLC	8 Hours

The Binary Concept, AND, OR and NOT functions, Boolean Algebra, Developing circuits from Boolean Expression expressions, Producing the Boolean equation from given circuit, Hardwired logic versus programmed logic, Programming word level logic instructions. Writing a ladder logic program directly from a narrative description. Processor Memory Organization, Program Scan, PLC Programming languages, Relay type instructions, Instruction addressing, Creating Ladder Diagrams from Process Control Descriptions

Module: 4	PLC Programming	7 Hours

Ladder diagram & sequence listing; large process ladder diagram construction, flow charting as programming method, Timer instructions, Counter Instructions, Data manipulation, data transfer operations, Data compare instructions, Math functions.

Module: 5	Program Control Instructions	7 Hours

SKIP and MASTER CONTROL RELAY Functions. Jump with non-return; jump with return. data handling functions, bit functions, Sequencer Functions, basic two axis ROBOT with PLC sequencer control; industrial three axis ROBOT with PLC control.

Module: 6	PLC Networking & Maintenance	7 Hours

Introduction, Levels of Industrial Control, Types of Networking, Network communications PLC Enclosures, Electrical Noise, Leaky Inputs and Outputs, Grounding, Voltage variations and Surges,

Program Editing, Programming and Monitoring, Preventive Maintenance, Troubleshooting, Connecting PC with PLC.		
	Total Lectures	**45 Hours**
Text Books		
1.	John W Webb & Ronald A Reis, "Programmable logic controllers: Principles and Applications", Prentice Hall India, **2015.**	
2.	Frank D Petruzella "Programmable Logic Controllers ", McGraw Hill Inc, 2005	
Reference Books		
1.	Kelvin T Erikson, "Programmable Logic Controllers ", Dogwood Valley Press, 2005.	
2.	Khalid Kamel, Eman Kamel, "Programmable Logic Controllers", McGrawhill, 2013.	
3.	Dilip Patel ,Introduction Practical PLC (Programmable Logic Controller) Programming· Bod Third Party Titles ,2018	
4.	A. B. Lawal , "PLC Programming Using RSLogix 500 & Real World Applications",2019	
5.	S. C. Jonathon Lin , "Programmable Logic Controllers" Industrial Press, Incorporated,2016	
Recommended by Board of Studies		
Approved by Academic Council	12th September 2020	

Course Code	**DESIGN APPROACH FOR ROBOTIC SYSTEMS**	**L**	**T**	**P**	**C**
20RO2009		3	0	0	3

Course Objectives

To impart knowledge on

1. To familiarize students with basic of systems and its design.
2. This course covers the design, material selection, construction, and testing of the robotic systems
3. To understand the concepts of Computer Aided Design

Course Outcomes

The student will be able to

1. Demonstrate and understanding of the concepts of various design methodology.
2. Analyse the different systems and its design.
3. Students able to identify the materials used for the development of different robotic systems.
4. Design Computer Aided Design for Robotics Engineering
5. Understanding of the concepts Three-dimensional design of Solids
6. Understanding of the concepts of Advanced topics on Robotics Design

Module: 1	**Material Selection for Design**	**8 Hours**
Introduction, Materials in design, evolution of engineering material, Introduction to the design process, Types of design, Design tools and materials data, Engineering materials and their properties, Identifying Desirable Characteristics, Materials selection and case studies.		
Module: 2	**Mechanism Design for Robotics**	**7 Hours**
Joints and Degrees of Freedom- Types of Joints , Types of Mechanisms, Degrees of Freedom in Mechanisms, Parameters and Variables of a Kinematic Pair-Cylindrical Joint in a Cartesian Space, Scalar Parameters of a Kinematic Pair, Vector Parameters of a Kinematic Pair, Parameters and Variables of a Mechanism-Denavit and Hartenberg Parameters of a Mechanism, Vector Parameters of a Mechanism.		
Module: 3	**Embodiment Design for Robotics**	**8 Hours**

Embodiment in Philosophy and Ethics, Embodiment in Psychology and Communication, Embodiment in Robotics and Design, Design Space, Design Paradigms, Behavior Design, Product Architecture – arrangement of the physical functions, Configuration Design – preliminary selection of materials, modeling and size of parts, Parametric Design – creating a robust design, and selection of final dimensions/parameters and tolerances.

Module: 4	**Computer Aided Design for Robotics Engineering**	**7 Hours**

Curves and Surfaces: Parametric representation of lines: Locating a point on a line, parallel lines, perpendicular lines, distance of a point, Intersection of lines. Parametric representation of circle, Ellipse, parabola and hyperbola. Synthetic Curves: Concept of continuity, Cubic Spline: equation, properties and blending. Bezier Curve: equations, properties; Properties and advantages of B-Splines and NURBS.Various types of surfaces along with their typical applications.

Module: 5	**Three-Dimensional Design of Solids**	**8 Hours**

Mathematical representation of solids: Geometry and Topology, Comparison of wireframe, surface and solid models, Properties of solid model, properties of representation schemes.Geometric Transformations: Homogeneous representation; Translation, Scaling, Reflection, Rotation, Shearing in 2D and 3D; Orthographic and perspective projections. Window to View-port transformation.

Module: 6	**Advanced Topics on Robotics Design**	**7 Hours**

Fabrication of different joints, Hands on practice and assignments for 3D design, Introduction to Bio-inspired design of robot, Basic concepts on Sensor design.

	Total Lectures	**45 Hours**

Text Books

1.	M.F. Ashby, Materials Selection in Mechanical Design, 3rd Ed., Elsevier, 2005
2.	Ibrahim Zied, CAD / CAM: Theory and Practice, McGraw-Hill,2014
3.	Plan ET, Khandani S. Engineering design process,2005

Reference Books

1.	Hugh Jack, Engineering Design, Planning, and Management, 1st Edition
2.	Gerhard Pahl, and Wolfgang Beitz. Engineering design: a systematic approach. Springer Science & Business Media, 2013.
3.	Wang, Wanjun. "Sensors and Actuators in Mechatronics." Mechatronics in Engineering Design and Product Development (1998): 15-16.
4.	Taya, Minoru, Makoto Mizunami, Elizabeth Van Volkenburgh, and Sh-hei Nomura. Bioinspired actuators and sensors. Cambridge University Press, 2016.
5.	Gomis-Bellmunt, Oriol, and Lucio Flavio Campanile. Design rules for actuators in active mechanical systems. Springer Science & Business Media, 2009.

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	**DESIGN APPROACH FOR ROBOTIC SYSTEMS**	**L**	**T**	**P**	**C**
20RO2009		3	0	0	3

Course Objective:

To impart knowledge on

1. To familiarize students with basic of systems and its design.
2. This course covers the design, material selection, construction, and testing of the

robotic systems
3. To understand the concepts of Computer Aided Design

Course Outcomes:

The student will be able to
1. Demonstrate and understanding of the concepts of various design methodology.
2. Analyze the different systems and its design.
3. Students able to identify the materials used for the development of different robotic systems.
4. Design Computer Aided Design for Robotics Engineering
5. Understanding of the concepts Three-dimensional design of Solids
6. Understanding of the concepts of Advanced topics on Robotics Design

Module: 1	**Material Selection for Design**	**8 Hours**

Introduction, Materials in design, evolution of engineering material, Introduction to the design process, Types of design, Design tools and materials data, Engineering materials and their properties, Identifying Desirable Characteristics, Materials selection and case studies.

Module: 2	**Mechanism Design for Robotics**	**7 Hours**

Joints and Degrees of Freedom- Types of Joints , Types of Mechanisms, Degrees of Freedom in Mechanisms, Parameters and Variables of a Kinematic Pair-Cylindrical Joint in a Cartesian Space, Scalar Parameters of a Kinematic Pair, Vector Parameters of a Kinematic Pair, Parameters and Variables of a Mechanism-Denavit and Hartenberg Parameters of a Mechanism, Vector Parameters of a Mechanism.

Module: 3	**Embodiment Design for Robotics**	**8 Hours**

What is Embodiment? Embodiment in Philosophy and Ethics, Embodiment in Psychology and Communication, Embodiment in Robotics and Design, Design Space, Design Paradigms, Behavior Design, Product Architecture – arrangement of the physical functions, Configuration Design – preliminary selection of materials, modeling and size of parts, Parametric Design – creating a robust design, and selection of final dimensions/parameters and tolerances.

Module: 4	**Computer Aided Design for Robotics Engineering**	**7 Hours**

Curves and Surfaces: Parametric representation of lines: Locating a point on a line, parallel lines, perpendicular lines, distance of a point, Intersection of lines. Parametric representation of circle, Ellipse, parabola and hyperbola. Synthetic Curves: Concept of continuity, Cubic Spline: equation, properties and blending. Bezier Curve: equations, properties; Properties and advantages of B-Splines and NURBS.Various types of surfaces along with their typical applications.

Module: 5	**Three-dimensional design of Solids**	**8 Hours**

Mathematical representation of solids: Geometry and Topology, Comparison of wireframe, surface and solid models, Properties of solid model, properties of representation schemes.Geometric Transformations: Homogeneous representation; Translation, Scaling, Reflection, Rotation, Shearing in 2D and 3D; Orthographic and perspective projections. Window to View-port transformation.

Module: 6	**Advanced topics on Robotics Design**	**7 Hours**

Fabrication of different joints, Hands on practice and assignments for 3D design, Introduction to Bio-inspired design of robot, Basic concepts on Sensor design.

	Total Lectures	**45 Hours**

Text Books

1. M.F. Ashby, Materials Selection in Mechanical Design, 3rd Ed., Elsevier, 2005
2. Ibrahim Zied, CAD / CAM: Theory and Practice, McGraw-Hill,2014

3.	Plan ET, Khandani S. Engineering design process,2005
Reference Books	
1.	Hugh Jack, Engineering Design, Planning, and Management, 1st Edition
2.	Gerhard Pahl, and Wolfgang Beitz. Engineering design: a systematic approach. Springer Science & Business Media, 2013.
3.	Wang, Wanjun. "Sensors and Actuators in Mechatronics." Mechatronics in Engineering Design and Product Development (1998): 15-16.
4.	Taya, Minoru, Makoto Mizunami, Elizabeth Van Volkenburgh, and Sh-hei Nomura. Bioinspired actuators and sensors. Cambridge University Press, 2016.
5.	Gomis-Bellmunt, Oriol, and Lucio Flavio Campanile. Design rules for actuators in active mechanical systems. Springer Science & Business Media, 2009.
Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	**ROBOTICS : SYSTEM AND ANALYSIS**	**L**	**T**	**P**	**C**
20RO3001		3	0	0	3

Course Objectives

To impart knowledge on

1. Advanced algebraic tools for the description of motion.
2. Motion control Design for articulated systems.
3. Software tools for analysis and design of robotic systems

Course Outcomes

The student will be able to

1. Understand the fundamentals or robotics
2. Acquire knowledge in kinematics of robotics
3. Comprehend dynamic analysis and forces
4. Explore trajectory planning
5. Understand motion control systems
6. Explain image processing and analysis with vision system

Module: 1	**Fundamentals of Robotics**	**7 Hours**

Robots, classification, history, robot components, joints, coordinate, characteristics, workspace, languages and applications.

Module: 2	**Kinematics of Robotic Position analysis**	**7 Hours**

Conventions, Matrix Representation, Homogeneous Transformation Matrices, Representation of Transformations, Inverse of Transformation Matrices. Forward and Inverse Kinematics of Robots – Position, Orientation, Denavit- Hartenberg Representation, The Inverse Kinematic Solution of Robots. Inverse Kinematic Programming of Robots. Degeneracy and Dexterity.

Module: 3	**Dynamic Analysis and Forces**	**7 Hours**

Lagrangian Mechanics: Overview. Effective Moments of Inertia, Dynamic Equations for Multiple-DOF Robots. Static Force Analysis of Robots, Transformation of Forces and Moments between Coordinate Frames

Module: 4	**Trajectory Planning**	**8 Hours**

Path versus Trajectory, Joint-Space versus Cartesian-Space Descriptions, Basics of Trajectory Planning, Joint-Space Trajectory Planning, Cartesian-Space Trajectories, Continuous Trajectory Recording.

Module: 5	**Motion Control Systems**	**8 Hours**

Control System Overview, Error Dynamics, Motion Control with Velocity Inputs, Torque or Force Inputs, Force Control, Hybrid Motion Force Control, Impedance Control, Joint Force-Torque Control. PerformanceModeling Tools: Simulation Models, Analytical Models.		
Module: 6	**Image Processing and Analysis with Vision Systems**	**8 Hours**
Image Processing versus Image Analysis, Fourier Transform and Frequency Content of a Signal. Frequency Content of an Image; Noise, Edges.Resolution and Quantization.Image-Processing Techniques. Noise Reduction, Edge Detection, Segmentation. Binary Morphology Operations Gray Morphology Operations.		
	Total Lectures	**45 Hours**

Reference Books

1. Saeed. B. Niku, Introduction to Robotics: Analysis, Control, Applications, 2nd Edition, Wiley. 2010
2. K.S Fu, R.C. Gonzalez, C.S.G. Lee, Robotics, McGraw Hill, 2008
3. Richard D, Klafter, Thomason A ChmielOwski, Michel Nagin "Robotics Engg-an Integrated Approach" PHI 2005
4. R.K. Mittal & I.J. Nagrath, "Robotics & Control" TMH-2007
5. Lynch.K.M, Park. F. C., Modern Robotics-Mechanics, Planning and Control, Cambridge University Press, 2017.

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	**INDUSTRIAL AUTOMATION**	**L**	**T**	**P**	**C**
20RO3002		3	0	0	3

Course Objective

To impart knowledge on
1. The concept of Industrial Automation
2. The pneumatic and hydraulic systems
3. The need of Robots in the Manufacturing Industries

Course Outcomes

The student will be able to
1. Describe the basics of Industrial Automation
2. Familiarize the concepts of Pneumatic systems
3. Explain the concepts of Hydraulic systems
4. Understand the in-depth concepts Programmable logic controller
5. Create solutions to automate the industrial processes
6. Apply the concept of industrial robotics

Module: 1	**Introduction**	**7 Hours**
Definition, automation principles and strategies, scope of automation, socio-economic consideration, low cost automation, Production concepts and automation strategies. Fixed Automation: Automated Flow lines, Transfer Mechanism, Indexing mechanism, Operator-Paced Free Transfer Machine, Buffer Storage, Control Functions, Automation for Machining Operations, Analysis of Automated Flow Lines: General Terminology and Analysis, Analysis of Transfer Lines without Storage, Partial Automation, and Automated Flow Lines with Storage Buffers.		
Module: 2	**Assembly Systems and Line Balancing**	**7 Hours**
Assembly Process, Assembly Systems, Manual Assembly Lines, Line Balancing Problem, Methods of Line Balancing, Computerized Line Balancing Methods, Other ways to improve the Line Balancing, Flexible Manual Assembly Lines. Automated Assembly Systems: Design and types,		

Vibratory bowl feeder and Non vibratory bowl feeder, Part Orienting Systems, Feed tracks, Escapements and part placing mechanism, Analysis of Single and Multi-station Assembly Machines.		
Module: 3	**Automated Materials Handling**	**7 Hours**
Material handling function, Types of Material Handling Equipment, Analysis of Material Handling Systems, Design, Conveyor Systems, Automated Guided Vehicle Systems.		
Module: 4	**Automated Storage Systems**	**8 Hours**
Storage System Performance, Automated Storage/Retrieval Systems, Carousel Storage Systems, Work-in-process Storage, Interfacing Handling and Storage with Manufacturing.		
Module: 5	**Automated Inspection and Testing**	**8 Hours**
Inspection and testing, Statistical Quality Control, Automated Inspection Principles and Methods, Sensor Technologies for Automated Inspection, Coordinate Measuring Machines, Other Contact Inspection Methods, Machine Vision, Other optical Inspection Methods. Modelling Automated Manufacturing Systems: Role of Performance Modelling, Performance Measures, Performance Modelling Tools: Simulation Models, Analytical Models.		
Module: 6	**Industrial Applications**	**8 Hours**
Introduction to Flexible Manufacturing for automation, Packing system of different balls - Automated Billiard Table controlled - Automated Filling of Two Milk Tanks - Chemical Cleaning Process of Metallic objects - Simple Robotic Arm - Temperature Control		
	Total Lectures	**45 Hours**

Reference Books

1.	Mikell P. Groover, "Automation, Production Systems and Computer-Integrated Manufacturing", Fourth edition, Pearson Publishers, 2015.
2.	Stephen J. Derby, "Design of Automatic Machinery", Special Indian Edition, Marcel Decker, New York, Yesdee publishing Pvt. Ltd, Chennai, 2004.
3.	Groover M. P., "Industrial Robotics, Technology, Programming and Application", McGraw Hill Book and Co., 2012.
4.	C.RayAsfahl, "Robots and manufacturing Automation", John Wiley and Sons New York, 2010.
5.	StamatiosManesis, George Nikolakopoulas, 'Introduction to Industrial Automation" CRC Press, 2018.

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	**COMPUTER AIDED MODELLING AND DESIGN**	**L**	**T**	**P**	**C**
20RO3003		3	0	0	3

Course Objectives

To impart knowledge on

1. Various computer aided design tools for industrial applications.
2. Graphical entities of CAD /CAM and computer numerical programming.
3. Application of computers in manufacturing sectors.

Course Outcomes

The student will be able to

1. Demonstrate the basic structure and components of cad.
2. Outline the process of representing graphical entities in a cad environment.
3. Construct the geometric model using different techniques to represent a product.
4. Illustrate various techniques and devices involved in cad hardware.
5. Analyze the models for design solutions using fem.
6. Discuss the various computer aided tools implemented in various industrial applications.

Module: 1	**Introduction**	**7 Hours**

Introduction to CAD, Scope and applications in mechanical engineering, Need for CAD system, use of computer, Computer fundamentals, Computer aided design process, CAD configuration, CAD tools, advantages and limitations in CAD, CAD Standards – IGES, GKS and PDES, CAD/ CAM integration.		
Module: 2	**Computer Graphics**	**8 Hours**
Computer Graphics Display and Algorithms: Graphics Displays, DDA Algorithm – Bresenham's Algorithm – Coordinate systems – Transformation of geometry – Translation, Rotation, Scaling, Reflection, Homogeneous Transformations – 2D and 3D Transformations – Concatenation – line drawing-Clipping and Hidden line removal algorithms – viewing transformations.		
Module: 3	**Geometric Modelling**	**8 Hours**
Wireframe models and entities – Curve representation – parametric representation of analytic curves – circles and conics – Hermite curve – Bezier curve – B-spline curves – rational curves. Surface Modeling – Surface models and entities – Parametric representation of analytic surfaces – Plane surfaces – Synthetic surfaces – Bicubic Surface and Bezier surface and B-Spline surfaces. Solid Modeling – Models and Entities – Fundamentals of solid modelling – B-Rep, CSG and ASM.		
Module: 4	**CAD Hardware**	**8 Hours**
Introduction to hardware specific to CAD, Product cycle, CRT, Random scan technique, raster scan technique, CAD specific i/o devices, DVST, Raster display, Display systems, sequential scanning and interlaced scan.		
Module: 5	**Finite Element Method**	**7 Hours**
Introduction to FEM, Principle of minimum potential energy, steps involved in FEM, discretization, types of nodes and elements, elemental stiffness matrix, elemental strain displacement matrix, types of force, elemental force matrix, assembly, shape function, introduction to 2 dimensional FEM.		
Module: 6	**Optimization And New Techniques Of CAD**	**7 Hours**
ntroduction to Optimization, Johnson method of optimization, normal specification problem, redundant specification problem, introduction to genetic algorithm. New Techniques: RPT, laser and non- laser process of RPT, STL format to CAD file, Introduction to reverse engineering and related software's viz. rapid form.		
	Total Lectures	**45 Hours**

Reference Books

1.	Ibrahim Zeid, "CAD - CAM Theory and Practice", Tata McGraw Hill Publishing Co. Ltd., 2009.
2.	Kunwoo Lee, "Principles of CAD/CAM/CAE Systems", Addison Wesley, 2005.
3.	Rao. S.S. "The Finite Element Method in Engineering", 2nd Edition, Pergamon Press, Oxford, 2009.
4.	P.N. Rao, "CAD/CAM Principles and Applications", Tata McGraw Hill Publishing Co. Ltd., 2010.
5.	Bathe K.J., "Finite Element Procedures", K.J. Bathe, Watertown, MA, Fourth edition, 2016

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	**DRIVES AND CONTROL SYSTEMS FOR AUTOMATION**	**L**	**T**	**P**	**C**
20RO3004		3	0	0	3

Course Objectives

To impart knowledge on

1. Various types of motors and its characteristics
2. The concepts of different drives and its applications
3. Various data acquisition method for automation application

Course Outcomes

The student will be able to

1. Describe the working principles of various types of motors, differences, characteristics and selection criteria.
2. Apply the knowledge in selection of motors, heating effects and braking concepts in various industrial applications
3. Explain control methods of special drives
4. Elucidate various linear and rotary motion principles and methods and use the same to application areas
5. Design programming using PLC and use of various PLCs to Automation problems in industries.
6. Discuss supervisory control and data acquisition method and use the same in complex automation areas.

Module: 1	**Introduction**	**7 Hours**
Working principle of synchronous, Asynchronous & stepper motors, Difference between Induction and servo motors, Torque v/s speed characteristics, Power v/s. Speed characteristics, Vector duty induction motors, Concepts of linear and frameless motors, Selection of feedback system, Duty cycle, , V/F control, Flux Vector control.		
Module: 2	**Industrials Drives**	**7 Hours**
DC and AC motors operation and selection, method of control and application of brushless DC motor, PMSM, stepper motor, A.C servomotor, selection criteria for servo motor and servo amplifier, universal motor, electric drive, types of industrial drives, the characteristics of drive, advantages of drives over other prime movers, motor rating, heating effects, electric braking, rheostatic and regenerative braking principles in power converters.		
Module: 3	**Motion laws for rotary and linear systems**	**7 Hours**
Converting rotary to linear system, concepts and principles of ball screws, rack and pinion, belt and pulley, chain drives, gear drives, Selection of converting systems, Dynamic response gearing, and control approaches of Robots, Control loops using Current amplifier.		
Module: 4	**Introduction to Programmable Logic Controllers**	**8 Hours**
Definitions of PLC, basic structure of PLC, working principles, data storage methods, inputs / outputs flag processing's, types of variables, definition of firmware, software, programming software tool and interfacing with PC (RS232 & TCP-IP), methods of PLC programming (LD, ST, FBD & SFC), function blocks logical / mathematical operators & data types, array & data structure, PID, types of tasks and configuration, difference between relay logic and PLC, selection of PLC controller (case study) Centralized concept.		
Module: 5	**Logic, instructions & Application of PLC**	**8 Hours**
What is logic, Conventional Ladder v/s PLC ladder, series and parallel function of OR, AND, NOT logic, Ex Or logic, Analysis of rung. Timer and Counter Instructions; on delay and Off delay and retentive timer instructions, PLC counter up and down instructions, combining counters and timers, Comparison and data handling instructions, Sequencer instruction, Visualization Systems, Types of visualization system, PC based Controller, Applications of HMI's, and Interfacing of HMI with controllers.		
Module: 6	**Supervisory control & data Acquisitions**	**8 Hours**
Introduction to Supervisory control & data Acquisitions, distributed Control System (DCS): computer networks and communication in DCS. different BUS configurations used for industrial automation – GPIB, HART and OLE protocol, Industrial field bus – FIP (Factory Instrumentation Protocol), PROFIBUS (Process field bus), Bit bus. Interfacing of SCADA with controllers, Basic programming of SCADA, SCADA in PC based Controller / HMI		
	Total Lectures	**45 Hours**

Reference Books

1.	Tan KokKiong, Andi Sudjana Putra, "Drives and control for Industrial Automation", Advances in Industrial Control, Springer, 2011
2.	P.ArunaJeyanthy, christeena Francis, Sunil K. Joseph, Electrical Drives and Control for Automation, Independently published , 2018

3.	Nabil Derbel, FaouziDerbel, OlfaKanoun Systems, Automation and Control, CPI books 2018
4.	Peng Zhang, Advanced Industrial control Technology, Elsevier, 2010
5.	Ryszardkoziol, Jerzy Sawicki, LudgerSzklarski, Digital Control of Electric Drives, Elsevier, 1992

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	EMBEDDED SYSTEMS FOR AUTOMATION	L	T	P	C
20RO3005		3	0	0	3

Course Objectives

To impart knowledge on

1. Understanding on the basic concepts, building blocks of embedded system
2. Fundamentals of Embedded networking and RTOS
3. Basic concepts of Embedded OS.

Course Outcomes

The student will be able to

1. Recall the basic concepts of embedded systems
2. Summarize the concepts of embedded networking and interrupt service mechanisms.
3. Identification of various RTOS features for real time applications
4. Analyze the scope of UML for creating visual models of software-intensive systems.\
5. Describe the basic concepts of embedded OS
6. Design real time embedded systems using the concepts of RTOS.

Module: 1	**Introduction To Embedded Systems**	**8 Hours**

Introduction to Embedded Systems – The build process for embedded systems- Structural units in Embedded processor , selection of processor & memory devices- DMA – Memory management methods- Timer and Counting devices, Watchdog Timer, Real Time Clock .

Module: 2	**Embedded Networking and interrupt service mechanism**	**8 Hours**

Embedded networking: Introduction, I/O Device Ports & Buses– Serial Bus communication protocols - RS232 standard – RS485 –USB – Inter Integrated Circuits (I2C) – interrupt sources , Programmed-I/O busy-wait approach without interrupt service mechanism- ISR concept–– multiple interrupts – context and periods for context switching, interrupt latency and deadline -Introduction to Basic Concept Device Drivers.

Module: 3	**RTOS Based Embedded System Design**	**8 Hours**

Introduction to basic concepts of RTOS- Task, process & threads, interrupt routines in RTOS, Multiprocessing and Multitasking, Pre-emptive and non-pre-emptive scheduling, Task communication- shared memory, message passing-, Inter-process Communication – synchronization betweenprocesses-semaphores, Mailbox, pipes, priority inversion, priority inheritance-comparison ofcommercial RTOS features - RTOS Lite, Full RTOS, VxWorks, µC/OS-II, RT Linux

Module: 4	**Open Source Hardware And Software Platforms**	**7 Hours**

Open source hardware features, licensing, advatages and disadvantages of open source hardware, examples – Raspberry Pi, Beagle Board, Panda board , open source software, examples of open source software products.

Module: 5	**Embedded JAVA**	**7 Hours**

Embedded JAVA

Introduction to Object Oriented Concepts. Core Java/Java Core- Java buzzwords, Overview of Java programming, Data types, variables and arrays, Operators, Control statements. Embedded Java – Understanding J2ME,Connected Device configuration, Connected Limited device configuration, Profiles, Anatomy of MIDP applications, Advantages of MIDP

Module: 6	**Embedded System Application Development**	**7 Hours**

Objectives, different Phases & Modelling of the embedded product Development Life Cycle (EDLC),Case studies on Smart card- Adaptive Cruise control in a Car -Mobile Phone software for key inputs	
Total Lectures	**45 Hours**
Reference Books	
1.	Rajkamal, 'Embedded system-Architecture, programming, Design', TataMcgraw Hill, 2011
2.	Peckol, "Embedded System Design", John wiley& Sons, 2010
3.	Shibu,K.V. "Introduction to Embedded Systems", TataMcgraw Hill, 2009
4.	Lyla B Das "Embedded Systems- An Integrated Approach" , pearson 2013
5.	Michael J Point, "Embedded C" Pearson Education 2007
6.	Steve Oualline, "Practical C Programming" 3rd Edition O'Reilly Media Inc., 2006
Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	**ADVANCED AUTOMATION LABORATORY**	**L**	**T**	**P**	**C**
20RO3006		0	0	4	2
Course Objectives					
To Impart knowledge on 1. Importance of Artificial Intelligence 2. Concepts of PLC & SCADA in Process Industries 3. Various tools for Automating the process					
Course Outcomes					
The student will be able to 1. Recall the basics of Process Control 2. Summarize the concepts of Automation 3. Explain the need of Artificial Intelligence 4. Illustrate the concepts of PLC in Industries 5. Familiarize the various tools for automating the process 6. Implement the SCADA technology in the Industrial Applications					
List of Experiments					
1.	AI based Pressure Process Station using LabVIEW				
2.	AI based Level Process Station using LabVIEW				
3.	AI based Flow Process Station using LabVIEW				
4.	AI based Temperature Process Station using LabVIEW				
5.	AI based Non-Interacting Two Tanks Process				
6.	AI based Interacting Two Tanks Process				
7.	Automation of Bottle Filling Machine using PLC				
8.	Automation of Lift Management using PLC & SCADA				
9.	Automation of Stamping Machine using PLC				
10.	Automation of Bottle Filling Machine using SCADA				
11.	Automation of Lift Management using SCADA				
12.	Mini project				
Total Lectures					**30 Hours**
Recommended by Board of Studies					
Approved by Academic Council	12th September 2020				

Course Code	**ADVANCED ROBOTIC PROCESS AUTOMATION LABORATORY**	**L**	**T**	**P**	**C**
20RO3007		0	0	4	2
Course Objectives					
To Impart knowledge on					

1. Explore the importance of RPA 2. Analyze the concepts of programming 3. Building bot using RPA	
Course Outcomes	
The student will be able to 1. Analyse the importance of RPA 2. Implement programming concepts 3. Implement excel and data tables 4. Implement UI interactions and selectors 5. Implement automation for pdf and email	
List of Experiments	
1.	Variables, data types and control flow
2.	Data manipulation
3.	Excel and data tables
4.	UI Interactions
5.	Selectors
6.	Project organization
7.	Error and exception handling
8.	Debugging
9.	PDF Automation
10.	Email automation
11.	Orchestrator for Developers and building BOT
12.	Mini Project
Total Lectures	**30 Hours**
Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	EMBEDDED AND IoT LABORATORY	L	T	P	C
20RO3008		3	0	0	3
Course Objectives					
To Impart knowledge on 1. Basic concepts of Python programming. 2. Architectural concepts of Raspberry pi module 3. Embedded applications in Raspberry pi					
Course Outcomes					
The student will be able to 1. Recall the syntax used in python programming 2. Create simple programs using python programming 3. Summarize the architectural overview and downloading procedure of Raspberry pi 4. Develop I/O interfacing with Raspberry pi 5. Create protocols with Raspberry pi 6. Develop image processing application with python programming					
List of Experiments					
1.	Introduction to controllers with basic programs				
2.	Introduction to python programming using variables, strings and data operators and Examples for python programming using for loop, while loop and if statement				
3.	Interfacing input output module				
4.	Monitoring patient body temperature				
5.	Detection of motion artifact using accelerometer sensor				
6.	Interfacing motion sensor camera				
7.	Home automation using MQTT protocol				
8.	Temperature sensor interfacing with ThingSpeak				
9.	Brightness control using PWM generation				

10.	GSM module interfacing
11.	Controlling sensor with twitter
12.	Mini project
	Total Lectures **30 Hours**
Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	**ADVANCED AI AND ML LABORATORY**	**L**	**T**	**P**	**C**
20RO3009		0	0	4	2

Course Objectives

Impart knowledge on

1. Importance of Artificial Intelligence
2. Concepts of AL and ML with datasets
3. Implementation of AI and ML algorithms with controllers

Course Outcomes

The student will be able to

1. Recall the basics of AI and ML
2. Implement the concepts of AI Algorithms
3. Implement the regression models
4. Implement optimization algorithm to train Neural networks
5. Implement various image processing with controller
6. Implement mini project with controller

List of Experiments

1.	Linear Regression Models
2.	Single Layer Perceptron Algorithm And Multiple Layer Perceptron Trained Using Back Propagation Algorithm
3.	Kohonen's Self Organizing Map
4.	Demonstration Of Preprocessing On Dataset
5.	Demonstration Of Classification Rule Process On Dataset Using Naïve Bayes Algorithm
6.	Demonstration Of Clustering Rule Process On Dataset Using Simple K-Means
7.	Particle Swarm Optimization Technique
8.	Adaptive Neuro-Fuzzy Inference System
9.	Optimization Algorithm To Train A Neural Network
10.	AI Based Image Processing With Controller
11.	ML Based Image Processing With Controller
12.	Miniproject
	Total Lectures **30 Hours**
Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	**COMPUTERAIDED PRODUCTION AND OPERATION MANAGEMENT**	**L**	**T**	**P**	**C**
20RO3010		3	0	0	3

Course Objective:

To impart knowledge on

1. Explore the Management principles in Production and Operation Management
2. Analyse the concept of Process Organization and Planning required
3. Learn the various tools of Manage Computer aided production

Course Outcomes:

The student will be able to

1. Describe the basics of Production and Operation Management
2. Understand the concepts of manufacturing strategy

3. Explain the need of requirements and resources planning
4. Illustrate the concepts of process and product organization
5. Familiarize the various tools for Production Management
6. Implement the Management concepts in the Industrial Applications

Module: 1	**Introduction to Production and Operation Management**	**8 Hours**
Systems Concept of Production - Types of Production System - Productivity - Strategy Management, Product Design and Analysis: New Product Development - Process Planning - Process Design - Value Analysis - Standardization - Simplification - Make or Buy Decision - Ergonomic Considerations in Product Design - Concurrent Engineering.		
Module: 2	**Manufacturing Strategy, Production Management and CAPM**	**8 Hours**
Corporate Strategy - Manufacturing Strategy, Strategic Decision in Manufacturing Strategy - Manufacturing Infrastructure, Competitive Objectives - Goal - Definition of CAPM - Elements of CAPM		
Module: 3	**MRP, MRPII & JIT**	**8 Hours**
Simple Materials Requirements Planning - Drawbacks of MRP - Closed Loop MRP Systems - Manufacturing resource planning (MRPII) - Application of MRP systems - Problems associated with MRP systems, Philosophy of Just in Time - JIT Procurement - JIT Shop floor control - Arguments against JIT		
Module: 4	**Process organization, Product organization and Group Technology**	**7 Hours**
Constraints and bottlenecks - Goldratt's approach, Process focus - Group technology and product focus - Scope of grouping analysis - Grouping techniques - Verification of groups - work cell design		
Module: 5	**Modern Production Management Tools**	**7 Hours**
Just in time Manufacturing - Computer Integrated Manufacturing and Flexible Manufacturing System - Total Quality Management - ISO 9000 Series - Kaizen - Business Process Reengineering - Supply Chain Management - Lean Manufacturing - Quality Function Deployment - Enterprise Resource Planning (ERP)		
Module: 6	**Industrial Applications**	**7 Hours**
Multi product batch production on a single machine - Production control in small industries - Production control in Aircraft industry - Job shop production control - Production control in Electromechanical Industry - Production control in Electronics Industry		
	Total Lectures	**45 Hours**

Reference Books

1. Spyros G. Tzafestas, "Computer-Assisted Management and Control of Manufacturing Systems", Springer, 2012.
2. Razvan Udroin, "Computer aided Technologies", Intech 2016,
3. R. Panneerselvam, "Production and Operations Management", Third Edition, PHI Learning Private Limited, 2012.
4. Mahapatra, "Computer-Aided Production Management", Prentice Hall Pvt. Limited, 2004.
5. Ajay K Garg, "Production and operations management" Tata McGraw Hill Ediucation Pvt Limited, 2012.

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	**RAPID-PROTOTYPING**	**L**	**T**	**P**	**C**
20RO3011		3	0	0	3

Course Objectives

To impart knowledge on

1. Basics of rapid prototyping/additive manufacturing and its applications in various fields, reverse engineering techniques.
2. Different processes in rapid prototyping systems.

3. Mechanical properties and geometric issues relating to specific rapid prototyping applications.

Course Outcomes

The student will be able to

1. Explain the various techniques of Rapid-prototyping.
2. Elucidate all phases of prototyping including modelling, tooling and process optimization.
3. Describe the principles of Solid ground curing & LOM for a suitable operation.
4. Design and automate, optimize the process and enhance the performance of the system through Concept modelers, Rapid tooling and Optimization skills.
5. Create a project work, analyse, and identify the proper RP technique which meets the requirements of the problem.
6. Apply the concept of Rapid-prototyping in fast growing industrial applications such as automobile industry, aircraft industry, etc.

Module: 1	**Introduction**	**8 Hours**

Introduction to Prototyping, Traditional Prototyping Vs. Rapid Prototyping (RP), Classification of Rapid Manufacturing Processes: Additive, Subtractive, Formative, Generic RP process.

Module: 2	**CAD Modelling and Data Processing for RP**	**8 Hours**

CAD model preparation, Data interfacing: formats (STL, SLC, CLI, RPI, LEAF, IGES, HP/GL, CT, STEP), conversation, validity checks, repair procedures; Part orientation and support generation, Support structure design, Model Slicing algorithms and contour data organization, direct and adaptive slicing, Tool path generation

Module: 3	**RP Processes**	**8 Hours**

Process Physics, Tooling, Process Analysis, Material and technological aspects, Applications, limitations and comparison of various rapid manufacturing processes. Photopolymerization (Stereolithography (SL), Microstereolithography), Powder Bed Fusion (Selective laser Sintering (SLS), Electron Beam melting (EBM)), Extrusion-Based RP Systems (Fused Deposition Modelling (FDM)), 3D Printing, Sheet Lamination (Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC)), Beam Deposition (Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD)).

Module: 4	**Errors in RP Processes**	**7 Hours**

Pre-processing, processing, post-processing errors, Part building errors in SLA, SLS.

Module: 5	**Solid Ground Curing and concepts modelers**	**7 Hours**

Principle of operation, Machine details, Applications. Laminated Object Manufacturing**:** Principle of operation. Process details,application.

Concepts Modelers: Principle, Thermal jet printer, Sander's model market.HP system 5, object Quadra systems.

Module: 6	**Rapid Tooling and RP Process Optimization**	**7 Hours**

Indirect Rapid tooling -Silicone rubber tooling –Aluminum filled epoxy tooling Spray metal tooling, Direct Rapid Tooling, Quick cast process, Copper polyamide, Rapid Tool, DMILS, Sand casting tooling, Laminate tooling.

Factors influencing accuracy. Data preparation errors, Part building errors, Error in finishing.

	Total Lectures	**45 Hours**

Reference Books

1.	Hague R J M and P E Reeves, "Rapid Prototyping, Tooling and Manufacturing, Rapra Technology Limited, 2000.
2.	Flham D.T &Dinjoy S.S "Rapid Manufacturing"-, Verlog London 2001.
3.	Ali K Kamrani, Emad Abouel Nasr, "Rapid Prototyping Theory and Practice", Springer, 2006
4.	Chua, Leong, Lim "Rapid prototyping – principles and Applications" world scientific publishing co.pvt. ltd, 2010
5.	Rafiq Noorani, Rapid Prototyping- principles and Applications, wiley 2006

Recommended by Board of Studies	

Approved by Academic Council	12th September 2020

Course Code	MOBILE ROBOTICS	L	T	P	C
20RO3012		3	0	0	3

Course Objectives

To impart knowledge on

1. Concepts of Sensing and Controlling the Mobile Robots
2. Kinematics models of mobile robots
3. Various type mobile robots

Course Outcomes

The student will be able to

1. Classify and describe the various types of robots
2. Familiarize the control concepts in the mobile robots
3. Describe the kinematic models and manoeuvrability of mobile robots
4. Understand the in depth concepts of sensing elements and actuators used in mobile robots
5. Create solutions to localize, plan and navigate the mobile robots using various techniques
6. Apply the concept of mobile robots in various applications

Module: 1	Control Modes, Intelligent Robotic Systems and Types of Robots	7 Hours

Control Concepts: Discontinuous - Continuous - Composite Control Modes, Intelligent Robotic Systems. Locomotion: Introduction - Key issues for locomotion - Types of Robots: Legged Mobile Robots - Wheeled Mobile Robots - Driving Robots - Omnidirectional Robots - Balancing Robots - Walking Robots - Autonomous Planes - Autonomous Vessels & Underwater Vehicles.

Module: 2	Mobile Robot Kinematics	7 Hours

Introduction - Kinematic Models and Constraints: Representing robot position - Forward kinematic models - Wheel kinematic constraints - Robot kinematic constraints - Examples: robot kinematic models and constraints. Mobile Robot Manoeuvrability: Degree of mobility - Degree of steerability - Robot manoeuvrability, Mobile Robot Workspace - Degrees of freedom - Holonomic robots - Path and trajectory considerations.

Module: 3	Perception and Actuators	7 Hours

Sensors for Mobile Robots: Sensor classification - Characterizing sensor performance - Wheel/motor sensors - Heading sensors - Ground-based beacons - Active ranging - Motion/speed sensors - Vision based sensors, Feature Extraction - Feature extraction based on range data (laser, ultrasonic, vision-based ranging) - Visual appearance based feature extraction - Actuators: DC Motors - H Bridges - PWM - Stepper Motors - Servos.

Module: 4	Mobile Robot Localization	8 Hours

Introduction - The Challenge of Localization: Noise and Aliasing - Localization based Navigation versus Programmed Solutions - Belief Representation - Map Representation - Probabilistic Map Based Localization - Probabilistic Localization - Coordinate Systems - Environment Representation - Visibility Graph - Voronoi Diagram - Potential Field Method - Wandering Standpoint Algorithm - Bug Algorithm Family - Dijkstra's Algorithm - A* Algorithm.

Module: 5	Planning and Navigation	8 Hours

Introduction - Competences for Navigation: Planning and Reacting - Path planning - Obstacle avoidance - Navigation Architectures: Modularity for code reuse and sharing, Control localization, Techniques for decomposition - Case studies: tiered robot architectures

Module: 6	Mobile Robot Applications	8 Hours

Factory & Industry Robots - Societal Robots - Assistive Devices - Telerobots & Web Robots - War Robots - Entertainment Robots - Research Robots - Maze Exploration - Map Generation - Real time image processing - Robot Soccer.

Total Lectures	45 Hours

Reference Books

1.	Spyros G Tzafestas, "Introduction to Mobile Robot Control", First Edition, Elsevier Insights, 2014.
2.	Roland Siegwart, Illah Reza Nourbakhsh and Davide Scaramuzza, "Introduction to Autonomous Mobile Robots", Second Edition, MIT Press, 2011.
3.	Thomas Braunl, "Embedded Robotics", Third Edition, Springer, 2008.
4.	Eugene Kagan, Shvaib, Irad Ben-Gal, "Autonomous Mobile Robots and Multi-Robot Systems Motion-Planning, Communication and Swarming", Wiley publication, 2019.
5.	Luc Jaulin, "Mobile Robotics", Wiley Publications 2019

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	ADVANCED EMBEDDED PROCESSORS	L	T	P	C
20RO3013		3	0	0	3

Course Objectives

To impart knowledge on

1. Architectural overview of 8 and 32 bit Microcontrollers.
2. Programming skills in Embedded Processors
3. Interfacing concepts with Embedded Processors.

Course Outcomes

The student will be able to

1. Recall the architectural overview of 8 bit processor
2. Discuss interfacing concepts in AVR microcontroller
3. Apply instruction set of ARM processors to create simple embedded programs.
4. Explain interrupts and memory concepts of ARM processor.
5. Create simple C/ASM program with ARM microcontroller
6. Elaborate the integrated Development Environment and programming with Rasbian.

Module: 1	**8051 and PIC Microcontroller**	**7 Hours**

Overview of 8 bit Microcontroller – General Architecture, Selection, On Chip resources, – Memory Organization–Addressing Modes – Instruction Set – I/O Ports-–Counters and Timers – Interrupt – UART – Analog to Digital Converter – Relay Interfacing – Temperature Sensor Interfacing.

Module: 2	**AVR Microcontroller Architecture**	**8 Hours**

Architecture – memory organization – addressing modes – I/O Memory – EEPROM – I/O Ports – SRAM –Timer –UART – Interrupt Structure- Serial Communication with PC – ADC/DAC Interfacing

Module: 3	**ARM Architecture And Programming**	**8 Hours**

Arcon RISC Machine – Architectural Inheritance – Core & Architectures -- The ARM Programmer's model -Registers – Pipeline - Interrupts – ARM organization - ARM processor family – Co-processors. Instruction set – Thumb instruction set – Instruction cycle timings

Module: 4	**ARM Application Development**	**8 Hours**

Introduction to RT implementation with ARM – –Exception Handling – Interrupts – Interrupt handling schemes- Firmware and bootloader – Free RTOS Embedded Operating Systems concepts –example on ARM core like ARM9 processor. Memory Protection and Management:Protected Regions-Initializing MPU, Cache and Write Buffer-MPU to MMU-Virtual Memory-Page Tables-TLB-Domain and Memory Access Permission-Fast Context Switch Extension.

Module: 5	**Design with ARM Microcontrollers**	**7 Hours**

Assembler Rules and Directives- Simple ASM/C programs- Hamming Code- Division-Negation-Simple Loops –Look up table- Block copy- subroutines-application.

Module: 6	**Raspberry Pi**	**7 Hours**

Onboard Processor – Linux OS - Integrated Development Environment- Programming with Raspbian- Interfacing: I/O Devices – I^2C Device – Sensors – Serial Communication-Case Study: Onboard Diagnostic System. Simple Interfacing concepts.	
Total Lectures	**45 Hours**
Reference Books	
1.	Rajkamal, "Microcontroller Architecture, Programming, Interfacing and Systems Design", Pearson. Education India, 2009.
2.	Kenneth Ayala, "The 8051 Microcontroller", Thomson Delmar Learning , New Jersey, 2004.
3.	Muhammad Ali Mazidi, "The 8051 Microcontroller and Embedded Systems using Assembly and C", Perason Education 2006.
4.	Steve Furber, "ARM System On-Chip Architecture", 2nd Edition, Pearson Education Limited, 2000.
5.	Eben Upton, "Raspberry PI User Guide", 3rd Edition, 2016
Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	**INDUSTRIAL INTERNET OF THINGS AND ITS APPLICATIONS**	**L**	**T**	**P**	**C**
20RO3014		3	0	0	3

Course Objectives

To impart knowledge on

1. Architecture of IoT components.
2. Sensor for IIoT.
3. Various protocols

Course Outcomes

The student will be able to

1. Recall the overview of IoT
2. Discuss architecture of IIoT
3. Discuss the sensor and its interfaces
4. Explain protocol and cloud concepts.
5. Explain web security and its need
6. Create simple IIoT applications

Module: 1	**Introduction**	**8 Hours**

Introduction to IOT, What is IIOT? IOT Vs. IIOT, History of IIOT, Components of IIOT - Sensors, Interface, Networks, People &Process, Hype cycle, IOT Market, Trends& future Real life examples, Key terms – IOT Platform, Interfaces, API, clouds, Data Management Analytics, Mining &Manipulation; Role of IIOT in Manufacturing Processes Use of IIOT in plant maintenance practices, Sustainability through Business excellence tools Challenges & Benefits in implementing IIOT

Module: 2	**Architectures**	**8 Hours**

Overview of IOT components ;Various Architectures of IOT and IIOT, Advantages & disadvantages, Industrial Internet - Reference Architecture; IIOT System components: Sensors, Gateways, Routers, Modem, Cloud brokers, servers and its integration, WSN, WSN network design for IOT

Module: 3	**Sensor and Interfacing**	**8 Hours**

Introduction to sensors, Transducers, Classification, Roles of sensors in IIOT , Various types of sensors, Design of sensors, sensor architecture, special requirements for IIOT sensors, Role of actuators, types of actuators. Hardwire the sensors with different protocols such as HART, MODBUS-Serial & Parallel, Ethernet, BACNet , Current, M2M etc.

Module: 4	**Protocols and Cloud**	**7 Hours**

Need of protocols; Types of Protocols, Wi-Fi, Wi-Fi direct, Zigbee, Z wave, Bacnet, BLE, Modbus, SPI , I2C, IIOT protocols –COAP, MQTT,6lowpan, lwm2m, AMPQ IIOT cloud platforms : Overview of cots cloud platforms, predix, thingworks, azure etc. Data analytics, cloud services, Business models: Saas, Paas, Iaas.		
Module: 5	**Privacy, Security and Governance**	**7 Hours**
Introduction to web security, Conventional web technology and relationship with IIOT, Vulnerabilities of IoT, Privacy, Security requirements, Threat analysis, Trust, IoT security tomography and layered attacker model, Identity establishment, Access control, Message integrity, Non-repudiation and availability, Security model for IoT, Network security techniques Management aspects of cyber security		
Module: 6	**IOT Analytics and Applications**	**7 Hours**
IOT Analytics: Role of Analytics in IOT, Data visualization Techniques, Introduction to R Programming, Statistical Methods. Internet of Things Applications : Smart Metering, e-Health Body Area Networks, City Automation, Automotive Applications, Home Automation, Smart Cards, Plant Automation, Real life examples of IIOT in Manufacturing Sector.		
	Total Lectures	**45 Hours**

Reference Books

1. Daniel Minoli, "Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications", Willey Publications, 2013
2. Bernd Scholz-Reiter, Florian 2. Michahelles, "Architecting the Internet of Things", Springer 2011
3. HakimaChaouchi, " The Internet of Things Connecting Objects to the Web" Willy Publications 2013
4. Olivier Hersent, David Boswarthick, Omar Elloumi, The Internet of Things: Key Applications and Protocols, 2nd Edition, Willy Publications 2012
5. 5.Giacomo Veneri, Antonio Capasso, "Hands-On Industrial Internet of Things", Pack Publishing Ltd, 2018

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	**OPTIMIZATION TECHNIQUES**	**L**	**T**	**P**	**C**
20RO3015		3	0	0	3

Course Objectives

To impart knowledge on

1. Fundamental concepts of soft computing, artificial neural networks and optimization techniques
2. Recent advancements in artificial neural networks and optimization techniques.
3. Optimization techniques.

Course Outcomes

The student will be able to

1. Apply neural network tool box for embedded applications.
2. Analyze the concept of fuzzy logic and neuro fuzzy systems.
3. Examine various optimization techniques
4. Choose appropriate optimization techniques for engineering applications.
5. Apply genetic algorithm concepts and tool box for embedded applications

Module: 1	**Introduction To Soft Computing And Neural Networks**	**7 Hours**
Introduction to soft computing: soft computing vs. hard computing – various types of soft computing techniques, from conventional AI to computational intelligence, applications of soft computing. Fundamentals of neural network: biological neuron, artificial neuron, activation function, single layer perceptron – limitations. Multi-layer perceptron –back propagation algorithm.		
Module: 2	**Artificial Neural Networks**	**7 Hours**

Radial basis function networks – reinforcement learning. Hopfield / recurrent network – configuration – stability constraints, associative memory and characteristics, limitations and applications. Hopfield vs. Boltzmann machine. Advances in neural networks – convolution neural networks. Familiarization of Neural network toolbox for embedded applications		
Module: 3	**Fuzzy Logic And Neuro Fuzzy Systems**	**7 Hours**
Fundamentals of fuzzy set theory: fuzzy sets, operations on fuzzy sets, scalar cardinality, union and intersection, complement, equilibrium points, aggregation, projection, composition. Fuzzy membership functions. Fundamentals of neuro-fuzzy systems – ANFIS. Familiarization of ANFIS Toolbox for process industry.		
Module: 4	**Introduction To Optimization Techniques**	**8 Hours**
Classification of optimization problems – classical optimization techniques. Linear programming – simplex algorithm. Non-linear programming – steepest descent method, augmented Lagrange multiplier method – equality constrained problems.		
Module: 5	**Advanced Optimization Techniques**	**8 Hours**
Simple hill climbing algorithm, Steepest ascent hill climbing – algorithm and features. Simulated annealing – algorithm and features..		
Module: 6	**Genetic algorithm**	**8 Hours**
Working principle, fitness function. Familiarization with Optimization Toolbox, genetic algorithm for embedded applications		
	Total Lectures	**45 Hours**

Reference Books	
1.	Laurene V. Fausett, "Fundamentals of neural networks, architecture, algorithms and applications, Pearson Education, 2008.
2.	Jyh-Shing Roger Jang, Chuen-Tsai Sun, EijiMizutani, "Neuro-Fuzzy and soft computing", Prentice Hall of India, 2003.
3.	Simon Haykin, "Neural Networks – A comprehensive foundation", Pearson Education, 2005.
4.	David E. Goldberg, "Genetic algorithms in search, optimization and machine learning", Pearson Education, 2009.
5.	Singiresu S. Rao, "Engineering Optimization – Theory and Practice", 4th edition, John Wiley & Sons, 2009.
6	Thomas Weise, "Global Optimization algorithms – Theory and applications", self-published, 2009.

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	**PRODUCT DESIGN AND DEVELOPMENT**	**L**	**T**	**P**	**C**
20RO3016		3	0	0	3

Course Objective:

To impart knowledge on

1. Product development
2. Different approaches in product development
3. The Concept of industrial design

Course Outcomes:

The student will be able to

1. Recall the need and process phase in product development
2. Identify structural approach to concept generation, creativity, selection and testing.
3. Categorize the various approaches in product development
4. Summarize industrial design in product development
5. Analyze the concept of development based on reverse engineering
6. Develop a concept for embedded based product for multi real time applications.

Module: 1	**Introduction to Product Development**	**8 Hours**

Need for Product Development- Generic product Development Process Phases- Product Development Process Flows, Product Development organization structures-Strategic importance of Product Planning process –Product Specifications-Target Specifications-Plan and establish product specifications –		
Module: 2	**Concepts on product Development**	**8 Hours**
Integration of customer, designer, material supplier and process planner, Competitor and customer -Understanding customer and behaviour analysis. Concept Generation, Five Step Method-Basics of Concept selection- Creative thinking –creativity and problem solving- creative thinking methods generating design concepts-systematic methods for designing –functional decomposition – physical decomposition –Product Architecture--changes - variety – component Standardization –example case study on Conceptual Design of DeskJet Printer as a product.		
Module: 3	**Introduction To Approaches In Product Development**	**8 Hours**
Product development management - establishing the architecture - creation - clustering –geometric layout development - Fundamental and incidental interactions - related system level design issues - secondary systems -architecture of the chunks - creating detailed interface specifications-Portfolio Architecture- competitive benchmarking- Approach – Support tools for the benchmarking process, trend analysis- Setting product specifications- product performance analysis -Industrial Design, Robust Design – Testing Methodologies.		
Module: 4	**Industrial Design**	**7 Hours**
Integrate process design - Managing costs - Robust design –need for Involving CAE, CAD, CAM, IDE tools –Simulating product performance and manufacturing processes electronically – Estimation of Manufacturing cost-reducing the component costs and assembly costs – Minimize system complexity - Prototype basics - Principles of prototyping - Planning for prototypes- Economic & Cost Analysis - Understanding and representing tasks-baseline project planning - accelerating the project, project execution.		
Module: 5	**Development Based On Reverse Engineering**	**7 Hours**
Basics on Data reverse engineering – Three data Reverse engineering strategies – Finding reusable software components – Recycling real-time embedded software based approach and its logical basics-Cognitive approach to program understated – Integrating formal and structured methods in reverse engineering – Incorporating reverse engineering for consumer product development-ethical aspects in reverse engineering.		
Module: 6	**Developing Embedded Product Design**	**7 Hours**
Discussions on Creating Embedded System Architecture(with at least one Case study example: Mobile Phone /Adaptive Cruise Controller/ Robonoid about) -Architectural Structures- Criteria in selection of Hardware & Software Components, product design by Performance Testing, Costing, Benchmarking ,Documentation, Reliability & Safety, Failure Rate, HARA (Hazard Analysis and Risk Assessment) SIL & ASIL, FMEA, FMEDA, FTA, Common Cause, Software Reliability, System Architectures		
	Total Lectures	**45 Hours**

Reference Books

1.	Karl T.Ulrich and Steven D.Eppinger "Product Design and Development", , McGraw –Hill International Edns.2003
2.	George E.Dieter, Linda C.Schmidt, “Engineering Design”, McGraw-Hill International Edition, 4th Edition, 2009.
3.	Product Design Techniques in Reverse Engineering and New Product Development, Kevin Otto & Kristin Wood, Pearson Education (LPE), 2001.
4.	Kevin Otto, Kristin Wood, “Product Design”, Indian Reprint, Pearson Education, 2004
5.	Yousef Haik, T. M. M. Shahin, “Engineering Design Process”, 2nd Edition Reprint, Cengage Learning, 2010.

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	IMAGE PROCESSING AND MACHINE VISION	L	T	P	C
20RO3017		3	0	0	3

Course Objective:

To impart knowledge on

1. Major concepts and techniques in computer vision and image processing
2. Computer vision and image processing knowledge by designing and implementing algorithms to solve practical problems
3. Current research in the fields and prepare for research in computer vision and image processing

Course Outcomes:

The student will be able to

1. Recall the concepts of image processing basics.
2. Explain the fundamentals of digital image processing.
3. Discuss image enhancement techniques. Image
4. Explain the importance of image compression
5. Explain the concepts of machine vision
6. Describe the importance of industrial machine vision

Module: 1	Introduction	8 Hours

Background, definition, Origin of DIP, Digital image representation, fundamental steps in image processing, elements of digital image processing systems, image acquisition, storage, processing, communication and display.

Module: 2	Digital Image Fundamentals	8 Hours

Structure of the human eye, image formation, brightness adaptation and discrimination, a simple image model, uniform and non-uniform sampling and quantization, some basic relationships between pixels, neighbors of a pixel, connectivity, Labeling. Relations, equivalence and transitive closure, distance measures, imaging geometry.

Module: 3	Image Enhancement in the spatial domain	8 Hours

Basic gray level transformations, histogram processing, Enhancement using arithmetic/logic operations, Basics of spatial filtering-comparison between smoothing and sharpening spatial filters. Image Enhancement in the frequency domain: 1D Fourier transform-2D Fourier transform and its Inverse-Smoothing & sharpening frequency domain filters (Ideal, Butterworth, Gaussian)-homomorphic filtering.

Module: 4	Image compression	7 Hours

Fundamentals-Image compression, Error-free compression, Huffman coding, block coding, constant area coding, variable length coding, bit-plane coding, lossless predictive coding-source and channel encoding-decoding-Lossy compression, lossy predictive coding, transform coding

Module: 5	Machine vision	7 Hours

Introduction, definition, Active vision system, Machine vision components, hardware's and algorithms, image function and characteristics, segmentation, data reduction, feature extraction, edge detection, image recognition and decisions, m/c learning, application of machine vision such as in inspection of parts, identification, industrial robot control, mobile robot application, Competing technologies, CCD line scan and area scan sensor, Videcon and other cameras, Triangulation geometry, resolution passive and active stereo imaging, laser scanner, data processing

Module: 6	Industrial M/C vision	7 Hours

Industrial machine vision in production and services, structure of industrial M/C vision, generic standards, rules of thumb, illumination, optics, image processing, interfacing machine vision system, vision system calibration.

	Total Lectures	45 Hours

Reference Books

1.	Rafael C.Gonzalez and Richard E. Woods, "Digital Image Processing", Richard E. Woods, pearson Education 2009
2.	Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing using MATLAB", Main purpose-Practical, 2004
3.	Milan Sonka, Vaclav Hlavac, Roger Boyle "Image Processing, Analysis and Machine Vision", Cengage learning, 2014.
4.	John G. Prokis, Dimitris G. Manolakis, "Digital Signal Processing (Principles, Algorithms and appls.)", PHI. Publication, 2007
5.	Jorge L C Sanz, "Image Technology: Advances in Image Processing, Multimedia and Machine Vision, Springer, 2012

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	ARTIFICIAL INTELLIGENCE IN ROBOTICS AND AUTOMATION	L	T	P	C
20RO3018		3	0	0	3

Course Objectives

To impart knowledge on

1. The concept of Industrial Automation
2. Different intelligent search methods
3. Artificial Intelligence in Robotics and Automation

Course Outcomes

The student will be able to

1. Describe the basics of AI
2. Understand the various intelligent search methods
3. Explain the concepts of knowledge and reasoning
4. Understand the in-depth concepts of learning methods
5. Explore the ethics of AI
6. Understand the application of AI for robotics

Module: 1	**Introduction**	**8 Hours**

Introduction to artificial intelligence and intelligent agents, categorization of AI Problem solving: Production systems and rules for some AI problems: water jug problem, missionaries-cannibals problem etc. Solving problems by searching : state space formulation, depth first and breadth first search, iterative deepening

Module: 2	**Intelligent search methods**	**8 Hours**

A* and its memory restricted variants Heuristic search: Hill climbing, best-first search, problem reduction, constraint satisfaction. Game Playing: Minimax, alpha-beta pruning.

Module: 3	**Knowledge and reasoning**	**8 Hours**

Propositional and first order logic, semantic networks, building a knowledge base, inference in first order logic, logical reasoning systems Planning: Components of a planning system, goal stack planning, non-linear planning strategies, probabilistic reasoning systems, Bayesian networks.

Module: 4	**Learning**	**7 Hours**

Overview of different forms of learning, Inductive learning, learning decision trees, computational learning theory, Artificial neural networks. Evolutionary computation: Genetic algorithms, swarm intelligence, particle swarm optimization. Applications: Robotics, Natural language processing etc.

Module: 5	**Ethics of AI**	**7 Hours**

Human Vs Robots, Robustness and Transparency of AI systems, Data Bias and fairness of AI systems, Accountability, privacy and Human-AI interaction.

Module: 6	**Robotic and Automation Application of AI**	**7 Hours**

Assembly, packaging, customer service, open source robotics, fraud prevention, brand management, software testing and development, human resource management.	
Total Lectures	**45 Hours**

Reference Books	
1.	Rich and Knight, "Artificial Intelligence", 3rd Edition, Tata McGraw Hill, 2014.
2.	Saroj Kaushik, "Artificial Intelligence", Cengage Learning, 2011.
3.	Deepak Khemani, "A First Course in Artificial Intelligence", Tata McGraw Hill, 2013.
4.	S. Russel and P.Norvig,"AI: A modern approach", 3rd Edition, Pearson Education, 2009.
5.	Francis X Govers, “Aritifical Intelligence for Robotics”, Packt Publishing Ltd, 2018

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	**ADVANCED MACHINE LEARNING**	**L**	**T**	**P**	**C**
20RO3019		3	0	0	3

Course Objectives

To impart knowledge on

1. The concepts of Machine Learning.
2. Recent advances in machine learning algorithms
3. Fundamentals of supervised and unsupervised learning paradigms towards application.

Course Outcomes

The student will be able to

1. Describe overview of Machine Learning techniques
2. Classify and contrast pros and cons of various machine learning techniques
3. Illustrate various methods for clustering
4. Infer various machine learning approaches and paradigms.
5. Explain the importance of support vector machine
6. Discuss the concept of association rule mining.

Module: 1	**Machine Learning Techniques - Overview**	**7Hours**

ML Techniques overview : Validation Techniques (Cross-Validations) Feature Reduction/Dimensionality reduction Principal components analysis (Eigen values, Eigen vectors, Orthogonality).

Module: 2	**Regression Basics**	**7Hours**

Regression basics : Relationship between attributes using Covariance and Correlation, Relationship between multiple variables: Regression (Linear, Multivariate) in prediction. Residual Analysis Identifying significant features, feature reduction using AIC, multi-collinearity Non-normality and Heteroscedasticity Hypothesis testing of Regression Model Confidence intervals of Slope R-square and goodness of fit Influential Observations – Leverage.

Module: 3	**Clustering**	**7 Hours**

Clustering : Distance measures Different clustering methods (Distance, Density, Hierarchical) Iterative distance-based clustering; Dealing with continuous, categorical values in K-Means Constructing a hierarchical cluster K-Medoids, k-Mode and density-based clustering Measures of quality of clustering.

Module: 4	**Classification**	**8 Hours**

Classification : Naïve Bayes Classifier Model Assumptions, Probability estimation Ÿ Required data processing M-estimates, Feature selection: Mutual information Classifier K-Nearest Neighbours Computational geometry; Voronoi Diagrams; Delaunay Triangulations K-Nearest Neighbour algorithm; Wilson editing and triangulations Aspects to consider while designing K-Nearest Neighbour.

Module: 5	**Support Vector Machines**	**8 Hours**

Support Vector Machines :- Linear learning machines and Kernel space, Making Kernels and working in feature space SVM for classification and regression problems. Decision Trees ID4, C4.5, CART Ensembles methods Bagging & boosting and its impact on bias and variance C5.0 boosting Ÿ Random forest Gradient Boosting Machines and XG Boost		
Module: 6	Case studies –II	**8 Hours**
Association Rule mining : The applications of Association Rule Mining: Market Basket, Recommendation Engines, etc. A mathematical model for association analysis; Large item sets; Association Rules Apriori: Constructs large item sets with mini sup by iterations; Interestingness of discovered association rules; Application examples; Association analysis vs. classification FP-trees		
	Total Lectures	**45 Hours**

Reference Books

1.	Christopher Bishop, "Pattern Recognition and Machine Learning", Springer, 2007.
2.	Kevin Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012
3.	Trevor Hastie, Robert Tibshirani, Jerome Friedman, "The Elements of Statistical Learning", Springer 2009.
4.	Arvin Agah, "Medical Applications of Artificial Intelligence", CRC Press, 2017
5	John Hearty, "Advanced Machine Learning with Python" Packt Publishing Ltd, 2016

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	**DESIGN OF MECHATRONICS SYSTEM**	**L**	**T**	**P**	**C**
20RO3020		3	0	0	3

Course Objective:

To impart knowledge on

1. Basic of systems and its design.
2. Fundamentals Control and drives.
3. Various interfacing techniques of Mechatronics System

Course Outcomes:

The student will be able to

1. Demonstrate an understanding of the concepts of systems and design.
2. Analyze various drives and control.
3. Explain real interface in Mechatronics
4. Analyse the concept of Automotive mechatronics
5. Design case studies on data acquisition
6. Design case studies on data acquisition and control

Module: 1	**System and Design**	**8 Hours**
Mechatronic systems – Integrated design issue in mechatronic – mechatronic key element, mechatronics approach – control program control – adaptive control and distributed system – Design process – Type of design – Integrated product design – Mechanism, load condition design and flexibility – structures – man machine interface, industrial design and ergonomics, information transfer, safety.		
Module: 2	**Drives and Control**	**8 Hours**
Control devices – Electro hydraulic control devices, electro pneumatic proportional controls – Rotational drives – Pneumatic motors: continuous and limited rotation – Hydraulic motor: continuous and limited rotation – Motion convertors, fixed ratio, invariant motion profile, variators.		
Module: 3	**Real time Interface**	**8 Hours**

Real time interface – Introduction, Elements of a data acquisition and Control system, overview of I/O process, installation of I/O card and software – Installation of the application software – over framing.		
Module: 4	**Automotive mechatronics**	**7 Hours**
Transmission Control – Automatic transmission – Mechanism – Control Modes - control algorithm – sensors - Mechatronic gear shift – Power train, Braking Control– Tire Road Interface – Vehicle dynamics during Braking - Control components – Anti lock Braking System – Sensotronic Braking System, Steering Control– Drive by Wire – Sensors – Actuators – Communication – Four wheel Steering Systems		
Module: 5	**Case studies –I**	**7Hours**
Case studies on data acquisition – Testing of transportation bridge surface materials – Transducer calibration system for Automotive application – strain gauge weighing system – solenoid force – Displacement calibration system – Rotary optical encoder – controlling temperature of a hot/cold reservoir – sensors for condition monitoring – mechatronic control in automated manufacturing.		
Module: 6	**Case studies –II**	**7 Hours**
Case studies on data acquisition and Control – thermal cycle fatigue of a ceramic plate – pH control system. Deicing temperature control system – skip control of a CD player – Auto focus Camera. Case studies on design of mechatronic product – pick and place robot – car park barriers – car engine management – Barcode reader.		
	Total Lectures	**45 Hours**

Reference Books

1.	Bolton, "Mechatronics – Electronic Control Systems in Mechanical and Electrical Engineering", Pearson Education Limited, 2015
2.	Devdas Shetty, Richard A. Kolkm, "Mechatronics System Design", Cengage Learning, 2010
3.	Smaili and F. Mrad, "Mechatronics- integrated technologies for intelligent machines", Oxford university press, 2008.
4.	Michael B. Histand and David G. Alciatore, " Introduction to Mechatronics and Measurement Systems", McGraw-Hill International Editions, 2000.
5.	.Lawrence J. Kamm, "Understanding Electro – Mechanical Engineering", An Introduction to Mechatronics, Prentice – Hall of India Pvt., Ltd., 2000.

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	**DEEP LEARNING FOR COMPUTER VISION**	**L**	**T**	**P**	**C**
20RO3021		3	0	0	3

Course Objective:

To impart knowledge on

1. Fundamental concepts of Neural network
2. Applications of Deep learning to computer vision
3. Applications of Deep learning to NLP

Course Outcomes:

The student will be able to

1. Recall the introduction to neural network
2. Explain the concepts of convolutional neural networks
3. Discuss deep learning unsupervised learning
4. Summarize the application of deep learning to computer vision
5. Describe the application of deep learning to NLP
6. Discuss the concept of recursive neural network.

Module: 1	**Introduction**	**7 Hours**
Feedforward Neural networks. Gradient descent and the backpropagation algorithm. Unit saturation, vanishing gradient problem, and ways to mitigate it. RelU Heuristics for avoiding bad local minima. Heuristics for faster training. Nestors accelerated gradient descent. Regularization. Dropout		

Module: 2	Convolutional Neural Networks	7 Hours
Architectures, convolution / pooling layers Recurrent Neural Networks - LSTM, GRU, Encoder Decoder architectures		
Module: 3	**Deep Unsupervised Learning**	**7Hours**
Autoencoders (standard, sparse, denoising, contractive, etc), Variational Autoencoders, Adversarial Generative Networks, Autoencoder and DBM, Attention and memory models, Dynamic memory networks.		
Module: 4	**Applications of Deep Learning to Computer Vision**	**8 Hours**
Image segmentation, object detection, automatic image captioning, Image generation with Generative adversarial networks, video to text with LSTM models. Attention models for computer vision tasks.		
Module: 5	**Applications of Deep Learning to NLP**	**8 Hours**
Introduction to NLP and Vector Space Model of Semantics -Word Vector Representations: Continuous Skip-Gram Model, Continuous Bag-ofWords model (CBOW), Glove, Evaluations and Applications in word similarity, analogy reasoning - Named Entity Recognition, Opinion Mining using Recurrent Neural Networks		
Module: 6	**Parsing and Sentiment Analysis using Recursive Neural Networks**	**8 Hours**
Sentence Classification using Convolutional Neural Networks - Dialogue Generation with LSTMs - Applications of Dynamic Memory Networks in NLP - Recent Research in NLP using Deep Learning: Factoid Question Answering, similar question detection, Dialogue topic tracking, Neural Summarization, Smart Reply		
	Total Lectures	**45 Hours**

Reference Books

1.	Nikhil Singh, Paras Ahuja, "A Complete Guide to become an Expert in Deep Learning and Computer Vision", BPB publications 2020
2.	Ahmed Fawzy Gad, Practical Computer Vision Applications Using Deep Learning with CNNs, Apress, 2018
3.	Ian Goodfellow, Yoshua Bengiom Aaron Courville, "Deep Learning", NIT Press, 2016.
4.	Mahmoud Hassaballah, Ali Ismail Awad, Deep Learning in Computer Vision- Principles and Applications, CRC press, 2020
5.	Rajalingappaa Shanmugamani, "Deep Learning for Computer Vision", Packt Publishing Ltd, 2018

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	ROBOT PROGRAMMING	L	T	P	C
20RO3022		3	0	0	3

Course Objective:

To impart knowledge on

1. Fundamentals of VAL language
2. Fundamentals of Rapid language
3. Application of virtual robot

Course Outcomes:

The student will be able to

1. Discuss the introduction to robot programming
2. Summarize the programming concepts of VAL I language
3. Summarize the programming concepts of VAL II language
4. Discuss the programming concepts of Rapid language
5. Summarize the application of virtual robot
6. Describe the programming concepts of AML language

Module: 1	Introduction to Robot Programming	7 Hours
Robot programming-Introduction-Types- Flex Pendant- Lead through programming, Coordinate systems of Robot, Robot controller- major components, functions-Wrist Mechanism-Interpolation-Interlock commands Operating mode of robot, Jogging-Types, Robot specifications- Motion commands, end effectors and sensors commands.		
Module: 2	**VAL Language**	**7 Hours**
Robot Languages-Classifications, Structures- VAL language commands motion control, hand control, program control, pick and place applications, palletizing applications using VAL, Robot welding application using VAL program-WAIT, SIGNAL and DELAY command for communications using simple applications.		
Module: 3	**VAL-II Programming**	**7Hours**
Basic commands, applications- Simple problem using conditional statements-Simple pick and place applications-Production rate calculations using robot.		
Module: 4	**RAPID Language and AML RAPID language**	**8 Hours**
Basic commands- Motion Instructions-Pick and place operation using Industrial robot- manual mode, automatic mode, subroutine command based programming. Move master command language-Introduction, syntax, simple problems. AML Language-General description, elements and functions, Statements, constants and variables-Program control statements-Operating systems, Motion, Sensor commands-Data processing.		
Module: 5	**Practical Study of Virtual Robot**	**8 Hours**
Robot cycle time analysis-Multiple robot and machine Interference-Process chart-Simple problems-Virtual robotics, Robot studio online software- Introduction, Jogging, components, work planning, program modules, input and output signals-Singularities-Collision detection-Repeatability measurement of robot-Robot economics.		
Module: 6	**AML Language**	**8 Hours**
General description, elements and functions, Statements, constants and variables-Program control statements-Operating systems, Motion, Sensor commands-Data processing.		
	Total Lectures	**45Hours**

Reference Books

1. Danny Staple, Learn Robotics Programming- Build and Control Autonomous Robots Using Raspberry Pi 3 and Python, Packt Publishing 2018
2. Cameron Hughes, Tracey Hughes, Robot Programming -A Guide to Controlling Autonomous Robots, Pearson Education, 2016.
3. Dinesh Tavasalkar, Hands-On Robotics Programming with C++ -Leverage Raspberry Pi 3 and C++ Libraries to Build Intelligent Robotics Applications, Packt publishing 2019.
4. J.Norberto Piers, Industrial Robots Programming - Building Applications for the Factories of the Future, Springer, 2007.
5. Bernardo Ronquillo Japon Hands-On ROS for Robotics Programming- Program Highly Autonomous and AI-capable Mobile Robots Powered by ROS, Packt Publishing, 2020

Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course code	VIRTUAL REALITY AND AUGMENTED REALITY	L	T	P	C
20RO3023		3	0	0	3

Course Objective:

To impart knowledge on

1. The elements, architecture, input and output devices of virtual and augmented reality systems

2. 3D interactive applications involving stereoscopic output, virtual reality hardware and 3D user interfaces
3. Geometry of virtual world

Course Outcomes:

The student will be able to

1. Summarize the characteristics, fundamentals and architecture of AR /VR.
2. Analyze the Hardware Requirement, Selection of Hardware for the AR / VR application development
3. Analyze the software development aspects for AR / VR
4. Design and develop the interactive AR / VR applications
5. Understand the geometry of visual world.
6. Analyze and build AR/VR applications for chosen industry, healthcare, education case study

Module: 1	**Introduction**	**7 Hours**

VR and AR Fundamentals, Differences between AR/VR Selection of technology AR or VR AR/VR characteristics Hardware and Software for AR/VR introduction. Requirements for VR/AR. Benefits and Applications of AR/VR. AR and VR case study.

Module: 2	**Hardware Technologies for AR / VR**	**7 Hours**

Visual Displays (VR cardboard, VR headsets, Mixed Reality headsets), Auditory Displays, Haptics and AR/VR, Choosing the Output devices for AR/VR applications, Hardware considerations and precautions with VR/AR headsets - 3D user interface input hardware - Input device characteristics, Desktop input devices, Tracking Devices, 3D Mice, SpecialPurposeInputDevices,DirectHumanInput,Home-BrewedInputDevices,ChoosingInput Devices for 3DInterfaces.

Module: 3	**Software technologies**	**7Hours**

Database - World Space, World Coordinate, World Environment, Objects - Geometry, Position / Orientation, Hierarchy, Bounding Volume, Scripts and other attributes,
VR Environment - VR Database, Tessellated Data, LODs, Cullers and Occludes, Lights and Cameras, Scripts, Interaction simple, Feedback, Graphical User Interface, Control Panel, 2DControls, Hardware Controls, Room/Stage/Area Descriptions, World Authoring and Playback, VR toolkits, Available software in the market (Unity and Vuforia based) .

Module: 4	**Geometry of Visual World**	**8 Hours**

Geometric modelling, transforming rigid bodies, yaw, pitch, roll, axis-angle representation, quaternions, 3D rotation inverses and conversions, homogeneous transforms, transforms to displays, look-at, and eye transform, canonical view and perspective transform, viewport transforms.

Module: 5	**Visual Perception**	**8 Hours**

Photoreceptors, Eye and Vision, Motion, Depth Perception, Frame rates and displays

Module: 6	**Case Studies in AR, VR**	**8 Hours**

Industrial applications, medical AR/VR, education and AR/VR.

	Total Lectures	**45Hours**

Reference Books

1. Alan B Craig, William R Sherman and Jeffrey D Will, “Developing Virtual Reality Applications: Foundations of Effective Design”, Morgan Kaufmann, Elsevier Science, 2009.
2. Gerard Jounghyun Kim, “Designing Virtual Systems: The Structured Approach”,Springer 2005.
3. Doug A Bowman, Ernest Kuijff, Joseph J LaViola, Jr and Ivan Poupyrev, “3D User Interfaces, Theory and Practice”, Addison Wesley, USA, 2005.
4. Oliver Bimber and Ramesh Raskar, “Spatial Augmented Reality: Meging Real and Virtual Worlds”, 2005.

5.	Burdea, Grigore C and Philippe Coiffet, "Virtual Reality Technology", Wiley Interscience, India, 2003.
Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

Course Code	**REAL TIME OPERATING SYSTEMS**	**L**	**T**	**P**	**C**
20RO3024		3	0	0	3

Course Objective:

To impart knowledge on

1. Fundamental concepts of how process are created and controlled with OS.
2. Programming logic of modelling Process based on range of OS features
3. Types and Functionalities in commercial OS, application development using RTOS

Course Outcomes:

The student will be able to

1. Contrast the fundamental concepts of real-time operating systems
2. Outline the concepts of RTOS Task and scheduler
3. Categorize real time models and languages
4. Summarize the concepts of RTOS kernel
5. Develop program for real time applications using android environment
6. Understand the structure of Free RTOS Structure

Module: 1	**Real time system concepts**	**7 Hours**
Foreground/Background systems- resources-shared resources-multitasking- tasks-context switches-kernels –schedulers-task priorities-dead locks inter task communication- interrupts - µCOS I, II and III comparison.		
Module: 2	**Kernel structure in µCOS**	**8 Hours**
Tasks-Task states- control blocks-ready list – scheduling –Idle task-statistics Task- Interrupts under µCOS-II, task management in µCOS- time management in µCOS		
Module: 3	**Semaphores**	**8Hours**
Event control blocks- semaphore management- creating , deleting a semaphore, waiting on a semaphore, creating and deleting Mutex, waiting on a mutex, event flag management.		
Module: 4	**Message Mailbox management**	**8 Hours**
Creating and deleting a mailbox µCOS – waiting for a message at a Mailbox, sending a message to a Mailbox, getting message without waiting- obtaining the status of a Mailbox, using a Mailbox as a binary semaphore.		
Module: 5	**Message Queue Management**	**7 Hours**
Creating and deleting a Message Queue- waiting for a Message Queue- sending a message to a queue FIFO, LIFO- getting a Message without waiting- flushing a Queue- obtaining status of Queue- using a Message Queue when reading analogue inputs and counting semaphores		
Module: 6	**Memory Management**	**7 Hours**
Memory control blocks- creating a partition, obtaining a memory block, returning a memory block-obtaining status of a memory partition- using memory partitions- waiting for memory blocks from a partition-porting µCOS		
	Total Lectures	**45Hours**

Reference Books

1.	Silberschatz,Galvin,Gagne" Operating System Concepts,6th ed,John Wiley,2003
2.	Raj Kamal, "Embedded Systems- Architecture, Programming and Design" Tata McGraw Hill,2006.
3.	Karim Yaghmour,Building Embedded Linux System",O'reilly Pub,2003
4.	Marko Gargenta,"Learning Android ",O'reilly 2011.
5.	Corbet Rubini, Kroah-Hartman, "Linux Device Drivers", O'reilly, 2016.
Recommended by Board of Studies	

Approved by Academic Council	12th September 2020

Course code	ENTREPRENEURSHIP DEVELOPMENT FOR ROBOTICS AND AUTOMATION	L	T	P	C
20RO3025		3	0	0	3

Course Objective:

To impart knowledge on

1. Fundamentals of Business promotion process.
2. Fundamentals of Success in business.
3. Ethics of Entrepreneurship.

Course Outcomes:

The student will be able to

1. Recall the basics for entrepreneurship
2. Analyze the challenges in entrepreneurship
3. Examine the responsibilities for entrepreneurship
4. Understand the ethics in entrepreneurship
5. Analyze the support for entrepreneur
6. Analyze the financial and accounting needs

Module: 1	Basics For Entrepreneurship	8 Hours

The entrepreneurial culture and structure -theories of entrepreneurship -entrepreneurial traits - types -behavioural patterns of entrepreneurs -entrepreneurial motivation -establishing entrepreneurial systems -idea processing, personnel, financial information and intelligence, rewards and motivation concept bank -Role of industrial Fairs.

Module: 2	Challenges For Entrepreneurship	8 Hours

Setting quality standards- recruitment strategies- time schedules- Financial analysis - credit facilities Marketing channel – advertisement- institutions providing technical, financial and marketing assistance-factory design -design requirements -applicability of the Factories Act.

Module: 3	Responsibilities in Entrepreneurship	8Hours

Steps for starting a small industry -selection of type of organization -Incentives and subsidies - Central Govt. schemes and State Govt. Schemes -incentives to SSI -registration, Registration and Licensing requirements for sales tax, CST, Excise Duty -Power -Exploring export possibilities- incentives for exports -import of capital goods and raw materials- Entrepreneurship development programmes in India- Role and Improvement in Indian Economy.

Module: 4	Ethics in ENTREPRENEURSHIP	7 Hours

Effective Costumer Care -Mechanism for Handling Complaints - Business Etiquettes and Body Language - Ethics, Values and Morale at Workplace - Managing Ethical Behaviour at Workplace

Module: 5	Support To Entrepreneurs	7 Hours

Sickness in small Business – Concept, Magnitude, Causes and Consequences, Corrective Measures - Business Incubators – Government Policy for Small Scale Enterprises – Growth Strategies in small industry – Expansion, Diversification, Joint Venture, Merger and Sub Contracting.

Module: 6	Financing And Accounting	7 Hours

Need – Sources of Finance, Term Loans, Capital Structure, Financial Institution, Management of working Capital, Costing, Break Even Analysis, Taxation – Income Tax, Excise Duty – Sales Tax.

	Total Lectures	45Hours

Reference Books

1.	Mariana Mazzucato, Strategy for Business- A Reader, SAGE Publications 2002
2.	Thomas Zimmerer et.al., Essentials of Entrepreneurship and small business Management 3rd Ed. Pearson Education, 2008.
3.	Greene, Entrepreneurship: Ideas in Action, Thomson Learning, Mumbai, 2000
4.	Edward Freeman, Sankaran Venkataraman "Ethics and Entrepreneurship" Society for Business Ethics, 2002.

5.	Robert Cressy, Douglas Cumming, Christine Mallin, Entrepreneurship, Governance and Ethics, Springer , 2012
Recommended by Board of Studies	
Approved by Academic Council	12th September 2020

DEPT. OF ROBOTICS ENGINEERING

LIST OF NEW COURSES

S.No.	Course Code	Name of the Course	L:T:P	Credits
1.	19RO1001	Material Science	3:0:0	3
2.	19RO1002	Engineering Practices	1:0:3	2.5
3.	19RO2001	Theory and Programming of CNC Machines	3:0:0	3
4.	19RO2002	Autonomous Vehicles	3:0:0	3
5.	19RO2003	Automotive Embedded Systems	3:0:0	3
6.	19RO2004	Robotic Control System	3:0:0	3
7.	19RO2005	Industrial Robotics and Material Handling Systems	3:0:0	3
8.	19RO2006	Micro Robotics	3:0:0	3
9.	19RO2007	Cognitive Robotics	3:0:0	3
10.	19RO2008	Cloud Robotics	3:0:0	3
11.	19RO2009	Medical Robotics	3:0:0	3
12.	19RO2010	Machine Learning for Robotics	3:0:0	3
13.	19RO2011	Robot Operating Systems	3:0:0	3
14.	19RO2012	Artificial Intelligence in Robotics	3:0:0	3
15.	19RO2013	Industrial Energy Management System	3:0:0	3
16.	19RO2014	Robotics and Automation in Food Industry	3:0:0	3
17.	19RO2015	Neural Networks and Fuzzy Systems	3:0:0	3
18.	19RO2016	Microcontrollers for Robotics	3:0:0	3
19.	19RO2017	Microcontrollers Laboratory for Robotics	0:0:2	1

19RO1001	MATERIAL SCIENCE	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on

1. Phase diagrams and alloys
2. Electric, Mechanical and Magnetic properties of materials
3. Advanced Materials used in engineering applications

Course Outcomes:

The Student will be able to

1. Describe the various phase diagrams and their applications
2. Explain the applications of Ferrous alloys
3. Discuss about the electrical properties of materials
4. Summarize the mechanical properties of materials and their measurement
5. Differentiate magnetic, dielectric and superconducting properties of materials
6. Describe the application of modern engineering materials

Module 1: Introduction (6 hrs)

Historical perspective-Classification-Atomic Structure and Inter atomic Bonding –Structure of Crystalline solids- Phase diagrams

Module 2: Ferrous Alloys (9 hrs)

The iron-carbon equilibrium diagram - phases, invariant reactions - microstructure of slowly cooled steels - eutectoid steel, hypo and hypereutectoid steels - effect of alloying elements on the Fe-C system - diffusion in solids - Fick's laws - phase transformations - T-T-T-diagram for eutectoid steel – pearlite, bainite and martensite transformations

Module 3: Electrical Properties (9 hrs)

Conducting materials-quantum free electron theory -Fermi Dirac Statistics-Band theory of solids - the density of states. Magnetostriction. Electron ballistics- materials for thermionic emission electron guns-electron gun for electron beam machining-electric discharge plasma - EDM machining.

Module 4: Mechanical Properties (8 hrs)

Tensile test - plastic deformation mechanisms - slip and twinning - strengthening methods - strain hardening - refinement of the grain size - solid solution strengthening - precipitation hardening - creep resistance - creep curves - mechanisms of creep - creep-resistant materials - fracture - the Griffith criterion - critical stress

intensity factor and its determination - fatigue failure - fatigue tests - methods of increasing fatigue life - hardness - Rockwell and Brinell hardness - Knoop and Vickers microhardness.

Module 5: Magnetic, Dielectric And Superconducting Materials (8 hrs)

Ferromagnetism – domain theory – types of energy – hysteresis – hard and soft magnetic materials – ferrites - dielectric materials – types of polarization – Langevin-Debye equation – frequency effects on polarization - dielectric breakdown – insulating materials – Ferroelectric materials - superconducting materials and their properties.

Module 6: Advanced Materials (5 hrs)

Liquid crystals-types-application as display devices-photonic crystals- ferro elastic materials-multiferroics, Bio mimetic materials. Composites-nanophase materials-physical properties and applications.

Text Books:

1. Balasubramaniam, R. "Callister's Materials Science and Engineering". Wiley India Pvt. Ltd., 2014.
2. Raghavan, V. "Physical Metallurgy: Principles and Practice". PHI Learning, 2015.

Reference Books:

1. William D CallisterJr, "Materials Science and Engineering-An Introduction", John Wiley and Sons Inc., Sixth Edition, New York,2010.
2. Raghavan, V. "Materials Science and Engineering : A First course". PHI Learning, 2015
3. Shetty.M.N., "Material Science and Engineering – Problems with Solutions", PHI, 2016
4. Shaffer J P, Saxena A, Antolovich S D, Sanders T H Jr and Warner S B, "The Science and Design of Engineering Materials", McGraw Hill Companies Inc., New York, 1999.

19RO1002	ENGINEERING PRACTICES	L	T	P	C
		1	0	3	2.5

Course Objectives:

To impart knowledge on

1. Carpentry Joints, Fitting and Welding Practices
2. Basics of Electronic Circuit components, Instruments and Wiring
3. PCB design and fabrication

Course Outcomes:

The Student will be able to

1. Assemble mechanical devices and equipment by applying carpentry and fitting practices.
2. Apply welding and drilling skills to fabricate useful products.
3. Design simple electric circuits and apply different types of wiring.
4. Identify the operation and handling of measuring instruments.
5. Perform troubleshooting of electric motors
6. Fabricate PCB boards for specific applications.

List of Experiments:

1. Making of rectangular planning in carpentry
2. Making of middle lap joint in carpentry
3. Making of Square filing in Fitting
4. Making of V joint in Fitting
5. Drilling holes and welding of Mild Steel plates
6. Study of simple electrical circuit diagrams and wiring
7. Study of electrical connection of basic electrical equipment
8. Study of handling of all measuring instruments and Oscilloscope (Multimeter, Wattmeter, Clamp meter, ammeter, voltmeter, CRO, DSO etc)
9. Study of Electrical Cables, HRC Fuse, MCB. simple relay and Contactors
10. Troubleshooting of Electric Motors
11. PCB layout design using software.
12. PCB fabrication, Components soldering and Trouble shooting
13. Assembly of simple Robots

19RO2001	THEORY AND PROGRAMMING OF CNC MACHINES	L	T	P	C
		3	0	0	3

Course Objectives:

1. To study the design aspects of an automation system
2. Learn about the design of belt conveyors
3. Understand the issues involved during integration of automation components

Course Outcomes:

The Student will be able to

1. Classify the types of CNC machines and read their electrical circuit diagram
2. Select the parameters for optimum performance and read the PLC ladder diagram with reference to the PLC I/O s
3. Perform the sizing of servomotors and do drive optimization.
4. Design electrical power, and control circuits for a CNC machine and interface various sensors to CNC/PLC
5. Develop CNC programs for lathes, select the right tools, take offsets and do machining of a component.
6. Estimate the machine hour rate of a CNC machine and do the regular and preventive maintenance.

Module 1: Introduction (8 hrs)

History - Advantages and disadvantages of CNC, block diagram of CNC - Principle of operation- Features available in CNC systems. DNC, Networking of CNC machines - Ethernet. Electrical cabinet and control panel wiring. Electrical standards. Types Of CNC Machines : Types and constructional features of machine tools- Turning centres, machining centers, grinding machines, EDMs, turret punch press, laser and water jet cutting machines, Design considerations – Axis representations, Various operating modes of a CNC machine.

Module 2: Control Units (7 hrs)

Functions of CNC, system hardware, contouring control - interpolation, software development process. Parameters and diagnosis features. Interfacing with keyboard, monitor, field inputs, outputs, MPG. Open architecture systems and PC based controllers. Role of PLC in CNC machines.- hardware and I/O configuration.

Module 3: Drive Units (8 hrs)

Axis drive arrangements, ball screw, timing belts and couplings, Analog and digital drives. AC&DC servomotors, DC and AC servo drives for axis motors, servo tuning. Stepper motors and drives, spindle motors & drives- DC &AC. Selection criteria, drive optimization and protection.

Module 4: Control And Feedback Devices (8 hrs)

MCCB, MCB, control relays, contactors, overload relays, cables & terminations. Applications of feedback devices in CNC machines- Absolute and incremental encoders, resolvers, linear scales, Proximity switches, limit switches – Thermal sensors, pressure and float switches. Positioning of sensors in CNC.

Module 5: NC Part Programming Process (8 hrs)

Axis notation, EIA and ISO codes, Explanation of basic codes.Tooling concepts, machining methods, part geometry and writing of tool motion statements.Canned cycles. Development of simple manual part programs for turning operations. Simulation of part programme. Post processors - CNC part programming with CAD/CAM systems.

Module 6: Economics And Maintenance (7 hrs)

Factors influencing selection of CNC Machines, Cost of operation of CNC Machines, Practicalaspects of introducing CNC machines in industries, Maintenance of CNC Machines Preventive Maintenance, TPM, Importance of earthing on the performance and life of machines.

Text Books:

1. Steve F Krar, “Computer Numerical Control Simplified“, Industrial Press, 2001.
2. Radhakrishnan P., “Computer Numerical Control Machines”, New Central Book Agency, 1992.

Reference Books:

1. YoremKoren, “Computer Control of Manufacturing Systems”, Pitman, London, 2005.
2. HMT Limited, “Mechatronics”, Tata McGraw Hill, New Delhi, 1998.
3. Suk Hwan, SeongKyoon, dae -Hyuk, “Theory and Design of CNC Machines”, Springer,\ 2008
4. Hans.B.Kief, Helmut, “CNC Handbook”, Mc GrawHill Professional, 2012.
5. Thyer.G.E., “Computer Numerical Control of Machine Tools”, Newnes, 2012.

19RO2002	AUTONOMOUS VEHICLES	L	T	P	C
		3	0	0	3

Course Objectives:

1. Introduce the fundamental aspects of Autonomous Vehicles.
2. Gain Knowledge about the Sensing Technology and Algorithms applied in Autonomous vehicles.
3. Understand the Connectivity Aspects and the issues involved in driverless cars.

Course Outcomes:

The Student will be able to

1. Describe the evolution of Automotive Electronics and the operation of ECUs.
2. Compare the different type of sensing mechanisms involved in Autonomous Vehicles.
3. Discuss about the use of computer vision and learning algorithms in vehicles.
4. Summarize the aspects of connectivity fundamentals existing in a driverless car.
5. Identify the different levels of automation involved in an Autonomous Vehicle.
6. Outline the various controllers employed in vehicle actuation.

Module 1: Introduction (8 hrs)

Evolution of Automotive Electronics -Basic Control System Theory applied to Automobiles -Overview of the Operation of ECUs -Infotainment, Body, Chassis, and Powertrain Electronics-Advanced Driver Assistance Systems-Autonomous Vehicles

Module 2: **Sensor Technology for Autonomous Vehicles (8 hrs)**

Basics of Radar Technology and Systems -Ultrasonic Sonar Systems -LIDAR Sensor Technology and Systems -Camera Technology -Night Vision Technology -Use of Sensor Data Fusion -Kalman Filters

Module 3: **Computer Vision and Deep Learning for Autonomous Vehicles (7 hrs)**

Computer Vision Fundamentals -Advanced Computer Vision -Neural Networks for Image Processing – TensorFlow -Overview of Deep Neural Networks -Convolutional Neural Networks

Module 4: **Connected Car Technology (8 hrs)**

Connectivity Fundamentals - DSRC (Direct Short Range Communication) - Vehicle-to-Vehicle Technology and Applications -Vehicle-to-Roadside and Vehicle-to-Infrastructure Applications -Security Issues.

Module 5:Autonomous Vehicle Technology (7 hrs)

Driverless Car Technology-Different Levels of Automation -Localization - Path Planning. Controllers to Actuate a Vehicle - PID Controllers -Model Predictive Controllers, ROS Framework

Module 6:Autonomous Vehicles' Biggest Challenges (7 hrs)

Technical Issues, Security Issues, Moral and Legal Issues.

Text Books:

1. Hong Cheng, "Autonomous Intelligent Vehicles: Theory, Algorithms and Implementation", Springer, 2011.
2. Williams. B. Ribbens: "Understanding Automotive Electronics", 7th Edition, Elsevier Inc, 2012.

Reference Books:

1. Shaoshan Liu, Liyun Li, "Creating Autonomous Vehicle Systems", Morgan and Claypool Publishers, 2017.
2. Marcus Maurer, J.ChristianGerdes, "Autonomous Driving: Technical, Legal and Social Aspects" Springer, 2016.
3. Ronald.K.Jurgen, "Autonomous Vehicles for Safer Driving", SAE International, 2013.
4. James Anderson, KalraNidhi, Karlyn Stanly, "Autonomous Vehicle Technology: A Guide for Policymakers", Rand Co, 2014.
5. Lawrence. D. Burns, ChrostopherShulgan, "Autonomy – The quest to build the driverless car and how it will reshape our world", Harper Collins Publishers, 2018

19RO2003	AUTOMOTIVE EMBEDDED SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To introduce the basic components of modern automotive systems.
2. Understand the application of microcontrollers in ECU design and the In-Vehicle Communication protocols.
3. To provide an overview of the Automotive Open Systems Architecture (AUTOSAR)

Course Outcomes:

The Student will be able to

1. Describe the function of basic components used in modern automotive systems.
2. Discuss about the applications of microcontrollers in ECU design.
3. Summarize the various In-Vehicle Communication Protocols and their features.
4. Outline the diagnostic protocols and their functions.
5. Illustrate the practical applications of Automotive Open Systems Architecture (AUTOSAR)
6. Discuss about the Quality and Safety Standards to be adopted in Automotive Systems.

Module 1: Automotive Embedded Systems (8 hrs)

Introduction to Modern Automotive Systems-Evolution of Electronics and Software in automobiles -ECUs and their application areas in Automotive -Engine Management Systems -Body & Comfort Electronics Systems -Infotainment Systems -Advanced Driver Assistance Systems and V2X Systems -Autonomous Driving Systems -Current Trends and Challenges

Module 2:Micro Controllers in ECU Design (8 hrs)

Overview of AURIX Micro Controller -Architecture, Memory Map, Lock Step etc. -Peripherals used in Automotive Applications -GTM, QSPI, DSADC etc. -AURIX SafeTLib -Real time Operating Systems and Scheduling Concepts -Practical Experiments using AURIX Eval Kit.

Module 3: In-Vehicle Communication Protocols (7 hrs)

Overview of In-Vehicle Communication Protocols – CAN, LIN, Flex Ray, MOST, Ethernet -Controller Area Network (CAN)-CANoe, CANalyzer Fundamentals -CAPL Scripting, Panel Simulation.

Module 4: In-Vehicle Diagnostics (7 hrs)

Overview of Diagnostic Protocols – KWP 2000 and UDS.

Module 5: AUTOSAR (Automotive Open Systems Architecture) (8 hrs)

Platform Based Development -AUTOSAR Overview -AUTOSAR RTE, BSW, SWC -AUTOSAR Methodology & Workflow -AUTOSAR Tools Overview -Practical Experiments using AUTOSAR Tools.

Module 6: Automotive Quality, Safety and Security Standards (7 hrs)

Common Failures in Automotive Systems -ASPICE Development Process -MISRA C Standard -ISO 26262 Functional Safety Standard -SAE J3061 Security Standard.

Text Books:

1. Ronald K Jurgen: "Distributed Automotive Embedded Systems" SAE International, 2007.
2. Williams. B. Ribbens: "Understanding Automotive Electronics", 7th Edition, Elsevier Inc, 2012.

Reference Books:

1. Robert Bosch: "Automotive Handbook", 6th Edition, John Wiley and Sons, 2004.
2. Ronald K Jurgen: "Automotive Electronics Handbook", 2nd Edition, McGraw-Hill, 1999
3. Nicolas Nivet, Francoise Simonot, "Automotive Embedded Systems Handbook", CRC Press, 2017.
4. Kevin Roebuck,"AUTOSAR – Automotive Open System Architecture – High Impact Strategies", Computers, 2011.
5. Dominique Paret, "Multiplexed Networks for Embedded Systems", Wiley International, 2007.

19RO2004	ROBOTIC CONTROL SYSTEM	L	T	P	C
		3	0	0	3

Course Objectives:

1. To provide knowledge on the various robotic systems with the help of mathematical models.
2. To introduce the control aspects of non-linear systems.
3. To learn the concepts of non-linear observer design.

Course Outcomes:

The Student will be able to

1. Describe the characteristics of a robotic system from its dynamic model.
2. Analyze the stability of robotic systems with the help of theorems.
3. Illustrate the various task space control schemes available.
4. Discuss about the various Non Linear Control schemes.
5. Explain the concepts of Optimal Control System.
6. Develop nonlinear observer schemes.

Module 1: Introduction and Overview of Robotic Systems and their Dynamics (8 hrs)

Forward and inverse dynamics. Properties of the dynamic model and case studies. Introduction to nonlinear systems and control schemes.

Module 2: System Stability and Types of Stability (7 hrs)

Lyapunov stability analysis, both direct and indirect methods. Lemmas and theorems related to stability analysis.

Module 3: Joint Space and Task Space Control Schemes (7 hrs)
Position control, velocity control, trajectory control and force control.
Module 4: Nonlinear Control Schemes (8 hrs)
Proportional and derivative control with gravity compensation, computed torque control, sliding mode control, adaptive control, observer based control and robust control.
Module 5: Optimal Control: Introduction - Time varying optimal control – LQR steady state optimal control – Solution of Ricatti's equation – Application examples.
Module 6: Nonlinear Observer Schemes: Design based on acceleration, velocity and position feedback. Numerical simulations using software packages.

Text Books:
1. R Kelly, D. Santibanez, LP Victor and Julio Antonio, "Control of Robot Manipulators in Joint Space", Springer, 2005.
2. A Sabanovic and K Ohnishi, "Motion Control Systems", John Wiley & Sons (Asia), 2011.

Reference Books:
1. R M Murray, Z. Li and SS Sastry, "A Mathematical Introduction to Robotic Manipulation", CRC Press, 1994.
2. J J Craig, "Introduction to Robotics: Mechanics and Control", Prentice Hall, 2004.
3. J J E Slotine and W Li, "Applied Nonlinear Control", Prentice Hall, 1991.
4. Sebastian Thrun, Wolfram Burgard, Dieter Fox, "Probabilistic Robotics", MIT Press, 2005.
5. Carlos, Bruno, Georges Bastin, "Theory of Robot Control", Springer, 2012.

19RO2005	INDUSTRIAL ROBOTICS AND MATERIAL HANDLING SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:
1. Learn about the types of robots used in material handling systems.
2. Understand the use of vision systems in automation systems.
3. Gain knowledge on the different methods of material handling.

Course Outcomes:
The Student will be able to
1. Differentiate the various types of Industrial Robots and their architecture.
2. Apply the concepts of image processing for robotic inspection systems.
3. Analyze the applications of robots in various industrial application.
4. Design and fabricate simple grippers for pick and place application.
5. Identify the right Robot for a given industrial application.
6. Select the right material handling system for a given application.

Module 1: Introduction (7 hrs)
Types of industrial robots, Load handling capacity, general considerations in Robotic material handling, material transfer, machine loading and unloading, CNC machine tool loading, Robot centered cell.
Module 2: Robots for Inspection (8 hrs)
Robotic vision systems, image representation, object recognition and categorization, depth measurement, image data compression, visual inspection, software considerations.
Module 3: Other Applications (7 hrs)
Application of Robots in continuous arc welding, Spot welding, Spray painting, assembly operation, cleaning, robot for underwater applications.
Module 4: End Effectors (8 hrs)
Gripper force analysis and gripper design for typical applications, design of multiple degrees of freedom, active and passive grippers.
Module 5: Selection of Robot (7 hrs)
Factors influencing the choice of a robot, robot performance testing, economics of robotization, Impact of robot on industry and society.
Module 6: Material Handling (8 hrs)
Concepts of material handling, principles and considerations in material handling systems design, conventional material handling systems - industrial trucks, monorails, rail guided vehicles, conveyor systems, cranes and hoists, advanced material handling systems, automated guided vehicle systems, automated storage and retrieval systems(ASRS), bar code technology, radio frequency identification technology. Introduction to Automation Plant design software.

Text Books:

1. Richard D Klafter, Thomas Achmielewski and MickaelNegin, “Robotic Engineering – An integrated Approach” Prentice HallIndia, New Delhi, 2001.
2. Mikell P Groover, "Automation, Production Systems, and Computer-Integrated Manufacturing", Pearson Education, 2015.

Reference Books:

1. James A Rehg, “Introduction to Robotics in CIM Systems”, Prentice Hall of India, 2002.
2. Deb S R, "Robotics Technology and Flexible Automation", Tata McGraw Hill, New Delhi, 1994.
3. Richard. K. Miller, “Industrial Robot Handbook”, Springer, 2013.
4. Cotsaftis, Vernadat, “Advances in Factories of the Future, CIM and Robotics”, Elsevier, 2013.
5. Gupta.A.K, Arora. S. K., “Industrial Automation and Robotics”, University Science Press, 2009.

19RO2006	MICROROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Provide brief introduction to micromachining and the principles of microsystems
2. Understand the various flexures, actuators and sensor systems.
3. Discuss the methods of implementation of micro robots.

Course Outcomes:

The Student will be able to

1. Describe the principles of microsystems and micromachining.
2. Analyze the effectsof scaling laws on physical and electrical properties and the materials to be used to MEMS.
3. Specify the characteristics of various flexures, actuators and sensor systems
4. Provide a task specification of micro robots and its applications based on the knowledge about micro robots
5. Outline the various methods of implementation of micro robots.
6. Discuss about the principle of micro fabrication and micro assembly.

Module 1: Introduction (7 hrs)

MST (Micro System Technology) – Micromachining - Working principles of Microsystems - Applications of Microsystems.

Module 2: Scaling Laws and Materials for MEMS (8 hrs)

Introduction - Scaling laws - Scaling effect on physical properties, scaling effects on Electrical properties, scaling effect on physical forces. Physics of Adhesion - Silicon-compatible material system - Shape memory alloys - Material properties: Piezoresistivity, Piezoelectricity and Thermoelectricity.

Module 3: Flexures, Actuators and Sensors (7 hrs)

Elemental flexures - Flexure systems - Mathematical formalism for flexures. Electrostatic actuators, Piezo-electric actuators, Magneto-strictive actuators. Electromagnetic sensors, Optical-based displacement sensors, Motion tracking with microscopes.

Module 4: Micro robotics (8 hrs)

Introduction, Task specific definition of micro-robots - Size and Fabrication Technology based definition of micro robots - Mobility and Functional-based definition of micro-robots - Applications for MEMS based micro-robots.

Module 5: Implementation of Micro robots (8 hrs)

Arrayed actuator principles for micro-robotic applications – Micro-robotic actuators - Design of locomotive micro-robot devices based on arrayed actuators. Micro-robotics devices: Micro-grippers and other micro-tools - Micro conveyors - Walking MEMS Micro-robots – Multi-robot system: Micro-robot powering, Micro-robot communication.

Module 6: Micro fabrication and Micro assembly (7 hrs)

Micro-fabrication principles - Design selection criteria for micromachining - Packaging and Integration aspects – Micro-assembly platforms and manipulators.

Text Books:

1. Mohamed Gad-el-Hak, “The MEMS Handbook”, CRC Press, New York, 2002.
2. Yves Bellouard, “Microrobotics Methods and Applications”, CRC Press, Massachusetts, 2011.

Reference Books:

1. NadimMaluf and Kirt Williams, '"An Introduction to Microelectromechanical systems Engineering", Artech House, MA, 2002.
2. Julian W Gardner, "Microsensors: Principles and Applications", John Wiley & Sons, 1994.
3. SergejFatikow, Ulrich Rembold, "Microsystem Technology and Microrobotics", Springer, 2013.
4. Nicolas Chaillet, Stephane Regnier, "Microrobotics for Micromanipulation", Wiley, 2013.
5. Vikas Choudhry, Krzystof, "MEMS: Fundamental Technology and Applications", CRC Press, 2013.

19RO2007	COGNITIVE ROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Provide brief introduction to robot cognition and perception
2. Understand the concepts of path planning algorithms.
3. Gain knowledge on the robot programming packages used in localization and mapping.

Course Outcomes:

The Student will be able to

1. Discuss about the basics of robot cognition and perception
2. Illustrate the different methods of map building and the robot simulation and execution of a program
3. Analyze the various path planning techniques by briefing about the robot's environment and explaining about the programs used
4. Develop knowledge about simultaneous localization and mapping based techniques and paradigms.
5. Elaborate the various robot programming packages for display,tele-operation and other applications.
6. Describe the aspects of Imaging Techniques used in Robotic Applications.

Module 1: Cybernetic View of Robot Cognition And Perception (6 hrs)

Introduction to the Model of Cognition, Visual Perception, Visual Recognition, Machine Learning, Soft Computing Tools and Robot Cognition.

Module 2: Map Building (8 hrs)

Introduction, Constructing a 2D World Map, Data Structure for Map Building, Explanation of the Algorithm, An Illustration of Procedure Traverse Boundary, An Illustration of Procedure Map Building ,Robot Simulation, Execution of the Map Building Program.

Module 3: Randomized Path Planning (8 hrs)

Introduction, Representation of the Robot's Environment, Review of configuration spaces, Visibility Graphs, Voronoi diagrams, Potential Fields and Cell Decomposition, Planning with moving obstacles, Probabilistic Roadmaps, Rapidly exploring random trees, Execution of the Quad tree-Based Path Planner Program.

Module 4: Simultaneous Localization and Mapping (SLAM) (8 hrs)

Problem Definition, Mathematical Basis, Examples: SLAM in Landmark Worlds, Taxonomy of the SLAM Problem, Extended Kalman filter, Graph-Based Optimization Techniques, ParticleMethods Relation of Paradigms.

Module 5: Robot Programming Packages (8 hrs)

Robot Parameter Display, Program for BotSpeak, Program for Sonar Reading Display, Program for Wandering Within the Workspace, Program for Tele-operation, A Complete Program for Autonomous Navigation.

Module 6: Imaging Geometry: (7 hrs)

Introduction – Necessity for 3D Reconstruction – Building Perception – Imaging Geometry – Global Representation – Transformation to Global Co-ordinate System.

Text Books:

1. Patnaik, Srikanta, "Robot Cognition and Navigation - An Experiment with Mobile Robots", Springer-Verlag Berlin and Heidelberg, 2007.
2. Howie Choset, Kevin LynchSeth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, "Principles of Robot Motion-Theory, Algorithms, and Implementation", MIT Press, Cambridge, 2005.

Reference Books:

1. Sebastian Tharun, Wolfram Burgard, Dieter Fox, "ProbabilisticRobotics", MIT Press, 2005.
2. Margaret E. Jefferies and Wai-Kiang Yeap, "Robotics and Cognitive Approaches to Spatial Mapping", Springer-Verlag Berlin Heidelberg 2008.
3. HoomanSomani,"Cognitive Robotics", CRC Press, 2015.
4. Jared Kroff,"Cognitive Robotics: Intelligent Robotic Systems", Wilford Press, 2016.

5. Lidia Ogiela, Marek Ogiela, “Advances in Cognitive Information Systems”, Springer, 2012.

19RO2008	CLOUD ROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Provide an overview of telerobotics
2. Understand the concept of networked telerobotic systems
3. Provide knowledge on the functions of online robots

Course Outcomes:

The Student will be able to

1. Discuss about the basic principles of telerobotics
2. Describe the concepts of wired and wireless communication for networked telerobotic systems.
3. Explain the fundamentals of robot manipulation and teleoperation
4. Design and fabricate the software architecture and interface for networked robot systems on the web
5. Analyze the performance of mobile robots controlled through the web
6. Outline the software architecture for telerobotics.

Module 1: Introduction (6 hrs)

Telerobotics: Overview and background – Brief history.

Module 2: Communications And Networking (8 hrs)

The Internet – Wired Communication Links – Wireless Links – Properties of Networked Telerobotics – Building a Networked Telerobotic system – State command Presentation – Command Execution/ State Generation – Collaborative Control

Module 3: Fundamentals Of Online Robots (8 hrs)

Introduction – Robot Manipulators – Teleoperation – Teleoperation on a local network – Teleoperation via a constrained link.

Module 4: Online Robots (8 hrs)

Introduction to networked robot system on the Web – Software Architecture and design – Interface design.

Module 5: Remote Mobility (8 hrs)

Autonomous Mobile Robot on the Web – Mobile Mini Robots – Performance of Mobile Robots controlled through WEB – Handling Latency in Internet based Tele operation

Module 6: Case Study (7 hrs)

Computer Networked Robotics – Online Robots and the Robot Museum.

Text Books:

1. Bruno Siciliano, OussamaKhatib, “Springer Handbook of Robotics”, Springer Science and Business, 2010.
2. Ken Goldberg, Roland Siegwart, “Beyond Webcams – An Introduction to Online Robots”, MIT Press, 2010.

Reference Books:

1. BorkoFurht, Armando Escalante, “Handbook of Cloud Computing”, Springer Science & Business, 2010.
2. Peter Sinčák, Pitoyo Hartono, MáriaVirčíková, JánVaščák, Rudolf Jakša , “Emergent Trends in Robotics and Intelligent Systems”, Springer, 2014.
3. Joao Pedro, Carvalho Rosa, “Cloud Robotics – Distributed Robotics using Cloud Computing”, Coimbra, 2016.
4. AnisKoubaa, ElhadiShakshuki, “Robots and Sensor Clouds”, Springer, 2015.
5. Nak. Y. Chung, “Networking Humans, Robots and Environments”, Bentham Books, 2013.

19RO2009	MEDICALROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Provide knowledge on the application of robotics in the field of health care
2. Overview of the sensor requirements for localization and tracking in medical applications
3. Understand the design aspects of medical robots

Course Outcomes:

The Student will be able to

1. Describe the types of medical robots and the concepts of navigation and motion replication.

2. Discuss about the sensors used for localization and tracking
3. Summarize the applications of surgical robotics
4. Outline the concepts in Rehabilitation of limbs and brain machine interface
5. Classify the types of assistive robots.
6. Analyze the design characteristics, methodology and technological choices for medical robots.

Module 1: **Introduction (7 hrs)**

Types of medical robots - Navigation - Motion Replication - Imaging - Rehabilitation and Prosthetics - State of art of robotics in the field of healthcare.

Module 2: Localization And Tracking (8 hrs)

Position sensors requirements - Tracking - Mechanical linkages - Optical - Sound-based - Electromagnetic - Impedance-based - In-bore MRI tracking - Video matching - Fiber optic tracking systems - Hybrid systems.

Module 3: **Control Modes (8 hrs)**

Radiosurgery - Orthopedic Surgery - Urologic Surgery and Robotic Imaging - Cardiac Surgery – Neurosurgery – case studies.

Module 4: Rehabilitation (7 hrs)

Rehabilitation for Limbs - Brain-Machine Interfaces - Steerable Needles – case studies.

Module 5: Robots In Medical Care (7 hrs)

Assistive robots –types of assistive robots – case studies.

Module 6: Design of Medical Robots (8 hrs)

Characterization of gestures to the design of robots- Design methodologies- Technological choices - Security.

Text Books:

1. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, “Robot Modeling and Control”, Wiley Publishers, 2006.
2. Paula Gomes, "Medical robotics- Minimally Invasive surgery", Woodhead, 2012.

Reference Books:

1. AchimSchweikard, Floris Ernst, “Medical Robotics”, Springer, 2015.
2. Jocelyne Troccaz, “Medical Robotics”, Wiley-ISTE, 2012.
3. VanjaBonzovic, ”Medical Robotics”, I-tech Education publishing,Austria,2008.
4. Daniel Faust, “Medical Robots”, Rosen Publishers, 2016.
5. Jocelyne Troccaz, “Medical Robotics”, Wiley, 2013.

19RO2010	MACHINE LEARNING FOR ROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Understanding the concepts of machine learning
2. Study in detail about unsupervised learning, dimensionality concepts
3. Concepts of neural networks in robots with case studies.

Course Outcomes:

The Student will be able to

1. Discuss about the concepts of machine learning
2. Describe the types of trees and bias
3. Outline the supervised learning methods with various case studies
4. Compare the learning methodologies and dimensionality concepts
5. Summarize the applications of neural networks in robotic applications.
6. Illustrate the applications of machine learning using case studies.

Module 1: Introduction (7 hrs)

Machine learning – Varieties of Machine learning – Learning Input- Output functions: Types of learning – Input Vectors – Outputs – Training regimes – Noise – Performance Evaluation.

Module 2: Foundations Of Supervised Learning (7 hrs)

Decision trees and inductive bias – Geometry and nearest neighbors – Logistic regression – Perceptron – Binary classification.

Module 3: Advanced Supervised Learning (8 hrs)

Linear models and gradient descent – Support Vector machines – Naïve Bayes models and probabilistic modeling – Model selection and feature selection – Model Complexity and Regularization.

Module 4: Unsupervised Learning (8 hrs)

Curse of dimensionality, Dimensionality Reduction, PCA, Clustering – K-means – Expectation Maximization Algorithm – Mixtures of latent variable models – Supervised learning after clustering – Hierarchical clustering

Module 5: Neural Networks: (7 hrs)
Network Representation, Feed-forward Networks, Back propagation, Gradient-descent method.
Module 6: Case Studies: (8 hrs)
Line following using Supervised Learning techniques – A simulation model for understanding both regression and classification techniques - Study of the effectiveness of the Bias-variance. Obstacle avoidance and navigation of a mobile robot in an unknown environment with the help of Neural Network -Use of stochastic PCA and the PCA neural network to find low dimensional features. Building a feed-forward neural network to ascertain automatic navigational queries.

Text Books:

1. Michalski, Carbonell, Tom Mitchell, 'Machine Learning', Springer, 2014.
2. Peter Flach, 'Machine Learning: The Art and Science of Algorithms that make sense of data', Cambridge, 2014.

Reference Books:

1. Hal Daume III, 'A Course in Machine Learning', Todo, 2015.
2. EthemAlpaydin,'Introduction to Machine Learning',The MIT Press, 2004
3. David MacKay, 'Information Theory, Inference and Learning Algorithms', Cambridge, 2003
4. Bruno Apolloni, Ashish Ghosh, FerdaAlpasian, "Machine Learning and Robot Perception", Springer, 2005.
5. Judy Franklin, Tom Mitchell, SebastinThrun, "Recent Advances in Robot Learning: Machine Learning", Springer, 2012.

19RO2011	ROBOT OPERATING SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:
1. Introduce the basics of Robot Operating Systems and its architecture.
2. Provide knowledge on the hardware interfacing aspects.
3. Understand the applications of ROS in real world complex applications

Course Outcomes:
The Student will be able to
1. Describe the need for ROS and its significance
2. Summarize the Linux commands used in robotics
3. Discuss about the concepts behind navigation through file system.
4. Explain the concepts of Node debugging
5. Analyze the issues in hardware interfacing
6. Discuss about the applications of ROS

Module 1: Introduction to ROS: **(7 hrs)**
Introduction –The ROS Equation - History - distributions -difference from other meta-operating systems– services - ROS framework – operating system – releases.
Module 2: Introduction to Linux Commands (7 hrs)
UNIX commands - file system – redirection of input and output - File system security - Changing access rights – process commands – compiling, building and running commands – handling variables
Module 3: Architecture of Operating System (8 hrs)
File system - packages – stacks – messages – services – catkin workspace – working with catkin workspace – working with ROS navigation and listing commands
Module 4: Computation Graph Level (7hrs)
Navigation through file system -Understanding of Nodes – topics – services – messages – bags – master – parameter server.
Module 5: Debugging And Visualization (8 hrs)
Debugging of Nodes – topics – services – messages – bags – master – parameter – visualization using Gazebo – Rviz – URDF modeling – Xacro – launch files.
Hardware Interface: Sensor Interfacing – Sensor Drivers for ROS – Actuator Interfacing – Motor Drivers for ROS.
Module 6: Case Studies: **Using ROS In Real World Applications (8 hrs)**
Navigation stack-creating transforms -odometer – imu – laser scan – base controller – robot configuration – cost map – base local planner – global planner – localization – sending goals – TurtleBot – the low cost mobile robot.

Text Books:

1. Lentin Joseph, "Robot Operating Systems (ROS) for Absolute Beginners, Apress, 2018
2. Aaron Martinez, Enrique Fernández, "Learning ROS for Robotics Programming", Packt Publishing Ltd, 2013.

Reference Books:

1. Jason M O'Kane, "A Gentle Introduction to ROS", CreateSpace, 2013.
2. AnisKoubaa, "Robot Operating System (ROS) – The Complete Reference (Vol.3), Springer, 2018.
3. Kumar Bipin, "Robot Operating System Cookbook", Packt Publishing, 2018.
4. Wyatt Newman, "A Systematic Approach to learning Robot Programming with ROS", CRC Press, 2017.
5. Patrick Gabriel, "ROS by Example: A do it yourself guide to Robot Operating System", Lulu, 2012.

19RO2012	ARTIFICIAL INTELLIGENCE IN ROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Study the concepts of Artificial Intelligence.
2. Learn the methods of solving problems using Artificial Intelligence.
3. Introduce the concepts of Expert Systems and Machine learning.

Course Outcomes:

The Student will be able to

1. Identify problems that are amenable to solution by AI methods.
2. Identify appropriate AI methods to solve a given problem.
3. Formalize a given problem in the language/framework of different AI methods.
4. Summarize the learning methods adopted in AI.
5. Design and perform an empirical evaluation of different algorithms on a problem formalization.
6. Illustrate the applications of AI in Robotic Applications.

Module 1: Introduction (7 hrs)

History, state of the art, Need for AI in Robotics. Thinking and acting humanly, intelligent agents, structure of agents.

Module 2: Problem Solving (8 hrs)

Solving problems by searching –Informed search and exploration–Constraint satisfaction problems– Adversarial search, knowledge and reasoning–knowledge representation – first order logic.

Module 3: Planning (8 hrs)

Planning with forward and backward State space search – Partial order planning – Planning graphs– Planning with propositional logic – Planning and acting in real world.

Module 4: Reasoning (7hrs)

Uncertainty – Probabilistic reasoning–Filtering and prediction–Hidden Markov models–Kalman filters– Dynamic Bayesian Networks, Speech recognition, making decisions.

Module 5: Learning (8 hrs)

Forms of learning – Knowledge in learning – Statistical learning methods –reinforcement learning, communication, perceiving and acting, Probabilistic language processing, and perception.

Module 6: AI In Robotics (7 hrs)

Robotic perception, localization, mapping- configuring space, planning uncertain movements, dynamics and control of movement, Ethics and risks of artificial intelligence in robotics.

Text Books:

1. Stuart Russell, Peter Norvig, "Artificial Intelligence: A modern approach", Pearson Education, India, 2016.
2. Negnevitsky, M, "Artificial Intelligence: A guide to Intelligent Systems",. Harlow: AddisonWesley, 2002.

Reference Books:

1. David Jefferis, "Artificial Intelligence: Robotics and Machine Evolution", Crabtree Publishing Company, 1992.
2. Robin Murphy, Robin R. Murphy, Ronald C. Arkin, "Introduction to AI Robotics", MIT Press, 2000.
3. Francis.X.Govers, "Artificial Intelligence for Robotics", Packt Publishing, 2018.
4. Huimin Lu, Xing Lu, "Artificial Intelligence and Robotics", Springer, 2017.

5. Michael Brady, Gerhardt, Davidson, "Robotics and Artificial Intelligence", Springer, 2012.

19RO2013	INDUSTRIAL ENERGY MANAGEMENT SYSTEM	L	T	P	C
		3	0	0	3

Course Objectives:

1. Provide an overview of Energy Management System in Industry.
2. Gain understanding of the renewable sources.
3. Introduce the concepts of waste management in industry.

Course Outcomes:

The Student will be able to

1. Discuss the need for industrial energy balance
2. Describe the functioning of utility plants and renewable energy sources
3. Compare the various distribution systems.
4. Explain the functioning of equipment used in energy management.
5. Summarize the concept of energy recovery from waste and the need of automation.
6. Discuss about the use of computers in Energy Management.

Module 1: Introduction (7 hrs)

World Energy Resources - Industrial Energy Balance -Energy End users – Industrial Energy Consumption.

Module 2: Utility Plants and Renewable Sources (8 hrs)

Solar, wind, hydraulic, energy from waste – energy storage – applicability in industry – Electrical Sub Stations – Boiler Plants

Module 3: Distribution Systems (6 hrs)

Electric Distribution Systems – Thermal Distribution Systems **–** Co generation plants.

Module 4: Equipment Facilities (8 hrs)

Pumps and Fans – Air Compressors – Industrial Cooling Systems – Heat Exchangers.

Module 5: Waste Management (8 hrs)

Introduction – Energy Recovery from Waste – Waste and Energy Management Functions in Industry.

Module 6: Computers for Energy Management (8 hrs)

Introduction – Factory Functioning – Energy Saving – Control of Boiler Plants and Substations – Air compressor plan control.

Text Books:

1. Giovanni Petrecca, "Industrial Energy Management -Principles and applications", Kluwer Academic Publishers, 2016.
2. KaushikBhattacharjee, "Industrial Energy Management Strategies – Creating a Culture of Continuous Improvement", Fairmont Press, 2018.

Reference Books:

1. Zoran Morvay, DušanGvozdenac, " Applied Industrial Energy and Environment Management", John Wiley and Sons, 2008
2. Alan P Rossiter, Beth P Jones, "Energy Management and Efficiency for the Process Industries", Wiley, 2013.
3. Steve Doty, Wayne C Turner, "Energy Management Handbook", CRC Press, 2004.
4. David Thorpe, "Energy Management in Industry: The Earthscan Expert Guide", Taylor and Francis, 2013.
5. PatrikThollander, Jenny Palm, "Improving Energy Efficiency in Industrial Energy Systems", Springer, 2012.

19RO2014	ROBOTICS AND AUTOMATION IN FOOD INDUSTRY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To introduce the need for robotics and automation in food industry
2. Provide an overview of the sensors and gripper mechanisms for food sector.
3. Understanding the various applications of automation in food industry.

Course Outcomes:

The Student will be able to

1. Specify the characteristics of robots used in food industry.
2. Identify the applications of sensors in food industry.

3. Describe about the different types of gripper mechanisms
4. Describe the use of sensor networks and quality control in food sector
5. Discuss about the advanced methods for control of food process.
6. Summarize the applications of automation and robotics in food industry.

Module 1: Introduction (7 hrs)

Process Control Systems and Structure in the Food Industry – Process Control Methods – Robotics in the food industry – Automation – Specification for a food sector robot – future trends.

Module 2: Sensors and Automation (8 hrs)

Sensors for automated food process control – Special Considerations – Measurement Methods – Device Integration – Applications - Machine Vision- Optical Sensors – SCADA in food industry.

Module 3: Gripper Technology (8 hrs)

Gripper Challenges in food industry – Gripping Physics – Pinching and enclosing grippers – Penetrating Grippers – Suction Grippers – Surface Effect Grippers –Selection of appropriate gripping mechanism.

Module 4: Sensor Networks and Intelligent Quality Control Systems (8 hrs)

Wireless sensor networks – applications in agriculture and food production – future trends – intelligent control systems using fuzzy logic.

Module 5: Advanced Methods for control of food processes (7 hrs)

Introduction – Case Study of Bio conversion in a batch fed reactor – Design of PID Controller for fed batch process – Real time optimization.

Module 6: Applications (7 hrs)

Case Study – Bulk sorting – Food chilling and processing – meat processing – poultry industry –sea food processing – confectionary -

Text Books:

1. Darwin Caldwell, Robotics and Automation in the Food Industry – Current and Future Technologies" Woodhead Publishing, 2013.
2. Moore.C.A., "Automation in Food Industry", Springer, 2012.

Reference Books:

1. Selwyn Piramuthu and Wie Zhou "RFID and Sensor Network Automation in the Food Industry", Wiley Blackwell, 2016.
2. Luo Zongwei, "Robotics, Automation and Control in Industrial and Service Settings", Advances in Civil and Industrial Engineering, 2015.
3. Jonathan Love, "Process Automation Handbook: A Guide to Theory and Practice", Springer, 2007.
4. Fellows. P. J. "Food Processing Technology: Principles and Practice", Woodhead Publishing, 2009.
5. Mittal, "Computerized Control Systems in the Food Industry", Routledge, 2018.

19RO2015	NEURAL NETWORKS AND FUZZY SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Introduce the fundamentals of Neural Networks and its applications.
2. Provide an overview of deep learning and convolutional neural networks.
3. Gain understanding about the fundamentals of Fuzzy Logic and its applications

Course Outcomes:

The Student will be able to

1. Classify the types of neural networks.
2. Discuss about the applications of neural networks.
3. Describe the concepts of deep learning and convolutional neural networks
4. Compare fundamentals of classical logic and fuzzy logic concepts.
5. Characterize the fuzzy membership functions.
6. Summarize the applications of fuzzy logic controllers.

Module 1: Introduction to Neural Networks (7 hrs)

Differences between Biological and Artificial Neural Networks - Typical Architecture, Common Activation Functions, McCulloch - Pitts Neuron, Simple Neural Nets for Pattern Classification, Linear Separability - Hebb Net, Perceptron, Adaline, Madaline - Architecture, algorithm, and Simple Applications.

Module 2: Neural Network Applications (8 hrs)

Training Algorithms for Pattern Association - Hebb rule and Delta rule, Heteroassociative, Autoassociative and Iterative Auto associative Net, Bidirectional Associative Memory - Introduction to Neural Network Controllers

Module 3: Deep Learning and Convolution Neural Networks (8 hrs)

Evolution of deep learning – Impact of deep learning – Motivation for deep architecture – Applications – Deep Learning in Computer Vision – Convolutional Neural Networks – Popular CNN Architecture – Simple Applications.

Module 4: Classical and Fuzzy Sets and Relations (7 hrs)

Properties and Operations on Classical and Fuzzy Sets, Crisp and Fuzzy Relations - Cardinality, Properties and Operations, Composition, Tolerance and Equivalence Relations, Simple Problems.

Module 5: Membership Functions (8 hrs)

Features of membership function, Standard forms and Boundaries, fuzzification, membership value assignments, Fuzzy to Crisp Conversions, Defuzzification methods.

Module 6: Applications (7 hrs)

Neural Networks: Case Studies: Inverted Pendulum, CMAC, Robotics, Image compression, and Control systems - Fuzzy Logic: Mobile robot navigation, Autotuning a PID Controller.

Text Books:

1. Jacek M. Zurada, 'Introduction to Artificial Neural Systems', Jaico Publishing home, 2002.
2. Timothy J. Ross, 'Fuzzy Logic with Engineering Applications', Tata McGraw Hill, 2009.

Reference Books:

1. LaureneFausett, Englewood cliffs, N.J., 'Fundamentals of Neural Networks', Pearson Education, 2008.
2. Simon Haykin, 'Neural Networks', Pearson Education, 2003.
3. George.J.Klir, 'Fuzzy Sets and Fuzzy Logic – Theory and Applications', Pearson, 2015.
4. Rajasekaran, VijayalakshmiPai, "Neural Networks, Fuzzy Systems and Evolutionary Algorithms", PHI Learning, 2017.
5. Shigeo Abe, "Neural Networks and Fuzzy Systems", Springer, 2012.

19RO2016	MICROCONTROLLERS FOR ROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To impart basic knowledge about architecture of controller.
2. To get familiarized with the instruction sets in controller.
3. To explore the necessity of controller in real time applications.

Course Outcomes:

The Student will be able to

1. Describe the architecture of 8051 controllers
2. Classify different types of instruction set and addressing modes
3. Express their knowledge in designing a system using 8051
4. Discuss the general features of RISC architecture
5. Summarize the specific features of cortex controller
6. Develop interfacing program with controller

Module 1: The 8051 Architecture (8 hrs)

Internal Block Diagram - CPU - ALU - address - data and control bus - working registers - SFRs - Clock and RESET circuits - Stack and Stack Pointer - Program Counter - I/O ports - Memory Structures - Data and Program Memory - Timing diagrams and Execution Cycles. Comparison of 8-bit microcontrollers - 16-bit and 32-bit microcontrollers. Definition of embedded system and its characteristics - Role of microcontrollers in embedded Systems. Overview of the 8051 family.

Module 2: Instruction Set and Programming (8 hrs)

Addressing modes: Introduction - Instruction syntax - Data types - Subroutines Immediate addressing - Register addressing - Direct addressing - Indirect addressing - Relative addressing - Indexed addressing - Bit inherent addressing - bit direct addressing. 8051 Instruction set - Instruction timings. Data transfer instructions - Arithmetic instructions - Logical instructions - Branch instructions - Subroutine instructions - Bit manipulation instruction. Assembly language programs - C language programs. Assemblers and compilers. Programming and debugging tools.

Module 3: Memory and I/O Interfacing: (7 hrs)
Memory and I/O expansion buses - control signals - memory wait states. Interfacing of peripheral devices such as General Purpose I/O - ADC - DAC - timers - counters - memory devices. External Communication Interface (8 Hours) Synchronous and Asynchronous Communication. RS232 - SPI - I2C. Introduction and interfacing to protocols like Blue-tooth and Zig-bee.

Module 4: High Performance RISC Architecture: (8 hrs)
ARM 9 RISC architecture merits and demerits – The programmer's model of ARM Architecture – 3- stage pipeline ARM organization - 3-stage pipeline ARM organization – ARM instruction execution – Salient features of ARM instruction set

Module 5: High Performance Microcontroller Architectures: (8 hrs)
Introduction to the Cortex-M Processor Family - ARM 'Cortex-M4' architecture for microcontrollers – Thumb 2 instruction technology – Internal Registers - Nested Vectored Interrupt controller - Memory map - Interrupts and exception handling – Applications of Cotex-M4 architecture

Module 6: Applications: (6 hrs)
LED – LCD and keyboard interfacing. Stepper motor interfacing – DC Motor interfacing – sensor interfacing.

Text Books:

1. M. A.Mazidi, J. G. Mazidi and R. D. McKinlay, " The8051Microcontroller and Embedded Systems: Using Assembly and C" ,Pearson Education, 2007.
2. Joseph Yiu The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors, 3rd Edition, Kindle Edition, 2013

Reference Books:

1. K. J. Ayala, "8051 Microcontroller", Delmar Cengage Learning,2005.
2. R. Kamal, "Embedded System", McGraw Hill Education,2009.
3. R. S. Gaonkar, ", Microprocessor Architecture: Programming and Applications with the 8085" , Penram International Publishing, 1996
4. Steve Furber , "ARM System –On –Chip architecture", Addision Wesley, 2000.

19RO2017	MICROCONTROLLERS LABORATORY FOR ROBOTICS	L	T	P	C
		0	0	2	1

Course Objectives:
1. To enable the students to understand the programming techniques of Microcontrollers.
2. To design suitable sensor application using Microcontrollers.
3. To understand the concepts of peripherals

Course Outcomes:
The Student will be able to
1. Understand and apply the fundamentals of assembly level programming of Microcontroller.
2. Work with standard real time interfaces of Microcontroller.
3. Generate signals with Microcontroller.
4. Perform timer-based operation with Microcontroller.
5. Develop a motor control with Microcontroller.
6. Develop interfacing with sensor

List of Experiments
1. Arithmetic operations
2. Sorting of number
3. Concepts of timer
4. Interfacing I/O peripherals
5. Interfacing ADC
6. Interfacing DAC
7. PWM signal generation
8. Stepper motor interface
9. Interfacing keyboard and display unit
10. Interfacing temperature sensor
11. Interfacing accelerometer sensor
12. Interfacing servo motor

ROBOTICS AND AUTOMATION

LIST OF COURSES

S.No.	Course Code	Name of the Course	L:T:P	Credits
1.	18RO2001	Material Science	3:0:0	3
2.	18RO2002	Introduction to Mechanical Systems	3:0:0	3
3.	18RO2003	Automatic Control Systems	3:1:0	4
4.	18RO2004	Electrical Machines and Control Systems Laboratory	0:0:2	1
5.	18RO2005	Sensor Signal Conditioning Circuits	3:0:0	3
6.	18RO2006	Sensors and Protocols for Instrumentation	3:0:0	3
7.	18RO2007	Sensor Signal Conditioning Circuits Laboratory	0:0:2	1
8.	18RO2008	Robot Kinematics and Dynamics	3:0:0	3
9.	18RO2009	Vision Systems	3:0:0	3
10.	18RO2010	Programmable Logic Controllers	3:0:0	3
11.	18RO2011	Automation System Design	3:0:0	3
12.	18RO2012	PLC and Robotics Laboratory	0:0:2	1
13.	18RO2013	Totally Integrated Automation	3:0:0	3
14.	18RO2014	Totally Integrated Automation Laboratory	0:0:2	1
15.	18RO2015	Field and Service Robotics	3:0:0	3

18RO2001	MATERIAL SCIENCE	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on

1. Phase diagrams and alloys
2. Electric, Mechanical and Magnetic properties of materials
3. Advanced Materials used in engineering applications

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Describe the various phase diagrams and their applications
2. Explain the applications of Ferrous alloys
3. Discuss about the electrical properties of materials
4. Summarize the mechanical properties of materials and their measurement
5. Differentiate magnetic, dielectric and superconducting properties of materials
6. Describe the application of modern engineering materials

Module 1: Introduction: (6 Hours)

Historical perspective-Classification-Atomic Structure and Inter atomic Bonding –Structure of Crystalline solids- Phase diagrams

Module 2: Ferrous Alloys: (9 Hours)

The iron-carbon equilibrium diagram - phases, invariant reactions - microstructure of slowly cooled steels - eutectoid steel, hypo and hypereutectoid steels - effect of alloying elements on the Fe-C system - diffusion in solids - Fick's laws - phase transformations - T-T-T-diagram for eutectoid steel – pearlitic, baintic and martensitic transformations - tempering of martensite – steels – stainless steels – cast irons.

Module 3: Electrical Properties:(9 Hours)

Conducting materials-quantum free electron theory -Fermi Dirac Statistics-Band theory of solids - the density of states. Dielectrics - types of polarization-measurement of dielectric Permittivity - Loss factor- Dielectric loss mechanisms. Magnetostriction. Electron ballistics- materials for thermionic emission electron guns-electron gun for electron beam machining-electric discharge plasma - EDM machining.

Module 4: Mechanical Properties: (8 Hours)

Tensile test - plastic deformation mechanisms - slip and twinning - role of dislocations in slip - strengthening methods - strain hardening - refinement of the grain size - solid solution strengthening - precipitation hardening - creep resistance - creep curves - mechanisms of creep - creep-resistant materials - fracture - the Griffith criterion - critical stress intensity factor and its determination - fatigue failure - fatigue tests - methods of increasing fatigue life - hardness - Rockwell and Brinell hardness - Knoop and Vickers microhardness.

Module 5: Magnetic, Dielectric And Superconducting Materials: (8 Hours)
Ferromagnetism – domain theory – types of energy – hysteresis – hard and soft magnetic materials – ferrites - dielectric materials – types of polarization – Langevin-Debye equation – frequency effects on polarization - dielectric breakdown – insulating materials – Ferroelectric materials - superconducting materials and their properties.
Module 6: Advanced Materials: (5 Hours)
Liquid crystals-types-application as display devices-photonic crystals-ferroelastic materials-multiferroics, Bio mimetic materials. Composites-nanophase materials-physical properties and applications.

Text Books
1. Balasubramaniam, R. "Callister's Materials Science and Engineering". Wiley India Pvt. Ltd., 2014.
2. Raghavan, V. "Physical Metallurgy: Principles and Practice". PHI Learning, 2015.

Reference Books
1. William D CallisterJr, "Materials Science and Engineering-An Introduction", John Wiley and Sons Inc., Sixth Edition, New York,2010.
2. Raghavan, V. "Materials Science and Engineering : A First course". PHI Learning, 2015
3. Shetty.M.N., "Material Science and Engineering – Problems with Solutions", PHI, 2016
4. Shaffer J P, Saxena A, Antolovich S D, Sanders T H Jr and Warner S B, "The Science and Design of Engineering Materials", McGraw Hill Companies Inc., New York, 1999.

18RO2002	INTRODUCTION TO MECHANICAL SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:
To impart knowledge on
1. The fundamentals of thermal, fluid mechanics and mechanical systems.
2. Air standard cycles of thermal systems
3. The basic static and dynamic concepts of the real world problem

Course Outcomes:
At the end of this course, students will demonstrate the ability to
1. Recall the fundamentals of systems
2. State the laws of thermodynamics
3. Describe the air standard cycles and their significance
4. Discuss about the principles of fluid mechanics
5. Construct free body diagrams to analyze static equilibrium
6. Apply the knowledge of Dynamics in Mechanical System Design

Module 1: Basic Concepts: (8 Hours)
Concept of continuum, macroscopic approach, Thermodynamic systems - closed, open and isolated. Property, state, path and process, quasistatic process, work, modes of work. Zeroth law of thermodynamics, concept of temperature and heat. Concept of ideal and real gases.
Module 2:Thermodynamics: (8 Hours)
Heat and work – Boyle's law and Charles law – specific heat and latent heat – system and surrounding – internal energy. First law of thermodynamics – Work done and heat transfer of Gas processes: Constant volume, Constant pressure, Isothermal, Adiabatic and Polytropic.
Module 3: Air Standard Cycles: (6 Hours)
Second law of thermodynamics – Air standard cycles: Carnot cycle, Otto cycle and Diesel cycle.
Module 4: Fluid Mechanics: (8 Hours)
Archimedes principle, buoyancy - Hydrostatic pressure – Manometry – Hydrostatic forces on immersed plane and curved surfaces – Hydrodynamics – Reynold's experiment – law of continuity-law of conservation of energy – Bernoulli's equation.
Module 5: Statics: (8 Hours)
Equilibrium – Forces in equilibrium – free body diagram – moment and couple – Equilibrium of a rigid body – Simple beams – distributed forces – Center of gravity and Centroid.
Module 6: Dynamics: (7 Hours)
Kinematics – Uniform acceleration – Motion under gravity – Angular motion – Motion due to forces – Work, energy, power and momentum.

Text Books:
1. BasantAgrawal, C.M. Agrawal, "Basic Mechanical Engineering", Wiley India, 2008.

2. Rajasekaran S and Sankarasubramanian G, “Engineering Mechanics – Statics and Dynamics”, Vikas Publishing House Pvt Ltd, New Delhi, 2006.

Reference Books:

1. Merle C. Potter, Elaine Patricia Scott, Thermal Sciences: An Introduction to Thermodynamics, Fluid Mechanics, and Heat Transfer”, Thomson Brookes, 2004.
2. Dubey.N.H.,” Engineering Mechanics – Statics and Dynamics”, Tata McGrawHill Education Pvt. Ltd., 2013.
3. Rajput.R.K., “Basic Mechanical Engineering”, Laxmi Publications, 2008.
4. Hibbeler.R.C., Ashok Gupta,” Engineering Mechanics – Statics and Dynamics”, PHI, 2010.

18RO2003	AUTOMATIC CONTROL SYSTEMS	L	T	P	C
		3	1	0	4

Course Objective:

To impart knowledge on

1. Linear models mainly state variable model and Transfer function model from Non Linear systems.
2. Linear systems in time domain and frequency domain.
3. Applications of Advanced control theory to practical engineering problems.

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Develop mathematical models of control components and physical systems
2. Analyze the time domain responses of LTI systems and determine transient/steady state time response related performance goals.
3. Derive equivalent differential equation, transfer function and state space model for a given system.
4. Examine the frequency domain specifications of the LTI systems
5. Evaluate stability of the linear systems with respect to time domain
6. Investigate the stability of systems based on frequency domain by using different techniques.

Module 1: Introduction: (8 Hours)

Components of Automatic control systems- Open loop and closed loop systems - Examples - Transfer function - Modeling of physical systems – Mechanical Systems - Translational and Rotational systems, Thermal, Hydraulic systems and Electrical Systems - Transfer function of DC servomotor, AC servomotor, Potentiometer, Tacho-generator, Stepper motor - Block diagram - reduction techniques, Signal flow graph – Mason’s gain formula.

Module 2: Time Domain Analysis: (8 Hours)

Continuous time signals, Standard Test signals, Classification of continuous time systems – Linear-Nonlinear – Time variant – Time invariant – Static – Dynamic, Time response of second order system - Time domain specifications - Types of systems - Steady state error constants -Generalized error series, Introduction to P, PI and PID modes of feedback control.

Module 3: State Space Analysis: (8 Hours)

Limitations of conventional control theory - Concepts of state, state variables and state model – state model for linear time invariant systems - Introduction to state space representation using physical - Phase and canonical variables- State equations – Transfer function from the State model – Solutions of the state equations -State Transition Matrix-Concepts of controllability and observability.

Module 4: Frequency Response Of Systems: (8 Hours)

Frequency domain specifications – Estimation for second order systems-Correlation between time and frequency domain specifications for second order systems.

Module 5: System Stability: (8 Hours)

Concept of stability – stability & location of the poles in S-plane - Characteristic equation, Routh-Hurwitz stability criterion, Root Locus concepts- Construction of root locus – Root contours, Absolute and Relative stability - Nyquist stability - Nyquist stability criterion - Assessment of relative stability – Gain and Phase Margin.

Module 6: Frequency Domain Analysis: (5 Hours)

Bode plot –Determination of Transfer Function from Bode plot - All pass minimum phase and non-minimum phase systems - Polar plot -Determination of gain and phase Margins from the plots.

Text books:

1. Smarajit Ghosh, “Control Systems Theory and Applications”, 2nd Edition, Pearson Education, New Delhi, 2012.
2. Ogata K, "Modern Control Engineering", 5th Edition, Pearson Education, New Delhi, 2009.

Reference Books:

1. Nagrath I J, and Gopal M, 'Control Systems Engineering", 5th Edition, Prentice Hall of India, New Delhi, 2008.
2. Richard C Dorf and Robert H Bishop, "Modern Control Systems", 12th Edition, Addison-Wesley, New Delhi, 2010.
3. Norman S Nise, "Control System Engineering", 6th Edition, John Wiley & Sons, Singapore, 2012.
4. S Palani,"Control Systems Engineering", 2nd Edition, McGraw Hill Education Pvt. Ltd, New Delhi, 2010.

18RO2004	ELECTRICAL MACHINES AND CONTROL SYSTEMS LABORATORY	L	T	P	C
		0	0	2	1

Course Objectives:

To impart knowledge on

1. The Characteristics of DC and AC Machines and power systems
2. Modeling and Control of various systems
3. Time domain and Frequency domain analysis of system models

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Obtain the characteristics of DC shunt and series motor
2. Perform experiment on electrical braking techniques in three-phase induction motor.
3. Conduct load test on three-phase induction motor and BLDC motor
4. Summarize the operations in a power system and develop single line diagram for a typical power system.
5. Determine the transfer function of AC and DC Servomotor
6. Study time domain and frequency domain response of a servo system along with the characteristics of PID Controllers of an industrial robot using MATLAB

Electrical Machines

1. Load Characteristics of DC Series and Shunt Motor.
2. Load Test on three-phase Induction Motor.
3. Load Test on Single Phase Transformer
4. Electrical Braking of three-phase Induction Motor.
5. Load Test on BLDC Motor.
6. Study of typical Power system and developing Single Line Diagram.

Control Systems:

1. Modeling of First Order Systems using NI Elvis
2. Determination of transfer functions of DC & AC servomotor.
3. Speed and Position control of DC motor
4. Stepper Motor Control using LabVIEW
5. Characteristics of PIDcontrollers using MATLAB.
6. Simulation of Robot Arm control in Matlab

18RO2005	SENSOR SIGNAL CONDITIONING CIRCUITS	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on

1. Basics concepts for selection of sensors and the signal conditioning necessary to include these in a data acquisition system.
2. Analog to digital and digital to analog conversion principles and their practical applications for data acquisition and control.
3. Selection of output drivers and devices

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Define the characteristics of operational amplifiers
2. Describe the linear applications of op-amp
3. Design circuits for non-linear applications of op-amp
4. Apply the knowledge of special ICs like IC 555 to design circuits
5. Discuss about the types of ADCs and DACs
6. Analyze the parameters to be considered for interfacing.

Module 1: Operational Amplifier Characteristics:(8 Hours)
Functional Block Diagram – Circuit symbol, Pin Configuration – The ideal OPAMP - Open loop gain, Inverting and Non-inverting amplifiers, Voltage follower, Differential amplifier, CMRR, slew rate – DC Characteristics - AC Characteristics.

Module 2: Linear Applications Of Op-Amp: (8 Hours)
Summing amplifier, Subtractor, Integrator and Differentiator – Analog PID Controllers -V-I and I-V converters, Sinusoidal oscillators - Active filters: Design of low pass and high pass filters**,** Instrumentation Amplifiers, Charge Amplifiers.

Module 3: Nonlinear Applications Of Op-Amp :(7 Hours)
Comparator – Regenerative comparator, Zero crossing detector, Window detector, Sample and hold circuit, Rectifiers, Clipper and Clamper, Logarithmic and Exponential amplifiers, Multiplier and Divider, Square and Triangular waveform generators

Module 4: Special Function ICs(8 Hours)
Block diagram of 723 general purpose voltage regulator- Fixed and adjustable three terminal regulators -555 Timer Functional block diagram and description – Monostable and Astable operation, Applications, 566 Voltage Controlled Oscillator. PLL Functional Block diagram – Principle of operation, Applications: Frequency synthesis, DC Motor speed control.

Module 5: A-D And D-A Converters: **(7 Hours)**
DAC/ADC performance characteristics – Digital to Analog Converters: Binary weighted and R-2R Ladder types – Analog to digital converters: Continuous, Counter ramp, Successive approximation, ADC specifications, resolution, accuracy, linearity, offset and quantization errors, sample rate and aliasing, line drivers and receivers, high power output drivers and devices, multi-channel ADCs, internal microcontroller ADCs,

Module 6: Interfacing and Data Acquisition Systems: (7 Hours)
Grounding Conflict, Ground Loops, Cross Talk, Shielded Wiring, Isolation, Linearization, Circuit protection, Impedance Matching, Parameters of Data Acquisition Systems such as dynamic range, calibration, bandwidth, processor throughput, time-based measurements and jitter-System Architecture, Case Studies

Text Books:

1. Gayakwad A R,"OP-Amps and Linear Integrated circuits", Pearson Education, New Delhi, 2004.
2. Frederick F. Driscoll, Operational Amplifier and Linear Integrated Circuits, PHI,2001
3. Bentley, John P. Principles of Measurement Systems, 4:th edition, Pearson/Prentice Hall, 2005.

Reference Books:

1. A. S. Sedra and K. C. Smith, "Microelectronic Circuits", New York, Oxford University Press, 1998.
2. Jacob Fraden, Handbook of Modern Sensors – Physics, Design and Applications, Fourth Edition, Springer, 2010.
3. Data Acquistion Handbook, A Reference for DAQ and analog and digital signal conditioning, 3rd Edition,
4. Coughlin F R, and Driscoll F F, "Operational Amplifiers and Linear Integrated Circuits", Prentice Hall of India, New Delhi, 1997.
5. Roy Choudhury and Shail Jain, "Linear Integrated Circuits", New Age International Limited, 2003.

18RO2006	SENSORS AND PROTOCOLS FOR INSTRUMENATION	L	T	P	C
		3	0	0	3

Course Objectives:
To impart knowledge on
1. The basics of measuring system and classify the types of error
2. Selection of the appropriate sensor for measuring various physical quantities
3. Different communication protocols

Course Outcomes:
At the end of the course, the student will demonstrate the ability to:
1. Classify the types of errors in measurement system and identify the types of sensors
2. Explain the principle and working of temperature, pressure and flow sensors.
3. Identify and apply appropriate sensor for measurement of displacement and velocity.
4. Apply various sensors for designing and building robots

5. Describe the functions of different communication protocols
6. Compare the various wireless communication protocols

Module 1: Measuring System: **(5 Hours)**

Sensor Systems – Classification of sensors: Factors in making the measurements-accuracy, precision, resolution, repeatability, reproducibility, hysteresis, sensitivity, range, selection and standard of sensors – SI Units – Base units of SI - Errors in Measurement – Types of errors – Calibration techniques.

Module 2: Temperature, Pressure and Flow Measurement:(10 Hours)

Temperature Measurement: Terminology,Bimetallic thermometer, Resistance Temperature Detectors, Thermistors, Thermocouples, Integrated circuit temperature transducers. Pressure Measurement: Resistive, Capacitance, Piezoelectric transducer, Flow and Level Measurement: Venturi flow meters, Electro-Magnetic flow meter- Level Measurement Techniques.

Module 3: Displacement & Velocity Measurement: **(8 Hours)**

Linear and angular measurement systems – Resistance potentiometer, strain gauge, capacitive transducers and variable inductance transducers, resolvers, LVDT, proximity sensors, ultrasonic and photo-electric sensors - linear scales, Laser Interferometers, tacho-generator, Encoders: absolute and incremental.

Module 4: Miscellaneous Sensors: (6 Hours)

Measurement of vibration, Tactile sensors: force, torque, pressure, Gyroscope, Vision based sensors. Case Study: Integrating and applying sensors to make a meaningful and understood design of robotic arm for different applications.

Module 5: Instrumentation Protocols: (8 Hours)

Modern instrumentation and control systems – OSI model – Protocols – Standards Grounding/shielding and noise - EIA-232&485 interface standard –Current loop and EIA-485 converters, Fibre optic cable components and parameters, CAN, Modbus, Profibus, Ethernet.

Module 6: Wireless Communication: (8 Hours)

Radio spectrum – Frequency allocation – Radio modem – RFID: Basic principles of radio frequency identification – Transponders – Interrogators, Wireless HART. Applications: Automotive communication technologies – Design of automotive X-by-Wire systems, - The LIN standard.

Text Books:

1. Peter Elgar,"Sensors for Measurement and Control", Addison-Wesley Longman Ltd, 1998.
2. Patranabis D, "Sensors and T1ransducers", Prentice-Hall of India Private Limited, New Delhi, 2003.
3. Steve Mackay, Edwin Wright, Deon Reynders and John Park, "Practical Industrial Data Networks: Design, Installation and Troubleshooting", Newnes (Elsevier), 2004.

Reference Books:

1. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering: An Integrated Approach", PHI Learning, New Delhi, 2009.
2. Ernest O Doebelin, "Measurement systems Application and Design", Tata McGraw-Hill Book Company, 2010
3. A.K.Sawhney, "Electrical & Electronic Measurement & Instruments", Dhanpat Rai& Co., 2010.
4. Practical Field bus, Device Net and Ethernet for Industry, IDC Technology, 2006
5. Dominique Paret, "Multiplexed Networks for Embedded Systems", John Wiley & Sons, 2007.

18RO2007	SENSOR SIGNAL CONDITIONING CIRCUITS LABORATORY	L	T	P	C
		0	0	2	1

Course Objective:

To impart knowledge on

1. The characteristics of operational amplifier
2. Applications of operational amplifier
3. Sensor Interfacing and the concepts involved.

Course Outcome:

At the end of the course, the student will demonstrate the ability to:

1. Interpret the characteristics of an operational amplifier
2. Implement simple circuits using operational amplifier
3. Design Analog PID controllers
4. Develop practical circuits for measurement.

5. Design Multivibrator circuits for a specific application
6. Analyze the effect of ADC parameters in Sensor Interfacing

List of Experiments:

1. Determination of Characteristics of Op-amp
2. Inverting and Non-Inverting Amplifier, Adder, Subtractor, Comparator using op-amp
3. Differentiator, Integrator using op-amp
4. Analog PID controller Design using Op-amp
5. Multivibrator Circuit Design using Op-amp
6. Design of A/D and D/A converter
7. Strain Gauge Measurement set up using Wheatstone Bridge Circuit
8. Design of Instrumentation Amplifier using Op-amp
9. Analyzing the effect of ADC Resolution, Range and Sampling rate
10. PWM signal generation for motor control

18RO2008	ROBOT KINEMATICS AND DYNAMCIS	L	T	P	C
		3	0	0	3

Course objectives:

To impart knowledge on

1. The principles of vision system and image processing
2. Applications of vision system in modern manufacturing environment
3. Robotic Operating System and OpenCV

Course outcomes:

At the end of the course, the student will demonstrate the ability to:

1. Select and classify various robotic systems
2. Utilize kinematics analysis of robotic manipulators
3. Perform Workspace analysis of a Robotic System
4. Describe the Differential Motion and Statics of robotic manipulators
5. Describe the construction of robotic manipulators and analyze dynamics and force of robotic manipulators
6. Plan off-line Robot trajectories to meet desired End-Effector tasks

Module 1: Introduction: (6 Hours)

Historical Perspective-Specifications of Robots- Classifications of robots – Work envelope - Flexible automation versus Robotic technology – Applications of Robots.

Module 2: Direct & Inverse Kinematics:(8 Hours)

Dot and cross products, Co-ordinate frames, Rotations, Homogeneous Coordinates, Link coordinates, D-H Representation, Arm equation -Two axis, three axis, four axis, five axis and six axisrobots. Inverse Kinematic problem, General properties of solutions, Tool configuration, Inverse Kinematics of Two axis Three axis, Four axis and Five axis robots.

Module 3: Workspace Analysis: (8 Hours) Workspace analysis of Four axis, Five axis and Six axis robots, Perspective transformation, structured illumination, Camera calibration, Work envelope of Four and Five axis robots, Workspace fixtures.

Module 4: Differential Motion And Statics: **(8 Hours)**

The tool Configuration jacobian matrix for three axis and, four axis robots, joint space singularities, resolved motion rate control, manipulator jacobian for three and four axis joint space singularities, induced joint torques and forces.

Module 5: Dynamic Analysis And Forces:(8 Hours)

Introduction, Langrangian mechanics, Effects of moments of Inertia, Dynamic equation for two axis planar articulated robot.

Module 6: Trajectory Planning :**(7 Hours)**

Trajectory planning, Pick and place operations, Continuous path motion, Interpolated motion, Straight-line motion.

Text books:

1. Robert J. Schilling, “Fundamentals of Robotics Analysis and Control”, PHI Learning, 2009.
2. Niku S B, “Introduction to Robotics, Analysis, Systems, Applications”, Prentice Hall, 2001.

References:

1. John J Craig, “Introduction to Robotics”, Pearson, 2009.
2. Deb S R and Deb S, “Robotics Technology and Flexible Automation”, Tata McGraw Hill Education Pvt. Ltd, 2010.

3. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India P Ltd., 2006.
4. Saha S K, “Introduction to Robotics”, Tata McGraw Hill Education Pvt. Ltd, 2010.

18RO2009	VISION SYSTEMS	L	T	P	C
		3	0	0	3

Course objectives:

To impart knowledge on

1. The principles of vision system and image processing
2. Applications of vision system in modern manufacturing environment
3. Concepts of Robotic Operating System and OpenCV

Course outcomes:

At the end of the course, the student will demonstrate the ability to:

1. Describe the basic components of specific visual system
2. Discuss the effect of low level vision algorithms
3. Explain the use of high level vision algorithms for specific purpose
4. Assess the identification of objects using a specified technique
5. Explain the applications of vision and tracking algorithms
6. Discuss the basics of ROS and OpenCV for Robotic vision

Module 1: Vision System: (6 Hours)

Basic Components - Elements of visual perception: structure of human eye, image formation in the eye – pinhole cameras - color cameras – image formation model – imaging components and illumination techniques - picture coding – basic relationship between pixels - Camera-Computer interfaces.

Module 2: Low Level Vision Algorithms: (7 Hours)

Image representation – gray level transformations, Histogram equalization, image subtraction, image averaging – Filters: smoothing spatial filters, sharpening spatial filters, smoothing frequency domain filters, sharpening frequency domain filters - edge detection

Module 3: High Level Vision Algorithms: (6 Hours)

Segmentation: Edge linking and boundary detection, Thresholding, Region-oriented segmentation, the use of motion – Description: Boundary Descriptors, Regional Descriptors, Recognition: Decision-Theoretic methods, structural methods.

Module 4: Object Recognition: (8 Hours)

Object recognition, Approaches to Object Recognition, Recognition by combination of views – objects with sharp edges, using two views only, using a single view, use of dept values

Module 5: Applications: (9 Hours)

Camera Calibration - Stereo Imaging - Transforming sensor reading, Mapping Sonar Data, Aligning laser scan measurements - Vision and Tracking: Following the road, Iconic image processing, Multiscale image processing, Video Tracking - Learning landmarks: Landmark spatiograms, K-means Clustering, EM Clustering, Kalman Filtering.

Module 6: Robot Vision: (9 Hours)

Basic introduction to Robotic operating System (ROS) - Real and Simulated Robots - Introduction to OpenCV, Open NI and PCL, installing and testing ROS camera Drivers, ROS to OpenCV – The cv_bridge Package

Text books:

1. Carsten Steger, Markus Ulrich, Christian Wiedemann, “Machine Vision Algorithms and Applications”, WILEY-VCH, Weinheim,2008.
2. Damian m Lyons,“Cluster Computing for Robotics and Computer Vision”, World Scientific, Singapore, 2011.

References Books:

1. Rafael C. Gonzalez and Richard E.woods, “Digital Image Processing”, Addition – Wesley Publishing Company, New Delhi, 2007.
2. Shimon Ullman, “High-Level Vision: Object recognition and Visual Cognition”, A Bradford Book, USA, 2000.
3. R.Patrick Goebel, “ ROS by Example: A Do-It-Yourself Guide to Robot Operating System – Volume I”, A Pi Robot Production, 2012.
4. Bernd Jahne, “Digital Image Processing”, Springer Publication, 2013.

18RO2010	PROGRAMMABLE LOGIC CONTROLLERS	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on

1. The fundamentals of Automation.
2. The concept of PLC and its Programming using Ladder Diagram.
3. The basics of HMI and Installations in PLC.

Course Outcomes:

At the end of the course, the student will demonstrate the ability to:

1. Identify and understand the automation concepts for Industries.
2. Apply PLC architecture knowledge to select PLC for specific problems.
3. Use PLC Ladder diagram for simple applications
4. Design real time application using PLC.
5. Create prototype for the real time application Using PLC,with HMI
6. Recognize the faults and identify the protocol to be used for the applications

Module 1: Introduction To Factory Automation : (7 Hours)

History and developments in industrial automation. Vertical integration of industrial automation, Control elements in industrial automation, PLC introduction.

Module 2: Programmable Logic Controllers : (8 Hours)

Basics of PLC, Advantages, Capabilities of PLC, Architecture of PLC, Scan cycle, Types of PLC, Types of I/O modules, Power supplies and isolators, configuring a PLC, PLC wiring.

Module 3: Programming Of PLC: (8 Hours)

General PLC programming procedures - Types of Programming -Programming on-off inputs/outputs- Simple process control programs using Relay Ladder Logic - Auxiliary commands and functions – PLC Basic Functions - Register basics - Timer functions – Counter.

Module 4: PLC Intermediate Functions: (8 Hours)

PLC intermediate functions: Arithmetic functions, Comparison functions, Skip and MCR functions, Data move systems - PLC Advanced intermediate functions: Utilizing digital bits, Sequencer functions, Matrix functions – PLC Advanced functions: Alternate programming languages, Analog PLC operation,

Module 5: HMI Systems: (8 Hours)

Necessity and Role in Industrial Automation, Text display - operator panels - Touch panels – Panel PCs - Integrated displays, interfacing PLC to HMI.

Module 6: Installation: (6 Hours)

Installation and maintenance procedures for PLC - Troubleshooting of PLC, PLC Networking- Networking standards & IEEE Standard - Protocols - Field bus - Process bus and Ethernet. Case studies

Text books:

1. John W Webb & Ronald A Reis, “Programmable logic controllers: Principles and Applications”, Prentice Hall India, 2003.
2. Frank D Petruzella “Programmable Logic Controllers ", McGraw Hill Inc, 2005

Reference Books:

1. Bolton W. , “Mechatronics”, Pearson Education, 2009
2. Kelvin T Erikson, “Programmable Logic Controllers ", Dogwood Valley Press, 2005.
3. Garry Dunning, “Introduction to Programmable Logic Controllers”, Thomson Delmar Learning, 2005.
4. Khalid Kamel, Eman Kamel, “Programmable Logic Controllers”, McGrawhill, 2013.

18RO2011	AUTOMATION SYSTEM DESIGN	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on

1. The fundamentals of various microelectronic systems.
2. The concepts related to automation components.
3. Automated system development with integration of multiple systems.

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Specify the automation elements and requirements.

2. Select the appropriate precision motion components based on the application.
3. Analyze the motion control with more precise arrangements
4. Describe the basic design considerations of material handling equipment.
5. Design and select a belt conveyor for real world applications.
6. Analyze the integrating automation components.

Module 1: Introduction: (7 Hours)

Integrated design issues in automation systems, the Mechatronics design process- benefits, modeling of electromechanical systems, building blocks of automation systems.

Module 2: Motion Control in Automation: (8 Hours)

Selection of motor for automation system, sizing of servo motor for a specific application, importance of sizing, selection of mechanical components, load cycle definition, load inertia and torque calculations, selection of motors.

Module 3: Precision Motion Components: (8 Hours)

LM Guide ways, Ball screws, bearings, Types, Selection, from the manufacturer's catalogue based on the applications, fixing arrangements and assembly

Module 4: Material Handling Systems:(8 Hours)

Overview of material handling equipment, AGVs, ASRS, grippers-types- design -selection, considerations in material handling system design, principles of material handling.

Module 5: Belt Conveyors: (8 Hours)

Information required for designing , angle of incline, belt conveyor elements, selection of belt, drive, greasing of idlers, Plow Vs Trippers, magnetic pulley, skirt boards, training of belt conveyors, weighing material in motion, shuttle belt conveyor, pinion –swivel arrangement, troughing, suspended idlers, belt cleaners, transfer of material from belt to belt, cover, safety protection at pulleys, belt speeds and widths, design of a belt conveyor, belt conveyor calculation, minimum pulley diameters, enclosures for conveyors, idler selection, conveyor belt troubles.

Module 6: System Integration: (6 Hours)

Issues and systematic approaches, case study- integration of machine tending robot with a CNC machine, design and simulation using CIROS software, economics of automation systems design and implementation.

Text books:

1. Mikell P Groover, "Automation Production Systems and Computer Integrated Manufacturing", Pearson education, New Delhi, 2001.
2. Jacob Fruchtbaum, "Bulk Materials Handling Handbook", CBS Publishers & Distributors, New Delhi, 1997.

Reference Books:

1. Devadas Shetty, "Mechatronics System design", PWS Publishing Company, USA 2010.
2. Wilfried Voss,"A comprehensible Guide to servo motor sizing", Copperhill Technologies Corporation.
3. Conveyor Equipment Manufacturers Association, "Belt Conveyors for Bulk Materials", CBI Publishing Company, Massachusetts, 1979.
4. HIWIN Linear Guideway – Technical Information Index.

18RO2012	PLC AND ROBOTICS LABORATORY	L	T	P	C
		0	0	2	1

Course Objectives:

To impart knowledge on

1. Developing automation systems using PLC
2. The drive systems used in Industrial applications
3. Simulation Software for Industrial Robots

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Develop Ladder diagrams for PLC Programming
2. Work with simple Automation Systems using PLC
3. Analyze Forward and Inverse Kinematics for Basic Robots
4. Programming and Analysis of Industrial Robots using Software
5. Visualize the configurations of various types of robots.
6. Describe the components of robots like arms, linkages, drive systems and end effectors.

Hands on Experiments related to Course Contents in Robotics

18RO2013	TOTALLY INTEGRATED AUTOMATION	L 3	T 0	P 0	C 3

Course Objectives:

To impart knowledge on

1. Various automation needs of the industries.
2. Fundamental concepts of SCADA Systems
3. The utility of Distributed Control Systems.

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Outline the selection, and application of various TIA control elements
2. Discuss the configuration of SCADA functionalities with Tags, Screens, and Trends
3. Compare various communication protocols for automation system
4. Identify and differentiate various sub systems of DCS
5. Describe various functions of Interfaces in DCS.
6. Analyze and design an appropriate system for the industrial applications.

Module 1: Totally Integrated Automation: (7 Hours)

Need, components of TIA systems, advantages, Programmable Automation Controllers (PAC), Vertical Integration structure. Necessity and Role in Industrial Automation, Need for HMI systems. Types of HMI.

Module 2: Supervisory Control and Data Acquisition (SCADA): (8 Hours)

Overview – Developer and runtime packages – architecture – Tools – Tag – Internal &External graphics, Alarm logging – Tag logging – structured tags– Trends – history– Report generation, VB & C Scripts for SCADA application.

Module 3: Communication Protocols of SCADA: (8 Hours) Proprietary and open Protocols – OLE/OPC – DDE – Server/Client Configuration – Messaging – Recipe – User administration – Interfacing of SCADA with PLC, drive, and other field device

Module 4: Distributed Control Systems (DCS): (8 Hours)

Introduction : DCS Evolution, DCS Architecture, Comparison – Local Control unit – Process Interfacing Issues – Redundancy concept - Communication facilities.

Module 5: Interfaces in DCS: (8 Hours)

Operator interfaces: low level, high level – Operator Displays – Engineering Interfaces: Low level, high level – General purpose computers in DCS

Module 6: Industrial Plant Design: (6 Hours)

Design criteria – Process sequencing - Plant layout modeling – Selection of industrial power and automation cables, Overview of plant simulation software.

Text Books:

1. John.W.Webb & Ronald A. Reis, "Programmable logic controllers: Principles and Applications", Prentice Hall India, 2003.
2. David Bailey, Edwin Bright, "Practical SCADA for industry", Newnes, Burlington, 2003.
3. Gordon Clarke, Deon Reyneders,Edwin Wright, "Practical Modern SCADA Protocols: DNP3, 60870.5 and Related systems", Newnes Publishing, 2004.
4. Michael P. Lukas, "Distributed Control systems", "Van Nostrand Reinfold company"1995

Reference Books:

1. Win C C Software Manual, Siemens, 2003
2. RS VIEW 32 Software Manual, Allen Bradly, 2005
3. CIMPLICITY SCADA Packages Manual, Fanuc India Ltd, 2004
4. William T Shaw, "Cybersecurity for SCADA systems", PennWell, 2006.
5. Stuart G McCrady, "Designing SCADA Application Software", Elsevier, 2013.
6. SIMATIC STEP 7 in the Totally Integrated Automation Portal", SIEMENS AG, 2012.

18RO2014	TOTALLY INTEGRATED AUTOMATION LABORATORY	L 0	T 0	P 2	C 1

Course Objectives:

To impart knowledge on

1. Fundamentals of PAC
2. Concepts of HMI and SCADA
3. Applications of DCS in Process Automation

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Design and development of logical programs for control, safety, and monitoring
2. Acquire skills in programming PACs
3. Acquiring knowledge in SCADA and interfacing SCADA with PLC and PCs
4. Apply knowledge of HMIs in Automation Systems.
5. Perform Configuration and simulation of robotic systems for Automation
6. Develop Automation systems using DCS

Hands-on Experiments related to Course Contents in Totally Integrated Automation

18RO2015	FIELD AND SERVICE ROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on

1. The applications and current trend in field and service robot
2. Path planning algorithms inside a field/service robot for navigation
3. Interaction interface concepts for humanoid robot

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Describe the applications and current trend in field and service robot
2. Explain about the kinematic modeling of mobile robots
3. Identify, formulate and solve algorithm related to localization, obstacle avoidance, and mapping
4. Apply and program robot for reactive concepts for robot interaction with human, between machines and among robots
5. Analyze the concepts of balancing legged robots and interaction interface concepts for humanoid robot
6. Implement path planning algorithms inside a field/service robot for navigation

Module 1: Introduction : (8 Hours)

History of service robotics – Present status and future trends – Need for service robots - applications-examples and Specifications of service and field Robots.Non conventional Industrial robots.

Module 2: Robot Kinematics: (7 Hours)

Kinematic Models and Constraints – Maneuverability – Workspace – Control

Module 3: Localization: (8 Hours)

Introduction - Bayes filter – Kalman Filter – Extended Kalman Filter - Information Filter - Histogram Filter - Particle Filter – Challenges of Localization- Map Representation- Probabilistic Map based Localization-Monte carlo localization Landmark based navigation-Globally unique localization-Positioning beacon systems- Route based localization.

Module 4: Mapping(6 Hours)

Metrical maps - Grid maps - Sector maps – Hybrid Maps – SLAM.

Module 5: Planning And Navigation: **(8 Hours)**

Introduction-Path planning overview- Global path planning – A* Algorithm - local path planning - Road map path planning- Cell decomposition path planning-Potential field path planning-Obstacle avoidance – Path control.

Module 6: Humanoids: (8 Hours) Wheeled and legged, Legged locomotion and balance, Arm movement, Gaze and auditory orientation control, Facial expression, Hands and manipulation, Sound and speech generation, Motion capture/Learning from demonstration, Human activity recognition using vision, touch, sound, Vision, Tactile Sensing, Models of emotion and motivation. Performance, Interaction, Safety and robustness, Applications.

Text Books:

1. Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, "Introduction to Autonomous Mobile Robots", Bradford Company Scituate, USA, 2011.
2. Riadh Siaer, "The future of Humanoid Robots- Research and applications",Intech Publications, 2012.

Reference Books

1. Sebastian Thrun, Wolfram Burgard, Dieter Fox, "ProbabilisticRobotics", MIT Press, 2005.
2. Karsten Berns, Ewald Von Puttkamer, "AutonomousLand VehiclesSteps towards Service Robots", Vieweg Teubner Springer, 2009.

3. Howie Choset, Kevin LynchSeth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, “Principles of Robot Motion-Theory, Algorithms, and Implementation”, MIT Press, Cambridge, 2005.
4. Bruno Siciliano, Oussama Khatib, Springer Hand book of Robotics, Springer, 2008.