DIVISION OF ROBOTICS ENGINEERING

LIST OF NEW COURSES

S.No	Course Code	Course Title	Credits L	T	P	C
1	23RO2001	Deep Learning	3	0	0	3
2	23RO2002	Introduction to Data Science	3	0	0	3
3	23RO2003	Industrial IoT Laboratory	0	0	4	2
4	23RO1001	Programming in C	3	0	0	3
5	23RO1002	C Programming Laboratory	0	0	2	1
6	23RO1003	Fundamentals of Python Programming for Robotics	3	0	0	3
7	23RO1004	Python Programming Laboratory for Robotics	0	0	2	1
8	23RO1005	Electronic System Design and Fabrication Laboratory	0	0	2	1
9	23RO1006	Rapid Prototyping Laboratory	0	0	2	1
10	23RO2004	Electron Devices and Circuits	3	0	0	3
11	23RO2005	Electrical Machines	3	0	0	3
12	23RO2006	Automatic Control Systems	3	1	0	4
13	23RO2007	Electron Devices and Circuits Laboratory	0	0	2	1
14	23RO2008	Electrical Machines and Control Systems Laboratory	0	0	2	1
15	23RO2009	Robot Kinematics and Dynamics	3	0	0	3
16	23RO2010	Microcontrollers for Robotics	3	0	0	3
17	23RO2011	Computer Vision	3	0	0	3
18	23RO2012	PLC and SCADA	3	0	0	3
19	23RO2013	Automation System Design	3	0	0	3
20	23RO2014	Mobile Robots	3	0	0	3
21	23RO2015	Artificial Intelligence in Robotics	3	0	0	3
22	23RO2016	Machine Learning for Robotics	3	0	0	3
23	23RO2017	Power Electronics and Drives	3	0	0	3
24	23RO2018	Unmanned Aerial Vehicle Networks	3	0	0	3
25	23RO2019	Drone Technology	3	0	0	3
26	23RO2020	Agricultural Robotics	3	0	0	3
27	23RO2021	Robot Navigation and Obstacle Avoidance	3	0	0	3
28	23RO2022	System Simulation Laboratory	3	0	0	3
29	23RO2023	Data Acquisition and Interfacing Laboratory	3	0	0	3
30	23RO3001	Robotics: System and Analysis	3	0	0	3
31	23RO3002	Humanoid Robots	3	0	0	3
32	23RO3003	Quadruped Robots	3	0	0	3

Course code	DEEP LEARNING	L	T	P	C
23RO2001		3	0	0	3

Course Objectives:

Enable the student to:

1. Apply the concepts of deep learning
2. Optimize deep generative models
3. Illustrate the applications of deep learning algorithms

Course Outcomes:

The student will be able to:

1. Demonstrate the basics of deep learning for a given context.
2. Implement various deep learning models for the given problem
3. Realign high dimensional data using reduction techniques for various applications
4. Analyze optimization and generalization techniques of deep learning.
5. Illustrate the concepts of autoencoders and deep generative models for a given data.
6. Evaluate the given deep learning application by applying the latest techniques.

Module: 1	Introduction	6 Hours

Linear models (SVMs and Perceptron's, logistic regression)- Intro to Neural Nets: shallow network- Training a network: loss functions, back propagation and stochastic gradient descent- Neural networks as universal function approximates		
Module: 2	**Deep networks**	**9 Hours**
History of Deep Learning- A Probabilistic Theory of Deep Learning-Backpropagation and regularization, batch normalization- VC Dimension and Neural Nets-Deep Vs Shallow Networks-Convolutional Networks- Generative Adversarial Networks (GAN), Semi-supervised Learning		
Module: 3	**Dimensionality Reduction and Convolution Network**	**9 Hours**
Linear (PCA, LDA) and manifolds, metric learning - dimensionality reduction in networks - Introduction to Convnet - Architectures – AlexNet, VGG, Inception, ResNet - Training a Convnet: weights initialization, batch normalization, hyperparameter optimization		
Module: 4	**Optimization and Generalization**	**8 Hours**
Optimization in deep learning– Non-convex optimization for deep networks- Stochastic Optimization Generalization in neural networks-Spatial Transformer Networks- Recurrent networks, LSTM - Recurrent Neural Network Language Models- Word-Level RNNs & Deep Reinforcement Learning - Computational & Artificial Neuroscience		
Module: 5	**Autoencoders and Deep Generative Models**	**8 Hours**
Autoencoders: Undercomplete, Regularized, stochastic, denoising, contractive, Applications Deep Generative Models-Boltzmann Machines, Deep Belief Networks Directed Generated nets		
Module: 6	**Case study and applications**	**5 Hours**
Imagenet- Detection-Audio Wave Net-Natural Language Processing -Word2Vec - Joint Detection BioInformatics- Face Recognition- Scene Understanding-Gathering Image Captions		
Total Lectures		**45 Hours**

Text Books	
1.	Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press, 2016. ISBN: 0262035618
2.	Deng & Yu, "Deep Learning: Methods and Applications", Now Publishers,2013, ISBN, 9781601988157
Reference Books	
1.	Michael Nielsen, Neural Networks and Deep Learning, Determination Press,2015
2.	Wei Di, Anurag Bhardwaj, Jianing Wei, "Deep Learning Essentials: Your hands-on guide to the fundamentals of deep learning and neural network", Packt Publishing, 2018, ISBN: 9781785880360
3.	Eugene Charniak, "Introduction to Deep learning", MIT Press, 2018, ISBN: 9780262039512
4.	Gulli, Antonio, and Sujit Pal, "Deep learning with Keras", Packt Publishing Ltd, 2017, ISBN: 978-1-78712-842-2

Recommended by Board of Studies	4th May 2023
Approved by Academic Council	03 June 2023

Course Code	INTRODUCTION TO DATA SCIENCE	L	T	P	C
23RO2002		3	0	0	3

Course Objectives:

Enable the student to:

1. Analyze the concepts, techniques and tools used in data science
2. Utilize Statistical descriptions of data for analysis
3. Apply data reduction and data visualization techniques for real time applications.

Course Outcomes:

The student will be able to:

1. Classify the data types used in data science applications.
2. Apply statistical techniques on various data types.
3. Create data frames using vectors and matrices
4. Utilize R programming for data handling
5. Analyze the strategies of data reduction
6. Compare the data visualization techniques.

Module: 1	**Introduction**	**6 Hours**

Definition of Data Science- Big Data and Data Science hype –Datafication- Current landscape of perspectives - Statistical Inference - Populations and samples -Statistical modeling, probability distributions, fitting a model – Over fitting. **Basics of R**: Introduction, R-Environment Setup, Programming with R, Basic Data Types.		
Module: 2	**Data types and Statistical Description**	**9 Hours**
Types of Data: Attributes and Measurement - Different Types of Attributes - Describing Attributes by the Number of Values - Asymmetric Attributes, Binary Attribute, Nominal Attributes, Ordinal Attributes, Numeric Attributes, Discrete versus Continuous Attributes. **Basic Statistical Descriptions of Data**: Measuring the Central Tendency: Mean, Median, and Mode, Measuring the Dispersion of Data: Range, Quartiles, Variance, Standard Deviation, and Interquartile Range, Graphic Displays of Basic Statistical Descriptions of Data.		
Module: 3	**Vectors and Matrices**	**9 Hours**
Creating and Naming Vectors, Vector Arithmetic, Vector sub setting, **Matrices**: Creating and Naming Matrices, Matrix Sub setting, Arrays, Class. **Factors and Data Frames**: Introduction to Factors: Factor Levels, Summarizing a Factor, Ordered Factors, Comparing Ordered Factors, Introduction to Data Frame, subset of Data Frames, Extending Data Frames, Sorting Data Frames. Lists: Introduction, Creating a List: Creating a Named List, Accessing and Manipulating List Elements, Merging Lists, Converting Lists to Vectors.		
Module :4	**Conditionals and Control Flow**	**8 Hours**
Relational Operators, Relational Operators and Vectors, Logical Operators, Logical Operators and Vectors, Conditional Statements. **Iterative Programming in R**: Introduction, While Loop, For Loop, Looping Over List. Functions in R: Introduction, writing a Function in R, Nested Functions, Function Scoping, Recursion, Loading an R Package, Mathematical Functions in R.		
Module: 5	**Data Reduction**	**8 Hours**
Overview of Data Reduction Strategies-Wavelet Transforms, Principal Components Analysis, Attribute Subset Selection, Regression and Log-Linear Models: Parametric Data Reduction, Histograms, Clustering, Sampling, Data Cube Aggregation.		
Module: 6	**Data Visualization**	**5 Hours**
Pixel-Oriented Visualization Techniques, Geometric Projection Visualization Techniques, Icon-Based Visualization Techniques, Hierarchical Visualization Techniques, Visualizing Complex Data and Relations.		
Total Lectures		**45 Hours**

Text Books	
1.	Schutt, Rachel, and Cathy O'Neil, "Doing data science: Straight talk from the frontline". O'Reilly, 2014.ISBN 9781449358655
2.	Jiawei, Han, Kamber Micheline, and Pei Jian, "Data Mining: Concepts and Techniques", 2012,ISBN: 978-0-12-381479-1
Reference Books	
1.	Tan, Pang-Ning, Michael Steinbach, Vipin Kumar, "Introduction to data mining", Pearson Education India, 2016, ISBN-13: 978-0-13-312890-1
2.	Hothorn, Torsten, and Brian S. Everitt, "A handbook of statistical analyses using R", CRC press, 2014, ISBN 9781482204582
3.	Dalgaard, Peter, "Statics and Computing Introductory Statistics with R", Springer, 2008, ISBN: 978-0-387-79054-1
4.	Saltz, Jeffrey S., and Jeffrey M. Stanton,"An introduction to data science", Sage Publications, 2017, 1506377513, 9781506377513

Recommended by Board of Studies	4th May 2023
Approved by Academic Council	03 June 2023

Course code	**INDUSTRIAL IOT LABORATORY**	**L**	**T**	**P**	**C**
23RO2003		0	0	4	2

Course Objectives:

Enable the student to:

1. Demonstrate the configuration of IoT Cloud platforms
2. Analyse various controllers used in IoT applications

3. Develop python programs for remote monitoring and control of IoT devices
Course Outcomes:
At the end of this course, students will be able to 1. Interface IoT devices and access cloud platforms 2. Implement communication protocols 3. Create data Loggers 4. Perform sensor interfacing applications with IoT 5. Demonstrate communication using Industrial Protocols 6. Develop controllers for robotic manipulators

List of Experiments

1.	Configuring microcontroller for IoT and introduction to Cloud platforms
2.	Monitoring sensor data in Thing Speak/Cloud platform
3.	IoT based Temperature logger using Thing Speak
4.	Controlling actuator data from Thing Speak
5.	MODBUS and IoT Cloud
6.	IoT based home automation system using Industrial Protocols
7.	Interfacing motion sensor with Raspberry pi and MQTT protocol
8.	Interfacing humidity sensor with communication protocol and cloud platforms
9.	IoT based motor speed control for wheeled robot.
10.	IoT based object recognition using ultrasonic sensor
11.	IoT based control of Robotic Manipulator
12.	Mini Project
Total Hours	**60 Hours**

Recommended by Board of Studies	4th May 2023
Approved by Academic Council	03 June 2023

Course Code	PROGRAMMING IN C	L	T	P	C
23RO1001		3	0	0	3

Course Objectives:

Enable the student to:

1. Acquire programming skills in C.
2. Solve real time problems using programming.
3. Apply memory management concepts and function-based modularization.

Course Outcomes:

The student will be able to:

1. Develop simple programs by understanding the fundamentals of C programming language.
2. Formulate innovative solutions for problems using the concept of branching and looping.
3. Analyze a problem in a program using functions.
4. Evaluate complex data structures and algorithms effectively with arrays.
5. Categorize different types of data using structures.
6. Apply pointers for arrays and structure handling.

Module 1	**Introduction to C Programming**	**7 Hours**

Software Development Life Cycle – Representation of a Program – Algorithm, flow chart, Pseudo-code - Fundamentals of C – Data types - Constants, Variables, Strings, Console I/O - Operators - Arithmetic, Unary, Relational and Logical, Unary, Assignment and Conditional Operators – Format Specifiers - Error Diagnostics.

Module 2	**Loops and Branching Statements**	**7 Hours**

Branching - if-else statement, switch statement, go to statement, Looping - while statement, do- while statement, for statement, Nested control structures, break statement, continue statement.

Module 3	**Functions**	**8 Hours**

Definition –Pre-defined functions – User-defined functions – Function calling (Parameters/Arguments) – Aspects of Function calling - function without arguments and without return value, function without arguments and with return value, function with arguments and without return value, function with arguments and with return value – Call by value/Pass by Value - Recursive Functions

Module 4	**Arrays**	**7 Hours**

Definition – Declaration – Initialization - Accessing the Arrays – Types of Arrays – one dimensional Array, Two-dimensional Array, Multi-dimensional Array – Linear Search Algorithm – Bubble Sort Algorithm - Passing arrays to functions		
Module 5	**Structures in C**	**8 Hours**
Definition – Difference between Arrays and Structures - Structure Variable Declaration – within the structure definition, main function - initialization of Structure Members – Accessing the structure members - Nested Structures.		
Module 6	**Pointers in C**	**8 Hours**
Definition – Features – Initialization of Pointers variables - & and * operators – Null Pointer - Pre and Post Decrement (Arithmetic operations) of Pointers – passing Pointers to Functions – Pointers and one-dimensional Arrays – Accessing Structure members with pointers - Dynamic Memory Allocation.		
	Total Lectures	**45 Hours**

Text Books	
1.	Byron Gottfried, "Schaum's Outline of Programming with C", McGraw Hill Education (India), 4th edition, 2018, ISBN: 978-9353160272
2.	Deitel H. M. and Deitel P. J "C: How To Program", Prentice Hall of India., New Delhi, 2015
Reference Books	
1.	Yashvant Kanetkar, "Let Us C", BPB Publications, 15th edition, 2016, ISBN:9788183331630
2.	Herbert Schildt, "The Complete Reference C", McGraw Hill Education (India), 4th edition, 2017, ISBN:978007041183
3.	Sumitabha Das, "Computer Fundamentals and C Programming" McGraw Hill Education (India), 18th edition, 2018, ISBN:9789387886070
4.	David Griffiths, "Head First C", O'Reilly Media, 1st edition, 2012, ISBN:978-1449399917.
5.	Ajay Mittal "Programming in C-A Practical approach", Pearson., New Delhi, 2010

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course code	**C PROGRAMMING LABORATORY**	**L**	**T**	**P**	**C**
23RO1002		0	0	2	1

Course Objectives:

Enable the student to:

1. Design and develop C programs for solving complex problems.
2. Elucidate the principles of programming for practical implementation.
3. Evaluate the effectiveness and appropriateness of C programming language for specific tasks.

Course Outcomes:

The student will be able to:

1. Develop simple programs with console input and output statements.
2. Analyze programming concepts with operators and strings.
3. Perform branching and looping operations using C.
4. Implement C programming using arrays.
5. Apply pointers to write C programs
6. Create structures in C.

List of Experiments:

1.	Implement Console Input/output functions.
2.	Implementation of operators.
3.	Execution of conditional statements.
4.	Create programming with Branching statements.
5.	Develop programming with looping statements.
6.	Build Arrays for real time applications.
7.	Develop program using strings.
8.	Create functions with C.
9.	Build pointer access in C.
10.	Develop programming with structure.
Total Lectures	**30 Hours**

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	FUNDAMENTALS OF PYTHON PROGRAMMING FOR ROBOTICS	L	T	P	C
23RO1003		3	0	0	3

Course Objectives:

Enable the student to:

1. Use the libraries and idioms in python programming.
2. Create python scripting using variables and flow control structures.
3. Develop python programs for robotic applications.

Course Outcomes:

The student will be able to:

1. Outline the structure and components of a python program.
2. Describe loops and decision statements in python.
3. Illustrate class inheritance in python for reusability.
4. Apply lists, tuples and dictionary concepts in python programs.
5. Assess object-oriented programs with python classes and GUI.
6. Develop simple codes for robotic applications.

Module 1	Introduction to Python, Data Types, Expression	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.

Module 2	Loops and Expressions	8 Hours

Loops and Expressions: 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 File Handling	7 Hours

Strings and Text Files: Strings - Accessing characters and substrings in Strings, data encryption and decryption, Text Files - Format, modes, writing text to a file, create new file, reading text from a file, reading numbers from a file, accessing and manipulating files.

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, join two list, searching and sorting a list, del, remove and pop, tuples, Python 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 Classes and Graphical User Interfaces	8 Hours

Design with Classes- Objects and Classes, Data Modeling and Structuring Classes with Inheritance and Polymorphism. GUI-Based Programs

Module 6	Micro Python	7 Hours

Micro Python: Micro Python Hardware- Workflow-setting up Micro Python on Board- Creating and Deploying code. Case studies: Object sensing and detection - Pick and Place Robot – Path planning - Unmanned vehicle - Control Robots.

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, Packt pub, 2018, ISBN 978-1-78883-292-2
5.	Nicholas H. Tollervey, Programming with Micro Python- Embedded Programming with Microcontrollers & Python, O'Reilly, 2018.

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	PYTHON PROGRAMMING LABORATORY FOR ROBOTICS	L	T	P	C
23RO1004		0	0	2	1

Course Objectives:

Enable the student to:
1. Develop python programs using loops and expression.
2. Apply the concepts of list, tuple and dictionary to solve real time problems.
3. Build function operations in python.

Course Outcomes:

The student will be able to:
1. Develop python scripts using operators and expressions.
2. Analyze loop flow with conditional and unconditional statements.
3. Perform number conversion with python.
4. Implement python functions for real time applications.
5. Demonstrate the use of list and dictionary in python.
6. Design Graphic User Interface in python.

List of Experiments:

1.	Develop python scripts for operations and expressions.
2.	Create python program using If statements.
3.	Develop python scripts using while loop.
4.	Construct data encryption & decryption with python scripts.
5.	Write python script for number conversion.
6.	Apply python text files operations for real time data.
7.	Develop program using list and tuples.
8.	Construct program using python dictionaries.
9.	Apply python functions for real time application.
10.	Develop python code for sentence generator.
11.	Apply concept of class and objects using python.
12.	Design of python graphic user interface using tkinter.
Total Lectures	**30 Hours**

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	ELECTRONIC SYSTEM DESIGN AND FABRICATION LABORATORY	L	T	P	C
23RO1005		0	0	2	1

Course Objectives:

Enable the student to:
1. Apply the concepts of active and passive components in circuit design.
2. Design and analyse simple electronic circuits.
3. Develop Printed Circuit Boards for simple applications.

Course Outcomes:

The student will be able to:
1. Identify the active and passive components used in electronic circuits.
2. Make use of instruments for measurement.

3. Design simple electronic circuits on breadboard. 4. Analyse electronic circuits. 5. Apply simulation tools for PCB design. 6. Develop electronic circuits on a PCB.	
List of Experiments:	
1.	Study of Active and Passive components.
2.	Electronic parameter measurement using various instruments.
3.	Build simple electronic circuits using breadboard.
4.	Circuit analysis and measurement.
5.	PCB design.
6.	PCB Fabrication.
Total Lectures	**30 Hours**
Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	**RAPID PROTOTYPING LABORATORY**	**L**	**T**	**P**	**C**
23RO1006		0	0	2	1

Course Objectives:

Enable the student to:

1. Select appropriate 3D simulation tools for prototyping.
2. Design simple and discrete components in simulation tools.
3. Develop a prototype of models using 3D printing techniques.

Course Outcomes:

The student will be able to:

1. Adopt suitable 3D modelling tools for simulation.
2. Design small parts using Fusion 360.
3. Apply solid works to design components of robot.
4. Develop models of discrete parts using solid works.
5. Use 3D printing techniques to fabricate models.
6. Recommend suitable modelling and prototyping techniques for a particular application.

List of Experiments:	
1.	Introduction to 3D modelling and simulation tools.
2.	Design of simple components using Fusion 360.
3.	Design of robot joint using Fusion 360.
4.	Design of discrete components using solid works.
5.	Design of robot links using solid works.
6.	Fabrication of robot components using additive manufacturing techniques.
Total Lectures	**30 Hours**
Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	**ELECTRON DEVICES AND CIRCUITS**	**L**	**T**	**P**	**C**
23RO2004		**3**	**0**	**0**	**3**

Course Objectives:

Enable the student to:

1. Acquire adequate knowledge in the basics of semiconductor devices.
2. Design transistor biasing circuits.
3. Develop amplifier and oscillator circuits.

Course Outcomes:

The student will be able to:

1. Determine the characteristics of solid-state devices like diode and transistor.
2. Select suitable components for electronic circuit design
3. Design power supply circuits, amplifiers and oscillators.
4. Analyse the amplitude and frequency response of amplifier circuits.
5. Apply field effect transistor circuits in electronic systems.

6. Develop electronic circuits for specific applications.		
Module 1	**Theory of Semiconductor and Diode**	**7 Hours**
Energy band structure of conductors, insulators and semiconductors – Comparison of Germanium, Silicon and gallium arsenide – Electron- hole generation and recombination –Intrinsic and extrinsic semiconductors - Doping a semiconductor - PN junction -Ideal diode - Unbiased diode - Forward bias - Reverse Bias – Breakdown - Barrier potential – DC resistance of a diode - Load lines -regulator. Datasheet interpretation of diode.		
Module 2	**DC Power Supply and Regulators**	**7 Hours**
Half wave rectifier – Full wave rectifier – ripple factors – DC and AC components in rectifiers. Full wave rectifier with Capacitor and inductor filters. Shunt regulator – Series Regulator –Current boosters - Fixed and adjustable three terminal regulators.		
Module 3	**Bipolar Junction Transistor**	**8 Hours**
Unbiased and biased transistor - Transistor Currents – CE Connection - Base curve – Collector curve – Load line – Operating point - Transistor as switch – Emitter Bias – Voltage divider bias: Load line and Q-point - Two-supply emitter bias. Datasheet interpretation of transistor.		
Module 4	**Field Effect Transistor**	**7 Hours**
FET – Types of FET, Junction Field Effect transistor operation, equation, n Channel JFET, p Channel JFET – MOSFET - characteristics – Types of MOSFET – Applications of FET.		
Module 5	**Amplifiers**	**8 Hours**
Two-transistor model – Analysing an amplifier - Voltage gain – Loading effect of input impedance - Multistage amplifiers – CC amplifier - Output impedance - Cascading CE and CC - Darlington connections – Class A, Class B - Class C, Class D operation - Push-pull Emitter Follower.		
Module 6	**Oscillators**	**8 Hours**
Theory of sinusoidal oscillation – Wien-bridge oscillator - RC Phase shift- Hartley Oscillator-Crystal Oscillator, Colpitts Oscillator - Monostable and astable Multivibrators.		
	Total Lectures	**45Hours**

Text Books	
1.	Robert Boylestad and Louis Nashelsky, "Electronic Devices & Circuit Theory", 9th Pearson Education Edition, 2016.
2.	Millman &Halkias, "Electronic Devices & Circuits", Tata McGraw Hill, 3rd Edition, 2013.
Reference Books	
1.	V.K. Mehta, "Principles of Electronics", Chand Publications,2015.
2.	Malvino. A P, "Electronic Principles", McGraw Hill International, 7th Edition 2016.
3.	David. A. Bell, "Electronic Devices & Circuits ", Oxford University Press, 5th Edition 2010.
4.	Thomas L. Floyd, "Electron Devices", Pearson Education Limited, 2018.
5.	Jacob Millman and Halkias. C., "Integrated Electronics", McGraw hill, New York, 2004.

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	ELECTRICAL MACHINES	L	T	P	C
23RO2005		**3**	**0**	**0**	**3**

Course Objectives:

Enable the student to:

1. Comprehend the constructional features, working principle and characteristics of motors.
2. Explore the different types of motors used for automation.
3. Examine the basics of selection of motors for a given application.

Course Outcomes:

The student will be able to:

1. Outline the basics of different types of DC and AC motor.
2. Compare the constructional features of different Motors.
3. Demonstrate the working principle of various types of Motors.
4. Relate the torque speed characteristics of several Motors.
5. Apply the various methods of speed control of motors used for Automation.
6. Analyze the different types of motors used for Automation with case studies.

Module 1	Introduction to DC and AC Motors	7 Hours
Constructional details – Principle of operation – Torque Speed Characteristics - DC Motor, Single Phase Induction Motor, Three Phase Induction Motor.		
Module 2	**Linear Motors**	**8 Hours**
Constructional features - Principle of operation – Torque Speed Characteristics – Linear Induction motor, DC Linear motor (DCLM), Linear Synchronous motor (LSM) - Case Studies.		
Module 3	**Stepper Motors**	**8 Hours**
Constructional features - Principle of operation – Types - Permanent Magnet Stepper motor, Hybrid Stepper motor - EMF and torque equations - Torque speed characteristics - Speed Control – Case Studies.		
Module 4	**Servo Motors**	**7 Hours**
Constructional features - Principle of operation – Types - EMF and torque equations - Torque speed characteristics - Speed Control – Case Studies.		
Module 5	**Brushless DC Motors**	**8 Hours**
Constructional features - Principle of operation – Types - Square wave and Sine wave - EMF and torque equations - Torque speed characteristics – speed control – Case Studies.		
Module 6	**Permanent Magnet Synchronous Motors**	**7 Hours**
Constructional features - Principle of operation – EMF, Input power and torque expression - Torque speed characteristics – speed control – Case Studies.		
	Total Lectures	**45 Hours**

Text Books	
1.	D. P. Kothari, I J Nagrath, "Electric Machines", 5th Edition, Tata McGraw Hill, 2017.
2.	Bhattacharya, "Electrical Machines", Tata McGraw Hill Education, 2008.
Reference Books	
1.	Jacek F. Gieras, Zbigniew J. Piech, Bronislaw Tomczuk, "Linear Synchronous Motors: Transportation and Automation Systems", CRC Press. New York, 2011.
2.	J. R. Hendershot, Timothy John Eastham Miller, "Design of Brushless Permanent-magnet Machines", Motor Design Books, 2010.
3.	Wilfried Voss, "A Comprehensible Guide to Servomotor Sizing", Copperhill Media, 2007.
4.	Theodore Wildi, "Electrical Machines, Drives and Power Systems", Pearson, 2014.
5.	Sen P.C., "Principles of Electrical Machines and Power Electronics", John Wiley Publications Private Limited, 3rd Edition, 2013.

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	AUTOMATIC CONTROL SYSTEMS	L	T	P	C
23RO2006		3	1	0	4

Course Objectives:

Enable the student to:

1. Derive transfer function model of non- linear systems.
2. Represent linear systems in time domain and frequency domain.
3. Design various controllers for practical engineering problems.

Course Outcomes:

The student will be able to:

1. Develop mathematical models of control components and physical systems.
2. Analyze the time domain responses of LTI systems.
3. Determine the frequency domain specifications of the LTI systems.
4. Investigate the stability of systems based on frequency domain using different techniques.
5. Derive equivalent transfer function and state space model for a given system.
6. Design controllers for practical applications.

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, Electrical Systems - Transfer function of Servomotor - Block diagram reduction techniques - Signal flow graph.		
Module 2	**Time Domain Analysis**	**7 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.		
Module 3	**Frequency Domain Analysis**	**8 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.		
Module 4	**Stability Analysis and Root Locus**	**7 Hours**
Frequency domain specifications- 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.		
Module 5	**State Space Analysis**	**8 Hours**
State space formulation – State model of linear system – State diagram– State space representation using physical variables - Solution of state equations-Concepts of controllability and observability.		
Module 6	**Controller Design**	**7 Hours**
Introduction to P, PI and PID modes of feedback control -Controller Tuning- Design of PI, PD and PID Controllers in Frequency domain.		
	Total Lectures:	**45 Hours**

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.	A. Nagoor Kani “Control systems Engineering, First Edition, RBA Publication,2010
5.	S Palani, “Control Systems Engineering”, 2nd Edition, McGraw Hill Education Pvt. Ltd, New Delhi, 2010.

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	**ELECTRON DEVICES AND CIRCUITS LABORATORY**	**L**	**T**	**P**	**C**
23RO2007		0	0	2	1

Course Objectives:

Enable the student to:

1. Determine the characteristics of semiconductors and special purpose electron devices.
2. Design rectifiers, amplifiers and regulators.
3. Develop oscillators and push pull amplifier circuits.

Course Outcomes:

The student will be able to:

1. Determine characteristics of diodes and transistors.
2. Design circuits for series voltage regulators.
3. Develop circuits using JFET and UJT.
4. Implement amplifier and oscillator circuits and verify the response.
5. Analyse the response of various special semiconductor devices.
6. Simulate practical circuits using PSPICE software.

List of Experiments:

1.	Characteristics of PN Junction and Zener Diode.
2.	Characteristics of Series Voltage Regulator.

3.	Characteristics of BJT.
4.	Characteristics of JFET.
5.	Characteristics of UJT.
6.	Study of Half and Full Wave Rectifier.
7	Study of Colpitts Oscillator.
8	Study of RC Phase Shift Oscillator.
9	Study of RC Coupled Amplifier.
10	Study of Push Pull Amplifier.
	Total Lectures **30 Hours**
Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	ELECTRICAL MACHINES AND CONTROL SYSTEMS LABORATORY	L	T	P	C
23RO2008		**0**	**0**	**2**	**1**

Course Objectives:

Enable the student to:

1. Determine the characteristics of DC and AC machines.
2. Assess the performance of various control systems precisely/ with precision.
3. Demonstrate the concept of position feedback and its role in achieving accurate control.

Course Outcomes:

The student will be able to:

1. Perform experiments to analyze the characteristics of DC shunt and series motor.
2. Calibrate the position control system unit to achieve precise positioning of load.
3. Determine the transfer functions of DC and AC Servomotors.
4. Distinguish open-loop and closed-loop control systems in DC Motor operation.
5. Develop LabView programs to control the movement and position of DC motors.
6. Analyze the effects of PID controller parameters on system stability.

List of Experiments:

1. Study of ON-OFF Temperature Control System.
2. Open Loop and Closed Loop Characteristics of DC Motor.
3. DC Position Control System.
4. Determination of transfer functions of DC & AC servomotor.
5. Stepper Motor Control using LabVIEW.
6. Characteristics of PID Controllers using MATLAB.
7. Load test on DC Shunt Motor.
8. Load test on DC Series Motor.
9. Load test on Single Phase Transformer.
10. Load test on Three Phase Induction Motor.

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Course code	ROBOT KINEMATICS AND DYNAMICS	L	T	P	C
23RO2009		3	0	0	3

Course Objectives:

Enable the student to:

1. Apply mathematical fundamentals for kinematic analysis.
2. Analyze Robot dynamics and forces.
3. Perform path and trajectory planning of robot.

Course Outcomes:

The student will be able to:

1. Represent robot coordinate frames and points in 3D space.
2. Derive transformation matrices for translation and rotation.
3. Perform forward and inverse kinematic analysis of manipulators.
4. Apply Jacobian matrices for differential kinematic analysis.
5. Analyze robot dynamics using Lagrangian Mechanics.

6. Execute simulation analysis of robot trajectory planning		
Module 1	**Introduction**	**7 Hours**
Dot and Cross Products, Coordinate Frames, Rotations: Fundamental and Composite Rotations, Orthogonal Matrix, Representation of a Point in Space, Representation of a Vector in Space, Representation of a Frame at the Origin of a Fixed-Reference Frame, Representation of a Frame Relative to a Fixed Reference Frame, Representation of a Rigid Body		
Module 2	**Transformations**	**8 Hours**
Representation of pure translation, Representation of pure rotation, Representation of translation and rotation, Rotational Transformation about the moving frame, Homogeneous Transformation Matrices, Inverse of Transformation Matrices, RPY angles, Euler angles		
Module 3	**Forward and Inverse Kinematics of Robots**	**10 Hours**
Forward and Inverse Kinematic Equations of 2 link manipulator, Denavit-Hartenberg Representation, The Arm Equation, The Inverse Kinematic Solution of Robots, General Solution for Articulated Robot Arms, Inverse Kinematic Programming of Robots.		
Module 4	**Differential Motions and Velocities**	**8 Hours**
Differential relationships, Jacobian, Differential Motions of a Frame, Joint Space Singularities, resolved motion rate control, Manipulator Jacobian of three and four axis robots, induced joint torques and forces.		
Module 5	**Dynamic Analysis and Forces**	**6 Hours**
Introduction, Newtonian and Lagrangian mechanics, Equations of motion of 2 DoF manipulator, Dynamic equation for two axis planar articulated robot. Effects of moments of Inertia,		
Module 6	**Trajectory Planning**	**6 Hours**
Path Vs. Trajectory, Joint Space and Cartesian Space Description, Basics of Trajectory planning, Joint Space Trajectory Planning, Pick and place operations, Continuous path motion, Interpolated motion, Straight-line motion. Simulation and Case Studies.		
		Total Lectures: 45 Hours

Text Books	
1.	Robert J. Schilling, “Fundamentals of Robotics Analysis and Control”, PHI Learning, 2019.
2.	Niku S B, “Introduction to Robotics, Analysis, Systems, Applications”, Prentice Hall, 2019.
Reference Books	
1.	John J Craig, “Introduction to Robotics”, Pearson, 2022.
2.	Deb S R and Deb S, “Robotics Technology and Flexible Automation”, Tata McGraw Hill Education Pvt. Ltd, 2017
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.
5.	Groover, “Industrial Robotics, Technology, Programming and Applications’’, Tata McGraw Hill, 2012

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Course Code	**MICROCONTROLLERS FOR ROBOTICS**	**L**	**T**	**P**	**C**
23RO2010		**3**	**0**	**0**	**3**

Course Objectives:

Enable the student to:

1. Outline the Architecture of Microcontroller.
2. Apply the programming concepts using Instruction sets of 8051 and ARM.
3. Interface peripherals with controllers for real time applications.

Course Outcomes:

The student will be able to:

1. Compare the architecture of various controllers.
2. Classify different types of instruction set and addressing modes.
3. Design real time systems using microcontrollers.
4. Discuss the general features of RISC architecture.
5. Summarize the specific features of cortex controller.
6. Develop interfacing program with controllers.

Module 1	8051 Architecture	7 Hours
Internal Block Diagram – Program counter and Data Pointer, CPU registers, Flags, Internal Memory, Stack- Special Function Register- Input /Output pins, Ports and Circuits, 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 Hours**
Addressing modes: Immediate addressing -Register addressing - Direct addressing - Indirect addressing - Relative addressing - Indexed addressing -. 8051 Instruction set - Instruction timings. Data transfer instructions - Arithmetic instructions - Logical instructions - Branch 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 Hours**
Connecting External Memory- Interfacing of peripheral devices such as General Purpose I/O - ADC - DAC - timers / counters -Serial Data Input/output - Interrupts - Interfacing to protocols like Blue-tooth and Zig-bee		
Module 4	**High Performance RISC Architecture**	**8 Hours**
ARM RISC architecture –Architectural Inheritance – The programmer's model of ARM Architecture – 3 stage pipeline ARM organization -5-stage pipeline ARM organization – ARM instruction execution – Salient features of ARM instruction se		
Module 5	**High Performance Microcontroller Architectures**	**8 Hours**
Introduction to the Cortex-M Processor Family - ARM Cortex-M4 architecture for microcontrollers – Internal Registers - Nested Vectored Interrupt controller - Memory map - Interrupts and exception handling – Instruction set -Applications of Cotex-M4 architecture		
Module 6	**Applications**	**7 Hrs**
LED – LCD and keyboard interfacing. Stepper motor interfacing – DC Motor interfacing – Sensor Interfacing.		
	Total Lectures	**45 Hours**

Text Books	
1.	M. A. Mazidi, J. G. Mazidi and R. D. McKinlay, "The8051Microcontroller and Embedded Systems: Using Assembly and C", Pearson Education, 2011
2.	Joseph Yiu The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors, 3rd Edition, Kindle Edition, 2019
Reference Books	
1.	K. J. Ayala, "8051 Microcontroller", Delmar Cengage Learning, 2007.
2.	R. Kamal, "Embedded System", McGraw Hill Education, 2009.
3.	Steve Furber, "ARM System –On –Chip architecture", Second edition, Addison Wesley, 2015.
4.	Larry D. Pyeatt "Modern assembly language programming with the ARM processor", Elsevier 2016
5.	Andrew N. Sloss, Dominic Symes, Chri Wright, "ARM System Developer's Guide: Designing and Optimizing system software", Elsevier 2004

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Course Code	COMPUTER VISION	L	T	P	C
23RO2011		3	0	0	3

Course Objectives:

Enable the student to:
1. Acquire knowledge on the principles of vision system and image processing.
2. Outline the applications of vision system in modern manufacturing environment.
3. Apply the concepts of Robotic Operating System and OpenCV

Course Outcomes:

The student will be able to:
1. Distinguish the basic components of specific visual system.
2. Summarize the effect of low-level vision algorithms.
3. Illustrate the use of high-level vision algorithms for specific purpose.
4. Analyse the techniques used for object identification.

5. Apply Robot Operating System and Open CV packages for Robotic vision. 6. Demonstrate various applications using vision and tracking algorithms		
Module 1	**Foundations of Vision System**	**7 Hours**
Elements of visual perception: structure of human eye, image formation in the eye – pinhole cameras - CCD, CMOS colour cameras – image formation model – imaging as a matrix – basic relationship between pixels – Fundamental Steps in Image Processing – Elements of digital image processing - illumination techniques.		
Module 2	**Low Level Vision Algorithms**	**7 Hours**
Colour spaces- Colour transformations, Histogram equalization – Binary Image Processing - Thresholding - Erosion/Dilation – Contour Analysis – Blob detection - Filters: smoothing spatial filters, sharpening spatial filters, smoothing frequency domain filters, sharpening frequency domain filters – Canny edge detection.		
Module 3	**High Level Vision Algorithms**	**7 Hours**
Hough Transforms, line detection and circular object detection, the use of motion – Description: Boundary Descriptors – chain codes - Regional Descriptors, Recognition: Decision-Theoretic methods, structural methods.		
Module 4	**Object Recognition**	**8 Hours**
Object recognition, Approaches to Object Recognition: Feature-based and model-based approach, Recognition by combination of views – objects with sharp edges, using two views only, using a single view.		
Modul: 5	**Applications**	**8 Hours**
Camera Calibration - Stereo Imaging – Structure from Motion – 3D Scene understanding – 3D reconstruction from videos – medical imaging and 3D visualization – 3D Object recognition and Pose Estimation		
Module 6	**Robot Vision**	**8 Hours**
Introduction to Robot vision – Robot perception pipeline – visual SLAM – introduction to ROS for robot vision – ROS packages and tools for vision-based robots.		
	Total Lectures	**45 Hours**

Text Books	
1.	Carsten Steger, Markus Ulrich, Christian Wiedemann, "Machine Vision Algorithms and Applications", Wiley, 2008.
2.	Damian m Lyons, "Cluster Computing for Robotics and Computer Vision", World Scientific, Singapore, 2011.
Reference 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.
5.	Richard Szeliski, "Computer Vision: Algorithms and Applications", 2nd Edition, Springer Publication, 2021.

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	**PLC AND SCADA**	**L**	**T**	**P**	**C**
23RO2012		**3**	**0**	**0**	**3**

Course Objectives:

Enable the student to:

1. Acquire knowledge on the concept of PLC and SCADA systems.
2. Implement the concepts of PLC and SCADA Systems for specific applications.
3. Demonstrate the application of PLC and SCADA systems for industrial automation.

Course Outcomes:

The student will be able to:

1. Outline the concepts of Industrial Automation.
2. Develop PLC Ladder logic for simple applications
3. Select suitable communication protocols for industrial automation.
4. Implement prototypes for real time application using PLC and HMI.
5. Summarize the configuration of SCADA functionalities with Tags, Screens, and Trends.
6. Design real time applications using PLC and SCADA.

Module 1	**Introduction to Industry Automation**	**8 Hours**
History and developments in Industrial Automation - Vertical Integration of Industrial Automation - Control elements in Industrial Automation – Safety standards - PLC Introduction: Basics of PLC – Advantages - Capabilities of PLC -Architecture of PLC - Scan cycle - Types of PLC: Types of I/O modules - Configuring a PLC - PLC wiring.		
Module 2	**Programming of PLC**	**8 Hours**
Introduction to state machine theory - Types of Programming - Process Control Programs using Relay Ladder Logic - PLC arithmetic functions - Timers and counters –data transfer-Comparison and manipulation instructions - PID instructions - PTO /PWM generation.		
Module 3	**Networking of PLCs**	**7 Hours**
Industrial Networking Buses (Flow Diagram Only) – Comparison of Industrial Buses - Protocols-Fieldbus-Process bus and Control Net–Device Net-Ethernet-Ether CAT–MOD bus protocol-CAN bus protocol.		
Module 4	**HMI Systems**	**7 Hours**
Necessity and Role of HMI in Industrial Automation – Types of HMI panels : Text display – operator panels - Touch panels - Panel PCs - Integrated displays, interfacing PLC to HMI.		
Module 5	**Supervisory Control and Data Acquisition (SCADA)**	**8 Hours**
SCADA overview – Developer and runtime packages – Architecture - Tools - Tag - Internal & External graphics - Alarm logging - Tag logging - Trends – History - Report generation - Communication Protocols of SCADA - Proprietary and Open Protocols. OLE/OPC - DDE - Server/Client - Interfacing of SCADA with PLC and other field device.		
Module 6	**Applications of PLC and SCADA**	**7 Hours**
Case studies of Machine automation, Process automation – Car manufacturing Automation, Packaging industry Automation, Pharmaceutical industry Automation, power plant Automaton.		
	Total Lectures	**45 Hours**

Text Books

1.	John W Webb & Ronald A Reis, “Programmable logic controllers: Principles and Applications”, Prentice Hall India, 2011.
2.	Hans Berger, "Automating with Simatic S7-1200", Publics Publishing, 2018.

Reference Books

1.	Bolton W. “Mechatronics”, Pearson Education, 2011.
2.	Frank D Petruzella “Programmable Logic Controllers ", McGraw Hill Inc, Fifth Edition 2019.
3.	Kelvin T Erikson, “Programmable Logic Controllers ", Dogwood Valley Press, 2005
4.	Rajesh Mehra, "PLCs & SCADA: Theory and Practice", Laxmi Publications, 2016.
5.	R.S. Manoj, "Industrial Automation with SCADA: Concepts, Communications and Security", Notion Press, 2019.

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	**AUTOMATION SYSTEM DESIGN**	**L**	**T**	**P**	**C**
23RO2013		**3**	**0**	**0**	**3**

Course Objectives:

Enable the student to:

1. Acquire knowledge on the concepts of various mechatronic systems used in industries.
2. Implement the concepts related to industrial automation components.
3. Develop automated system with integration of multiple systems.

Course Outcomes:

The student will be able to:

1. Outline the elements of automation and their requirements.

2. Illustrate the concepts of various mechatronic systems. 3. Analyze the design considerations of material handling equipment. 4. Assess the features of programmable automation system 5. Design belt conveyor for real world applications. 6. Apply the design aspects in high-speed automatic assembly.		
Module 1	**Transfer Lines and Automated Assembly**	**7 Hours**
General terminology and analysis, analysis of transfer lines without storage, partial automation. Automated flow lines with storage buffers. Automated assembly-design for automated assembly, types of automated assembly systems, part feeding devices, analysis of multi-station assembly machines. AS/RS, RFID system, AGVs, modular fixturing. Flow line balancing.		
Module 2	**Design of Mechatronic Systems**	**8 Hours**
Stages in design, traditional and mechatronic design, possible design solutions. Case studies-pick and place robot, engine management system.		
Module 3	**Design of Material Handling Systems**	**7 Hours**
Principles of material handling, Material handling equipment: Unit Load formation equipment - Positioning Equipment – Conveyors – Cranes – Industrial Trucks, Types of AGVs, AS/RS Types, considerations in design of material handling system, LM Guide ways, Case Study: Design of MH Systems using Automation Design Studio.		
Module 4	**Design of Belt Conveyors**	**8 Hours**
Belt Conveyors: Information required for designing, angle of incline, belt conveyor elements, selection of belt, drive, greasing of idlers, Plow Vs Trippers, magnetic pulley, skirt boards, weighing material in motion, 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 5	**Design for High-Speed Automatic Assembly**	**8 Hours**
Introduction, Design of parts for high-speed feeding and orienting, high speed automatic insertion. Analysis of an assembly. General rules for product design for automation. Case Study: design and simulation using CIROS software, economics of automation systems design and implementation.		
Module 6	**Programmable Automation**	**7 Hours**
Special design features of CNC systems and features for lathes and machining centres. Drive system for CNC machine tools. Introduction to CIM; condition monitoring of manufacturing systems, Case study-integration of machine tending robot with a CNC machine		
	Total Lectures	**45 Hours**

Text Books	
1.	Mikell P Groover, "Automation Production Systems and Computer Integrated Manufacturing", Pearson education, New Delhi, 2013.
2.	Jacob Fruchtbaum, "Bulk Materials Handling Handbook", CBS Publishers & Distributors, New Delhi, 2013.
Reference Books	
1.	Bolton W, "Mechatronics ", Pearson Education, 1999.
	Devadas Shetty, "Mechatronics System design", PWS Publishing Company, USA 2010.
2.	Steve F Krar, "Computer Numerical Control Simplified ", Industrial Press, 2001.
3.	Wilfried Voss, "A comprehensible Guide to servo motor sizing", Copperhill Technologies Corporation.
4.	Conveyor Equipment Manufacturers Association, "Belt Conveyors for Bulk Materials", CBI Publishing Company, Massachusetts, 1979.
5.	HIWIN Linear Guideway – Technical Information Index.
6.	Joffrey Boothroyd, Peter Dewhurst and Winston A. Knight, "Product Design for manufacture and Assembly", CRC Press, 2011.

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	**MOBILE ROBOTS**	**L**	**T**	**P**	**C**
23RO2014		3	0	0	3
Course Objectives:					

Enable the student to: 1. Acquire knowledge on the concepts of mobile robots based on configuration. 2. Select suitable sensors for robot perception. 3. Demonstrate the localization and mapping for path planning of robot.		
Course Outcomes:		
The student will be able to: 1. Classify the types of mobile robots. 2. Perform the kinematic analysis of mobile robots. 3. Suggest the sensing mechanism suitable for perception. 4. Analyze the localization techniques used in autonomous robots. 5. Build autonomous map using SLAM techniques. 6. Apply path planning algorithms for navigation of a mobile robot .		
Module 1	**Robot Locomotion**	**7 Hours**
Types of locomotion, key issues for locomotion, hopping robots, legged robots, wheeled robots, aerial mobile robots, mobile robot applications.		
Module 2	**Mobile Robot Kinematics**	**8 Hours**
Kinematic models and constraints, forward kinematic models, holonomic and nonholonomic constraints, maneuverability, mobile robot workspace, motion control		
Module 3	**Perception and Sensing**	**10 Hours**
Proprioceptive/Exteroceptive and passive/active sensors, performance measures of sensors, wheel sensors, heading sensors, IMU, ground beacons, global positioning system (GPS), Doppler effect-based sensors, vision-based sensors.		
Module 4	**Localization**	**8 Hours**
Challenges of localization: sensor noise, aliasing, effector noise, belief representation, map representation, probabilistic map-based localization: Markov localization, Bayesian localization, Kalman localization, positioning beacon systems.		
Module 5	**Autonomous Map Building**	**6 Hours**
Simultaneous Localization and Mapping (SLAM) , Mathematical definition, Extended Kalman Filter (EKF) SLAM, Visual SLAM, Graph based SLAM, Particle Filter SLAM, Open source SLAM Software.		
Module 6	**Planning and Navigation**	**6 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		
	Total Lectures	**45 Hours**

Text Books	
1.	R. Siegwart, I. R. Nourbakhsh, “Introduction to Autonomous Mobile Robots”, The MIT Press, 2011.
2.	Sebastian Thrun, Wolfram Burgard, Dieter Fox, "Probabilistic Robotics", MIT Press, 2005
Reference Books	
1.	Peter Corke, Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer Tracts in Advanced Robotics, 2011
2.	Gregory Dudek, Michael Jenkin ·Computational Principles of Mobile Robotics, Cambridge University Press, 2010
3.	Eugene Kagan, Shvaib, Irad Ben-Gal, Autonomous Mobile Robots and Multi-Robot Systems: Motion-Planning, Communication, and Swarming. United Kingdom: Wiley, 2019
4.	H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki, and S. Thrun, Principles of Robot Motion: Theory, Algorithms and Implementations, PHI Ltd., 2005.
5.	Bruno Siciliano, Oussama Khatib, "Springer Hand Book of Robotics", Springer, 2008.

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	ARTIFICIAL INTELLIGENCE IN ROBOTICS	L	T	P	C
23RO2015		3	0	0	3
Course Objectives:					
Enable the student to: 1. Acquire knowledge on the concepts of Artificial Intelligence.					

2. Solve problems using various methods in Artificial Intelligence. 3. Apply the concepts of planning and reasoning for an Intelligent System.		
Course Outcomes:		
The student will be able to: 1. Outline the concepts of AI in Robotics. 2. Select the appropriate AI methods to solve a given problem. 3. Formulate a given problem in the language/framework of different AI methods. 4. Summarize the learning methods adopted in AI. 5. Examine the issues involved in knowledge bases, reasoning systems and planning. 6. Explore the applications of AI in Robotics.		
Module 1	**Introduction**	**7 Hours**
History, state of the art, need and Scope for AI in Robotics-Thinking and acting humanly, intelligent agents, structure of agents – Water Jug problem – Missionaries – Cannibals problem.		
Module 2	**Problem Solving**	**8 Hours**
State Space Search **-** Solving problems by searching – Uninformed Search: depth-first, Breadth- first search, iterative deepening; Informed search and exploration: A*, AO*, Hill climbing, best-first search-Constraint satisfaction problems– Adversarial search: minimax, Alpha-Beta pruning.		
Module 3	**Knowledge Representation and Planning**	**7 Hours**
Knowledge and reasoning – knowledge representation – Propositional and first order logic. 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**	**8 Hours**
Uncertainty – Probabilistic reasoning–Filtering and prediction–Hidden Markov models–Kalman filters–Dynamic Bayesian Networks, Speech recognition, making decisions.		
Module 5	**Learning**	**8 Hours**
Forms of learning – Knowledge in learning – Statistical learning methods –reinforcement learning, communication, perceiving and acting, Probabilistic language processing and perception.		
Module 6	**Application of AI in Robotics**	**7 Hours**
Robotic perception, localization, mapping- configuring space, planning uncertain movements, dynamics and control of movement, Ethics and risks of artificial intelligence in robotics.		
	Total Lectures	**45 Hours**

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: Addison Wesley, 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.

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	**:MACHINE LEARNING FOR ROBOTICS**	**L**	**T**	**P**	**C**
23RO2016		**3**	**0**	**0**	**3**
Course Objectives:					
Enable the student to: 1. Acquire theoretical knowledge on classification techniques used in machine learning. 2. Apply suitable machine learning techniques for robotics systems and to gain knowledge from it. 3. Recognize the performance of algorithms and to provide solution for various real-world applications in robotics engineering.					
Course Outcomes:					
The student will be able to :					

1. Examine the mathematical and statistical techniques used in machine learning fundamentals. 2. Outline supervised and unsupervised learning approaches using several case studies. 3. Formulate a given problem in a language/framework of different machine learning algorithms. 4. Contrast the learning approaches and dimensionality principles. 5. Evaluate and select appropriate machine learning algorithm for real time applications. 6. Demonstrate the case studies in machine learning applications.			
Module 1	**Introduction to Machine Learning**		**7 Hours**
Machine learning – Varieties of Machine learning – Learning Input- Output functions: Types of learning –Input Vectors – Outputs – Training regimes – Performance Evaluation- ROC Curves, Evaluation Metrics, Significance tests, Error correction.			
Module 2	**Foundations of Supervised Learning**		**7 Hours**
Linear, Non-linear, Multi-class and multi-label classification. Classification and Regression Trees(CART), Regression: Linear Regression, Multiple Linear Regression, Decision trees and inductive bias.			
Module 3	**Advanced Supervised Learning**		**7 Hours**
Linear models and gradient descent – Support Vector machines – Naïve Bayes models and probabilistic modeling, Geometry and nearest neighbors, Random Forest.			
Module 4	**Unsupervised Learning Algorithms**		**8 Hours**
Introduction to clustering- Types of Clustering - K-means clustering - Hierarchical clustering, , Self-Organizing Map - Curse of dimensionality- Principal Component Analysis (PCA).			
Module 5	**Neural Networks and Deep Learning**		**8 Hours**
Neural Networks – Biological Motivation- Perceptron – Multi-layer Perceptron – Feed Forward Network – Back Propagation-Activation and Loss Functions- Limitations of Machine Learning – Deep Learning– Convolution Neural Networks.			
Module 6	**Case Studies**		**7 Hours**
Line following Robot using Supervised Learning techniques –A simulation model for understanding both regression and classification techniques - Obstacle avoidance and navigation of a mobile robot in an unknown environment with the help of Neural Network -, Rehabilitation Robotics using Transfer Learning.			
		Total Lectures	**45 Hours**

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.	Ethem Alpaydin,'Introduction to Machine Learning', The MIT Press, 2004
3.	David MacKay, 'Information Theory, Inference and Learning Algorithms', Cambridge, 2003
4.	Bruno Apolloni, Ashish Ghosh, Ferda Alpaslan, "Machine Learning and Robot Perception", Springer,2005.
5.	Judy Franklin, Tom Mitchell, Sebastin Thrun, "Recent Advances in Robot Learning: Machine Learning", Springer, 2012.

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	**POWER ELECTRONICS AND DRIVES**	**L**	**T**	**P**	**C**
23RO2017		**3**	**0**	**0**	**3**

Course Objectives:

Enable the students to:

1. Outline the concepts of power electronic devices and their characteristics.
2. Explore the operation of power electronic converters with its control strategies.
3. Demonstrate the speed control of DC and AC motor drives.

Course Outcomes:

The student will be able to:

1. Discuss the working of various power semiconductor devices.

2. Implement and verify the performance characteristics of power converters. 3. Select suitable converters for robotic applications. 4. Apply speed control methods to DC motors with solid state power converters. 5. Analyze speed control methods of AC motors with solid state power converters and inverters. 6. Demonstrate the working of various power converters, choppers and inverters.		
Module 1	**Power Semiconductor Devices**	**8 Hours**
Power diodes - Power transistors - Characteristics of SCR - TRIAC – Power MOSFET - IGBT - Thyristor protection circuits – Thyristor triggering circuits- Selection of device		
Module 2	**Converters**	**8 Hours**
Single phase - Three phase - Fully controlled rectifiers - Effect of source and load inductance -single phase- Three phase AC voltage controller -Control Circuits for AC to DC and AC to AC converters		
Module 3	**Inverters**	**7 Hours**
AND: Voltage Source inverters - bridge inverters- 120° and 180° conduction - Pulse Width Modulation - Single and Multiple PWM - SPWM - Generation of pulses for SPWM -		
Module 4	**Choppers**	**7 Hours**
DC choppers: Buck- Boost - Buck Boost - Generation of timing pulses for DC choppers - Applications Uninterrupted power supplies - SMPS - Basics of Magnetic design for power electronics		
Module 5	**DC Drives for Automation**	**8 Hours**
Basic Elements of Drive - Load characteristics - Selection of Drive, Operating modes - quadrant operation of chopper - Closed loop control of DC drives.		
Module 6	**AC Drives for Automation**	**7 Hours**
Stator and rotor voltage control - frequency and voltage control - Current Control - Basics of vector control- Block diagram - Stepper Motor Drive - BLDC Motor Drive - PMSM Drive-protection devices for drives		
	Total Lectures	**45 Hours**

Text Books	
1.	Rashid M H, "Power Electronics –Circuits, Devices and Applications", PHI, 2014
2.	Ramu Krishnan, "Electric Motor Drives: Modeling, Analysis, and Control", Prentice Hall, 2001.
Reference Books	
1.	Bimal K Bose, “Modern Power Electronics and AC Drives", Pearson Education, 2002
2.	Roger C Dugan, Surya Santoso, Mark F McGranaghan, "Electrical Power Systems Quality", McGraw Hill, 2003.
3.	Mohan, Undel, "Power Electronics", John Wiley and sons, 2003.
4.	Vedam Subramaniam, "Thyristor control of Electrical Drives", Tata McGraw-Hill, 1998.
5.	Joseph Vithayathil, “Power Electronics – Principles and Applications”, Tata McGraw-Hill Limited, New Delhi, Indian Edition, 2017.

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	UNMANNED AERIAL VEHICLE NETWORKS	L	T	P	C
23RO2018		**3**	**0**	**0**	**3**

Course Objectives:
Enable the student to: 1. Acquire knowledge on the concept of UAV Systems. 2. Apply the principles of Networking in UAV Systems. 3. Infer the UAV Network Performance.
Course Outcomes:
The student will be able to: 1. Develop an unmanned aerial vehicle. 2. Analyze the communication and networking basics for UAV systems. 3. Implement the trajectory management for UAV systems. 4. Investigate the security aspects of UAV systems. 5. Examine the network performance UAV system. 6. Summarize the regulations for UAV operation.

Module 1	Introduction to UAV Systems	8 Hours
Introduction, Classes of UAV Systems, Basic Aerodynamics, Stability and Control, Propulsion, Payloads, Launch and Recovery		
Module 2	**UAV Communication and Networking Basics**	8 Hours
Wireless communication principles and challenges for UAVs, Communication protocols, standards, Spectrum management, regulatory considerations, Line-of-sight (LOS), beyond-line-of-sight (BLOS) communication, Ad-hoc networking, mesh networking for UAVs.		
Module 3	**UAV Mobility and Trajectory Management**	**7 Hours**
UAV mobility models, mobility prediction, Trajectory planning and optimization for UAVs Handover in UAV, resource management in UAV networks		
Module 4	**UAV Network Security and Privacy**	**8 Hours**
Vulnerabilities, threats in UAV networks, Security protocols, encryption techniques for UAVs Privacy concerns in UAV, data collection and communication in UAV.		
Module 5	**UAV Network Performance Evaluation and Simulation**	**8 Hours**
Metrics for evaluating UAV network performance, Simulation tools, methodologies for UAV networks, Performance analysis of UAV network protocols		
Module 6	**UAV Regulations and Future Trends**	**7 Hours**
Regulatory frameworks, airspace integration, Ethical and legal considerations for UAV operations Emerging trends in UAV network, future developments in UAV networks		
	Total Lectures	**45Hours**

Text Books	
1.	Kamesh Namuduri, Jae H. Kim, James P. G. Sterbenz UAV Networks and Communications, Cambridge University Press, 2017, ISBN - 9781316335765
2.	Mohammad Mozaffari, Walid Saad, Mehdi Bennis, Xiangqi Lin, Wireless Communications and Networking for Unmanned Aerial Vehicles, Cambridge University Press, 2020, ISBN - 9781108691017
Reference Books	
1.	Paul Gerin Fahlstrom, Thomas James Gleason, Introduction to UAV Systems, John Wiley & Sons, Ltd, ISBN: 978-1-119-97866-4, 2012.
2	Mohammad H. Sadraey, Unmanned Aircraft Design A review of fundamentals. Morgan & Claypool, 2017
3	Reg Austin, Unmanned Aircraft Systems: UAVs Design Development and Deployment, John Wiley & Sons ISBN 978-0-470-05819-0, 2010
4	Fei Hu, Dong Xiu Ou, Xin-lin Huang UAV Swarm Networks: Models, Protocols, and Systems, CRC Press, ISBN 9780367519988, 2022.
5	Walid Saad, Wireless Communications and Networking for Unmanned Aerial Vehicles, Cambridge University Press, 2020.

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	DRONE TECHNOLOGY	L	T	P	C
23RO2019		**3**	**0**	**0**	**3**

Course Objectives:

Enable the student to:

1. Explore material and electronics used in drones.
2. Utilize the knowledge for rectifying the problems in a Drone.
3. Make use of drone for various applications.

Course Outcomes:

The student will be able to:

1. Outline the basic concepts in flight dynamics.
2. Identify the hardware requirements for a drone.
3. Illustrate the key aspect of maintenance in a drone.
4. Analyze the performance of drone.
5. Assess the required payload for a Drone

6. Develop applications using drones		
Module 1	**Flight Dynamics Of Aerial Vehicles**	**8 Hours**
Definitions of Drone, UAV, RPA, Quad copters -Basic Components and Categories – Principles of Flight - Flight Maneuvers – Airframes - Creating a Frame: Materials, Different Frame Shapes – Building Airframes – Flight dynamics - Applications - Future potential - Comparison with other aerial vehicles.		
Module 2	**Hardware Anatomy of Quadcopter**	**8 Hours**
Power Train – Propellers, Motors- Total Lift - Electronic Speed Controllers – Flight Battery – Radio transmitter and receiver – Flight Controller – Sensor, GPS, Compass, Camera Assembling for Quad copter – Connectors, Mounting of Propellers and Powering up.		
Module 3	**Testing and Maintenance of Quadcopter**	**7 Hours**
Key Flight Safety Rules - Preflight Checklist and Flight Log Information – Flight Instructions - Repair and Maintenance: Crash analysis, Common issues, Voltage testing.		
Module 4	**Design and Control of Quadcopter**	**8 Hours**
Flight Performance Analysis – Dynamics and Design – Design Challenge – Guidance, Navigation, and Control of Drones		
Module 5	**Payload For UAV**	**8 Hours**
Types – Non-dispensable Payloads - Electro-optic Payload Systems - Electrooptic Systems Integration - Radar Imaging Payloads - Other Non-dispensable Payloads - Dispensable Payloads - Payload Development.		
Module 6	**Case Studies**	**7 Hrs**
Applications of drones in agriculture, smart cities, delivery drones, health care, defense surveillance.		
	Total Lectures	**45Hours**

Text Books	
1.	Reg Austin, Unmanned Aircraft Systems: UAVs Design, Development and Deployment, Wiley Publications, 2010, ISBN: 978-0-470-05819-0
2.	Donald Norris, "Build Your Own Quadcopter -Power Up Your Designs with the Parallax Elev-8", McGraw-Hill Education, 2014, ISBN: 9780071822282.
Reference Books	
1.	VasilisTzivaras, "Building a Quadcopter with Arduino", Packt Publishing, 2016.
2.	Zavrsnik, Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance. Springer, 2015.
3.	Sachi Nandan Mohanty, Drone Technology- Future Trends and Practical Applications, Scrivener Publishing, 2023, ISBN 978-1-394-16653-4
4.	John Baichwal, "Building your own Drones", Que Publishing, 2016.
5	Terry Kilby & Belinda Kilby, "Getting started with Drones", Maker Media, San Francisco, 2015.

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	**AGRICULTURAL ROBOTICS**	L	T	P	C
23RO2020		3	0	0	3

Course Objectives:

Enable the student to:

1. Identify the applications of robots in agriculture.
2. Apply automation technology for precision farming.
3. Develop robotic systems for agricultural applications.

Course Outcomes:

The student will be able to:

1. Outline the basic concepts in precision farming.
2. Select an automation strategy for agricultural applications.
3. Analyze the actuation mechanisms for agricultural applications.
4. Comment on Huma Robot Collaboration in agriculture.
5. Identify agricultural applications that can be automated.
6. Design and develop robotic systems for farm automation.

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

History of Mechanized Agriculture - Farming Operations and Related Machines - Tillage, Planting Cultivation, and Harvesting, Agricultural Automation Applications.		
Module 2	**Precision Agriculture**	**8 Hours**
Sensors – types and agricultural applications, Global Positioning System (GPS) - GPS for civilian use, Differential GPS, Carrier-phase GPS, Real-time kinematic GPS, Military GPS, Geographic Information System, Variable Rate Applications and Controller Area Network		
Module 3	**Actuation and Control**	**7Hours**
Actuators: Pneumatic Hydraulic, Electrical. Nozzles and metering methods, Thermal methods, Optical Methods, Control for Precision Agriculture, Case studies.		
Module 4	**Human Robot Collaboration and Intelligent Systems**	**8 Hours**
Introduction-Interaction roles, Levels of collaboration, Interface design, HRI in agricultural robots, Intelligent Autonomous systems in crop irrigation, future trend.		
Module 5	**Applications**	**8 Hours**
Robots in crop spraying, crop irrigation, weed management and control, orchard management, In-field grading of harvested crops, Case Studies.		
Module 6	**Case studies**	**7 Hours**
Robots in forestry, Advances in Robot milking, Automated meat processing operations, Applications of drones in agriculture.		
	Total Lectures	**45 Hours**

Text Books	
1.	Burleigh Dodds, Robotics and automation for improving agriculture Burleigh Dodds Science Publishing; 1st edition, 2019
2.	Dan Zhang, Bin Wei, Robotics and Mechatronics for Agriculture, CRC Press ,2017.
Reference Books	
1.	Quyen Vu, Vinh Nguyen. Ground and Air Robotic Manipulation Systems in Agriculture Springer, 2022
2.	K R Krishna, Push Button Agriculture Robotics, Drones, Satellite-Guided Soil and Crop Management, AAP , 2016
3.	K.R. Krishna, Aerial Robotics in Agriculture Parafoils, Blimps, Aerostats, and Kites, AAP, 2021
4.	Manoj Karkee and Qin Zhang Editors Fundamentals of Agricultural and Field Robotics, Springer, 2021
5.	Ajit K. Srivastava, Carroll E. Goering, Roger P. Rohrbach, Dennis R. Buckmaster, "Engineering Principles of Agricultural Machines", ASABE Publication, 2012.

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	**ROBOT NAVIGATION AND OBSTACLE AVOIDANCE**	**L**	**T**	**P**	**C**
23RO2021		3	0	0	3

Course Objectives:

Enable the student to:

1. Explore the mathematical concepts involved in robot navigation.
2. Analyze the concepts involved in obstacle detection.
3. Apply various obstacle avoidance techniques.

Course Outcomes:

The student will be able to:

1. Outline the basic concepts of autonomous navigation and path planning.
2. Analyse autonomous navigation and path planning algorithms.
3. Design autonomous navigation and path planning algorithms.
4. Evaluate the effectiveness of different autonomous navigation.
5. Assess the effectiveness of path planning algorithms in different situations.
6. Implement the algorithms in real-world applications.

Module 1	**Introduction**	**7 Hours**
Definition and basic concepts of autonomous navigation and path planning - Applications of autonomous navigation and path planning - Sensors and odometry		
Module 2	**Various techniques and algorithms for Path Planning**	**7 Hours**

Introduction -State estimation methods -Kalman filter-unscented Kalman filter-particle filtering-Camera modelling and calibration-structure from motion- visual motion estimation		
Module 3	**Navigation Techniques and Algorithms**	**7 Hours**
Sensor-based navigation -Dead reckoning -Beacon-based navigation -Landmark-based navigation		
Module 4	**Obstacle Avoidance Techniques**	**8 Hours**
Potential field method - Virtual force field method -Artificial potential fields method		
Module 5	**Optimal Path Planning Techniques and Trajectory Planning**	**8 Hours**
Dijkstra's algorithm - A* algorithm - Probabilistic Road map method - Trajectory planning for Mobile Robots and Unmanned Aircraft System (UAS)		
Module 6	**Case Studies**	**8 Hours**
Introduction to Robot Operating System (ROS), ROS2, and GAZEBO - Real-world case studies and examples of autonomous navigation and path planning - Analysis and evaluation of different techniques and algorithms used in different situations - Performing at least two experiments each with ROS and GAZEBO		
	Total Lectures	**45 Hours**

Text Books	
1.	Steven M. LaValle, Planning Algorithms Hardcover – Illustrated, 29 May 2006
2.	Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, Introduction to Autonomous Mobile Robots", Bradford Company Scituate, USA, 2004.
Reference Books	
1.	Cook G. and Zhang F. "Mobile Robots: Navigation, control and sensing, surface Robots and AUVs", 2nd Edition, IEEE Press, Wiley, 2020.
2.	Nurmaini S. "Intelligent navigation for Embedded mobile robot: The application of embedded controller", LAP Lambert Academic Publishing 2012.
3.	J. J. Graig, "Introduction to Robotics – Mechanics and Control", 2nd edition, Pearson Education, Inc.2004.
4.	Cuesta F. and Ollero A. "Intelligent mobile robot navigation" Springer, Berlin, Heidelberg, 2005.
5.	Matveev A. S., Savkin A. V., Hoy M. and Wang C. "Safe Robot Navigation Among Moving and Steady Obstacles" Butterworth-Heinemann, 2016.

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	**SYSTEM SIMULATION LABORATORY**	**L**	**T**	**P**	**C**
23RO2022		0	0	4	2

Course Objectives:

Enable the student to:

1. Simulate electronic circuits using PSPICE and Proteus.
2. Develop virtual instruments using LabVIEW.
3. Perform system simulation using Automation Studio and MATLAB

Course Outcomes:

The student will be able to:

1. Apply LabVIEW software to develop virtual instruments.
2. Perform process simulation using LabVIEW.
3. Analyse process simulation using Automation Studio.
4. Integrate system components using Automation Studio.
5. Develop MATLAB codes for various programs.
6. Select the appropriate simulation tool for a suitable application.

List of Experiments:

1.	Introduction to PSPICE.
2.	Simulation of electronic circuits using PSPICE.
3.	Introduction to LabVIEW.
4.	Process simulation using virtual instrumentation.
5.	System Analysis using LabVIEW.
6.	Basics of Automation Studio.

7	System simulation using Automation Studio.
8	Process integration using Automation studio.
9	Basics of MATLAB programming.
10	System simulation using MATLAB.
Total Lectures	**60 Hours**
Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	DATA ACQUISITON AND INTERFACING LABORATORY	L	T	P	C
23RO2023		0	0	4	2

Course Objectives:

Enable the student to:

1. Identify the sensing mechanism used in an instrument.
2. Interface sensors and analyse their characteristics.
3. Select appropriate sensing mechanism for a particular application.

Course Outcomes:

The student will be able to:

1. Compare analog and digital sensing techniques,
2. Analyse the sensor performance characteristics.
3. Implement sensor interfacing using proteus.
4. Develop speed and position sensors for robotic systems.
5. Perform proximity, pressure and range sensing using appropriate sensors.
6. Apply suitable sensor technology for agricultural application.

List of Experiments:

1.	Study of analog and digital sensing techniques.
2.	Sensor performance characteristics.
3.	Simulation of hardware interfacing using proteus.
4.	Sensor interfacing simulation using proteus.
5.	Interfacing speed measurement sensors.
6.	Position measurement using optical sensors.
7	Proximity sensor interfacing.
8	Pressure Measurement by interfacing MEMS sensors.
9	Lidar Sensor interfacing for range measurement.
10	Interfacing sensors for agricultural application.
Total Lectures	**60 Hours**
Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	ROBOTICS: SYSTEM AND ANALYSIS	L	T	P	C
23RO3001		**3**	**0**	**0**	**3**

Course Objectives:

Enable the student to:

1. Classify the robots based on configuration.
2. Perform Forward and Inverse Kinematic Analysis of robots.
3. Develop path and trajectory planning applications.

Course Outcomes:

The student will be able to:

1. Compare the anatomy of robot configurations.
2. Analyze the representation of a point in space.
3. Solve forward and inverse kinematic problems.
4. Perform differential kinematic analysis using Jacobian matrix.
5. Derive the robot dynamic equations.
6. Simulate the path and trajectory planning applications for Robots.

Module 1	Introduction	7 Hours

History of Robots, classification, Robot Components: Link, Joint, Manipulator, Wrist, End-effector: Gripper, Types, Actuator and Sensor, Configuration space, Joint Space, Workspace, Robot Specifications, robot programming, applications.		
Module 2	**Homogeneous Transformation**	**8 Hours**
Degrees of Freedom – Matrix Representation: Representation of a point and vector in space, Global and Local Coordinate axes – Homogeneous Transformation Matrices – Transformations: Representation of pure translation, Representation of pure Rotation – Representation of Combined Transformations – Inverse of Transformation Matrices – Euler Angles – Roll, Pitch, Yaw angles		
Module 3	**Forward and Inverse Kinematics**	**8 Hours**
Forward Kinematics of 2 and 3 link manipulator, Denavit-Hartenberg representation, Arm equation, Inverse Kinematic programming, degeneracy and dexterity, differential kinematics, Jacobians, joint space singularities, resolved motion rate control		
Module 4	**Differential Kinematics**	**7 Hours**
Angular Velocity – Linear Velocity – Jacobian representation of Linear and Angular Velocity Calculation of Jacobian for Two, Three and Four axis Robots – Inverse Jacobian – Singularities: Wrist and Arm Singularities -Manipulability – Induced joint torques and forces.		
Module 5	**Robot Dynamics and control**	**8 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, Introduction to Robot controller with feedback		
Module:6	**Path and Trajectory Planning**	**7 Hours**
Path versus Trajectory, Joint-Space versus Cartesian-Space Descriptions, Basics of Trajectory Planning, Joint-Space Trajectory Planning, Cartesian-Space Trajectories, Continuous Trajectory Recording. Simulation and Case Studies		
	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.	Robert J. Schilling, "Fundamentals of Robotics, Analysis and Control", PHI Learning, 2009.
5.	Saha S K, "Introduction to Robotics", Tata McGraw Hill Education Pvt. Ltd, 2010.

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	HUMANOID ROBOTICS	L	T	P	C
23RO3002		**3**	**0**	**0**	**3**

Course Objectives:

Enable the student to:
1. Outline the mechanism of humanoid robots.
2. Develop a simple humanoid robot.
3. Select suitable control and balancing methods of humanoid robots.

Course Outcomes:

The student will be able to:
1. Classify the types of humanoid robots.
2. Apply kinematics and dynamic analysis to humanoid robots.
3. Summarize the methods for gait generation.
4. Identify humanoid sensing and actuation mechanism.
5. Analyze the walking pattern generations of humanoid robots.
6. Apply humanoid robots for day- to-day applications.

Module 1	**Humanoid Mechanism and Design**	**7 Hours**
Introduction: Humanoid Mechanism and Design - Leg Mechanism of LOLA - Compliant Leg Mechanism of Coman - Human-Like Toe Joint Mechanism -Wire Driven Multi-fingered Hand - DLR Multi-Fingered Hands – Under actuation with Link Mechanisms – Barrett Hand Grasper: Programmable Flexible Part Handling and Assembly - Human-Like Hand Mechanism Human-Like Face and Head Mechanism -		

Mechanism Design of Human-Like HRP-4C -Mechanism Design Outline of Hubo -Mechanism Design of DLR Humanoid Robots		
Module 2	**Humanoid Kinematics and Dynamics**	**8 Hours**
Historical Perspective and Scope - Differential Kinematics - Dynamics Analysis: Equations of Motion - Dynamic Formulations and Computational Algorithms - Contact Dynamics - Reduced-Order Models - Calibration and Parameter Estimation - A Comparative Study Between Humans and Humanoid Robots		
Module 3	**Humanoid Control and Balance**	**7 Hours**
Linear Inverted Pendulum-Based Gait - Gait Based on the Spring-Loaded Inverted Pendulum - Limit Cycle Gaits - Neuromuscular Control Models of Human Locomotion Compliance/Impedance Control Strategy for Humanoids - Passivity-Based Control Strategy for Humanoids - Model Predictive Control - Humanoid Body Control Using Neural Networks and Fuzzy Logic -Whole-Body Control of Humanoid Robots -Introduction to Humanoid Balance - Human Sense of Balance - Torque-Based Balancing - Angular Momentum-Based Balance Control - Stepping for Balance Maintenance Including Push-Recovery - Feedback Control of Inverted Pendulums -Balancing via Position Control - Optimization-Based Control Approaches to Humanoid Balancing		
Module 4	**Humanoid Motion Planning, Optimization, and Gait Generation**	**8 Hours**
Introduction: Motion Planning, Optimization, and Biped Gait Generation - Whole-Body Motion Planning - Obeying Constraints During Motion Planning - Manipulation and Task Execution by Humanoids - Human Motion Imitation - Principles Underlying Locomotor Trajectory Formation - Biped Footstep Planning - Adaptive Locomotion on Uneven Terrains - SLAM and Vision-based Humanoid Navigation		
Module 5	**Humanoid Sensing, Actuation, and Intelligence**	**8 Hours**
Pneumatic Prime Movers - Transmissions - Importance of Humanoid Robot Detection - Humanoid Multi-robot Systems - Multi-Axis Force-Torque Sensor - Applications of IMU in Humanoid Robot - Range Sensors: Ultrasonic Sensors, Kinect, and LiDAR - Tactile Sensing - Sensor Fusion and State Estimation of the Robot		
Module 6	**Applications of Humanoids**	**7 Hrs**
Introduction - Humanoid Robots for Entertainment - Humanoid Robots in Education-Application of Next age: Next-Generation Industrial Robot -Toward New Humanoid Applications: Wearable Device Evaluation Through Human Motion Reproduction - Inclusion of Humanoid Robots in Human Society: Ethical Issues		
	Total Lectures	**45**

Reference Books	
1	Goswami Ambarish, Vadakkepat Prahlad, "Humanoid Robotics: A Reference", Springer, 2019.
2	Shuji Kajita et. al., “Introduction to Humanoid Robotics”, Springer, 2014.
3	John J Craig, "Introduction to Robotics: Mechanics and Control", Third Edition, 2003.
4	Lorenzo Sciavicco and Bruno Siciliano, "Modelling and Control of Robot Manipulators"., Springer, 2001
5	Jean-Claude Latombe, "Robot Motion Planning", Springer Science, 1991.

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

Course Code	**QUADRUPED ROBOTS**	**L**	**T**	**P**	**C**
23RO3003		**3**	**0**	**0**	**3**

Course Objectives:

Enable the student to:

1. Acquire knowledge on the concept of Quadruped robots.
2. Classify various gaits for quadruped robots.
3. Apply kinematics and dynamic analysis to Quadruped robots.

Course Outcomes:

The student will be able to:

1. Outline the working of walking robots.
2. Classify various generation of periodic gaits.
3. Analyze the stability analysis of Quadruped robots.
4. Apply kinematics and dynamics analysis for walking robots.
5. Demonstrate the use of soft computing and virtual sensors in quadruped robots.

6. Apply soft computing methods for walking robots.		
Module 1	**Walking Robots**	**7 Hours**
Walking Robots – Introduction, Stability in Walking Robots, Generation of Periodic Gaits, Gait Generation, Continuous Gaits, Discontinuous Gaits, Two-phase Discontinuous Gaits, Four-Phase Discontinuous Gaits, Two-phase Discontinuous Crab Gaits		
Module 2	**Generation of discontinuous Gaits**	**8 Hours**
Strategy for Discontinuous Walking, Discontinuous Turning Gaits, Circling Gaits, Spinning Gaits, Path Tracking with Discontinuous, Generation of Non-Periodic Gaits, Free-crab Gait, Free Turning Gaits, Free Spinning Gaits		
Module 3	**Stability**	**7 Hours**
New Approaches to Stability, Geometric Stability and Required Torques, Effects of Considering a Limited, Motor Torque: Simulation Study, Global-stability Criterion, Control Techniques		
Module 4	**Kinematics and Dynamics**	**8 Hours**
Kinematics and Dynamics, Forward Kinematics: The Denavit-Hartenberg Convention, Inverse Dynamics of Walking Robots, The Complete Dynamic Model		
Module 5	**Soft Computing Techniques**	**8 Hours**
Improving Leg Speed by Soft Computing Techniques, Improving Leg Speed in On-line Trajectory Generation, The Acceleration Tuning Approach, Experimental Workspace Partitioning, Fuzzy Sets and Rules, Fuzzy Inference Map		
Module 6	**Virtual Sensors**	**7 Hours**
Virtual Sensors for Walking Robots, Virtual Sensors Based on Neural Networks, Virtual sensor Design, Using Virtual Sensors in Real Walking, The Neural Network, Human-machine Interfaces.		
	Total Lectures	**45 Hours**

Reference Books

1	Pablo Gonzalez de Santos, Elena Garcia and Joaquin Estremera, “Quadrupedal Locomotion - An Introduction to the Control of Four-legged Robots”, Springer, 2006.
2	Alexander, R. N., “Terrestrial Locomotion, Mechanics and Energetics of Animal Locomotion”, Alexander, R.N. and Gold spink, G., editors. Chapman and Hall, London, 1977.
3	D.J. Todd, “Walking machines: an introduction to legged robots”. ISBN: 0850389321
4	Berns, K. “The Walking Machine Catalogue”, 2005
5	Craig, J. J., “Introduction to Robotics”, Addison-Wesley, 2nd edition, 1989.

Recommended by Board of Studies	
Approved by Academic Council	25 Aug 2023

DEPARTMENT OF ROBOTICS ENGINEERING

LIST OF NEW COURSES

S. No	Course Code	Course Title	Hours per week			Credits
			L	T	P	
1	21RO2009	Natural Language Processing Applications	3	0	0	3
2	21RO2010	Reinforcement Learning	3	0	0	3
3	21RO2011	Intelligent Robotics Laboratory	0	0	4	2
4	21RO2012	Robotics and its Applications	3	0	0	3
5	21RO2013	Introduction to Automation	3	0	0	3
6	21RO3006	Autonomous Mobile Robots	3	0	0	3
7	22RO1001	Material Science	3	0	0	3
8	22RO1002	Fundamentals of Python Programming for Robotics	3	0	3	4.5
9	22RO1003	Basic Robotics Laboratory	0	0	2	1
10	22RO2001	Electrical Circuit Analysis	3	1	0	4
11	22RO2002	Electrical Machines and Drives	3	0	0	3
12	22RO2003	Sensor Signal Conditioning Circuits	3	0	0	3
13	22RO2004	Sensor Signal Conditioning Circuits Laboratory	0	0	2	1
14	22RO2005	Microcontrollers and Embedded Systems Laboratory for Robotics	0	0	2	1
15	22RO2006	Programmable Logic Controller Laboratory	0	0	2	1
16	22RO2007	Robotics Laboratory	0	0	2	1
17	22RO2008	Vision and Image Processing Laboratory	0	0	2	1
18	22RO2009	Under Water Robotics	3	0	0	3
19	22RO2010	Aerial Robotics	3	0	0	3
20	22RO2011	Robotics Process Automation	3	0	0	3
21	22RO3001	Advanced Robotics Laboratory	0	0	4	2
22	22RO3002	Advanced Soft Robots for Healthcare Applications	3	0	0	3
23	22RO3003	Robot Economics	3	0	0	3
24	22RO3004	Cybernetics	3	0	0	3
25	22RO3005	Real-Time Operating System	3	0	0	3
26	22RO3006	Artificial Intelligence In Robotics and Automation	3	0	0	3

Course Code	NATURAL LANGUAGE PROCESSING APPLICATIONS	L	T	P	C
21RO2009		3	0	0	3

Course Objectives:

Enable the student to:

1. learn the leading trends and systems in natural language processing
2. obtain knowledge on significance of pragmatics for natural language understanding.
3. gain application based knowledge on natural language processing and to show the points of syntactic, semantic and pragmatic processing.

Course Outcomes:

The student will be able to:

1. describe the real-world applications of NLP
2. summarize the approaches to syntax and semantics in NLP.
3. explain the concepts of discourse, generation, dialogue and summarization within NLP.
4. discuss the fundamentals of Robotic Natural Language Understanding
5. compare the machine learning techniques used in NLP
6. build text based dialogue systems

MODULE: 1	OVERVIEW OF NLP	7 Hours

Introduction, History, Early work in NLP, Example of real-world applications that use NLP: Siri, Cortana, Bixby, Phone operators, Google Home.

MODULE: 2	BASICS OF NATURAL LANGUAGE PROCESSING	9 Hours

Natural Language Processing, Parts of NLP, Levels of NLP, Corpus, Tokens, and Engrams, Tokenization, White-space Tokenization, Regular Expression Tokenization, Normalization, Stemming, Lemmatization, Part of Speech tags in NLP.		
MODULE: 3	**GRAMMAR IN NLP AND NLP PYTHON LIBRARIES**	**8 Hours**
Introduction, Different Types of Grammar in NLP, Context-Free Grammar (CFG), Constituency Grammar (CG), Dependency Grammar (DG), Natural Language Toolkit (NLTK), TextBlob, CoreNLP, Gensim, spaCy, polyglot, scikit–learn, Pattern.		
MODULE: 4	**FUNDAMENTALS FOR ROBOTIC NATURAL LANGUAGE UNDERSTANDING**	**8 Hours**
Introduction, Natural Language Understanding in Accordance with Semiotics (**Syntax, Semantics, Pragmatics**), Semantic Analysis and Pragmatic Analysis, Robust Natural Language Understanding, Response Synthesis, Syntax and Semantics of Discourse.		
MODULE: 5	**NEURAL NETWORKS WITH NLP**	**7 Hours**
Neural Networks with NLP, Introduction to Recurrent Neural Networks (RNN), Inside Recurrent Neural Networks, RNN architectures, Long-Dependency Problem, Predict House Prices with an RNN, Long Short-Term Memory, Predict the Next Solution of a Mathematical Function, Introduction to Neural Language Models, RNN Language Model, Encoding a Small Corpus, The Input Dimensions of RNNs, Predict the Next Character in a Sequence.		
MODULE: 6	**BUILD A TEXT-BASED DIALOGUE SYSTEM (CHATBOT)**	**6 Hours**
Introduction, Word Representation in Vector Space, Word Embeddings, Cosine Similarity, Word2Vec, Problems with Word2Vec, Gensim, Creation of a Word Embedding- Global Vectors (GloVe)Using a Pretrained GloVe to See the , Distribution of Words in a Plane, Dialogue Systems, Tools for Developing Chatbots, Types of Conversational Agents, Classification by Input-Output Data Type, Classification by System Knowledge, Creation of a Text-Based Dialogue System Create Your First Conversational Agent, Create a Conversational Agent to Control a Robot.		
Total Lectures		**45 Hours**

Text Books:	
1.	Alberola, Á. M., Gallego, G. M., & Maestre, U. G. (2019). *Artificial vision and language processing for robotics.* Packt Publishing. ISBN: 9781838552268.
2.	Yokota, M. (2020). *Natural language understanding and cognitive robotics*. CRC Press. ISBN: 9781032087481
Reference Books:	
1.	Zhang, Y., & Teng, Z. (2021). *Natural language processing: A machine learning perspective*. Cambridge University Press. ISBN: 9781108420211
2.	Vajjala, S., Majumder, B., Gupta, A., & Surana, H. (2020). *Practical natural language processing: A comprehensive guide to building real-world NLP systems*. O'Reilly Media. ISBN: 9781492054054
3.	Bird, S., Klein, E., & Loper, E. (2009). *Natural language processing with Python*. O'Reilly Media. ISBN: 978-0596516499
4.	Hapke, H., Howard, C., & Lane, H. (2019). *Natural language processing in action: Understanding, analyzing, and generating text with Python*. Simon & Schuster. ISBN 9781617294631.

Recommended by Board of Studies	
Approved by Academic Council	18th December 2021

Course Code	REINFORCEMENT LEARNING	L	T	P	C
21RO2010		3	0	0	3

Course Objectives:

Enable the student to:

1. gain a clear and simple understanding of the key ideas and algorithms of reinforcement learning.
2. explore how the learning is valuable to achieve goals in the real world.

3. explore real-life environments while choosing from an arbitrary number of possible actions, rather than from the limited options of a video game.
Course Outcomes:
The student will be able to: 1. describe the need for machine learning for various problem solving 2. discuss the basics of Reinforcement Learning 3. explain various tabular solution methods 4. summarize the approximate solution methods 5. analyze classic conditioning methods and explore few applications 6. recognize current advanced techniques and applications in RL

MODULE: 1	**INTRODUCTION**	**8 Hours**
Introduction to Reinforcement Learning, Examples of Reinforcement Learning, History of Reinforcement Learning, Elements of Reinforcement Learning, Limitations and Scope, An Extended Example: Tic-Tac-Toe.		
MODULE: 2	**REINFORCEMENT LEARNING CONCEPT AND TERMINOLOGY**	**8 Hours**
Reinforcement Learning concept and terminology, how to use reinforcement learning, Agent – can be associated with the program that is run of CPU (robot brain), Environment, Action space, Reward, Observation, State, Transition, Markov Decision Process (MDP).		
MODULE: 3	**INTRODUCTION TO TABULAR SOLUTION METHODS**	**8 Hours**
Multi-arm Bandits, Epsilon Greedy Approach, Upper Confidence Bound, Bellman equation approach		
MODULE: 4	**MONTE CARLO METHODS**	**8 Hours**
Monte Carlo Prediction, Monte Carlo Estimation of Action Values, Monte Carlo Control, Monte Carlo Control without Exploring Starts, Off-policy Prediction via Importance Sampling, Incremental Implementation		
MODULE: 5	**TEMPORAL-DIFFERENCE METHODS**	**7 Hours**
TD Prediction, Advantages of TD Prediction Methods, Optimality of TD, Sarsa: On-Policy TD Control, Q-Learning: Off-Policy TD Control		
MODULE: 6	**CASE STUDY AND COURSE PROJECT**	**6 Hours**
Deploy the Q-learning algorithm to solve a maze environment with 3 obstacles for a flying drone.		
Total Lectures		**45 Hours**

Text Books:	
1.	Sutton, Richard S., and Andrew G. Barto., (2018) *Reinforcement learning: An introduction*. MIT press. ISBN: 9780262039246
2.	Phil Winder, (2021), *Reinforcement Learning*, O'Reilly Media ISBN: 9781098114831
Reference Books:	
1.	Graesser, Laura, and Wah Loon Keng. (2019) *Foundations of deep reinforcement learning: theory and practice in Python*. Addison-Wesley Professional, ISBN: 9780135172490
2.	Szepesvári, Csaba. (2010) "*Algorithms for reinforcement learning*." Synthesis lectures on artificial intelligence and machine learning 4. ISBN: 1608454924
3.	Dong, Hao, Hao Dong, Zihan Ding, Shanghang Zhang, and Chang. (2020) *Deep Reinforcement Learning*. Springer Singapore. ISBN: 9789811540950
4.	Ravichandiran, Sudharsan. (2018) *Hands-on reinforcement learning with Python: master reinforcement and deep reinforcement learning using OpenAI gym and tensorFlow*. Packt Publishing Ltd. ISBN: 9781788836524
5.	https://www.theconstructsim.com/robotigniteacademy_learnros/ros-courses-library/reinforcement-learning-for-robotics/

Recommended by Board of Studies	
Approved by Academic Council	18th December 2021

Course Code	**INTELLIGENT ROBOTICS LABORATORY**	**L**	**T**	**P**	**C**
21RO2011		0	0	2	1
Course Objectives:					
Enable the student to:					

1. learn the practical aspects of computer vision like object and colour detection 2. gain insight on application-based experiments on intelligent robotic systems 3. understand implementation of face detection and recognition applications	
Course Outcomes:	
The student will be able to: 1. install IDE for computer vision applications 2. perform simple operations using webcam 3. implement communication set up using Arduino 4. build simple application projects using Intelligent Robot systems 5. write intelligent algorithms for face detection and recognition 6. implement Face Attendance Systems using intelligent techniques	
List of Experiments	
1.	Computer Vision with Jetson Nano, Installations -Downloads, Setup, IDE
2.	Image Video Webcam, Common Functions, Resize and Crop, Draw Shapes and Text
3.	Object Detection, Color Detection, Contours/Shape Detection
4.	Arduino Communication-Arduino Installation, Serial Receive Arduino, Serial Receive Python, Serial Send Arduino, Serial Send Python
5.	Eye Tracking
6.	Robot Car
7.	Lane Follower
8.	Face Detection
9.	Face Recognition
10.	Face Attendance
Total Lectures	**36 Hours**
Recommended by Board of Studies	
Approved by Academic Council	18th December 2021

Course Code	ROBOTICS AND ITS APPLICATIONS	L	T	P	C
21RO2012		3	0	0	3

Course Objectives:		
Enable the student to: 1. gain the fundamental understanding of the robots and their characteristics 2. obtain knowledge on fixed base and mobile robots and their working principles 3. identify the various areas of application for inclusion of the robotic technology.		
Course Outcomes:		
The student will be able to: 1. describe the concept of robots and robotics 2. identify and select sensors and actuators robotic applications 3. analyse the working principle of the serial chain manipulators 4. elaborate on the principle and characteristics of mobile robots 5. identify the robotic technology used in the different domains 6. discuss different applications of the robots in several applications.		
MODULE: 1	**INTRODUCTION**	**7 Hours**
Introduction, robot definitions by different agencies, history of robotics, laws of robotics, advantages and disadvantages, degrees of freedom, robot joints, robot coordinates, reference frames, characteristics of robots, workspace, applications, other robots and applications, social issues.		
MODULE: 2	**SENSORS AND ACTUATORS**	**9 Hours**
Introduction, sensor characteristics, sensor utilization, position sensors, velocity sensors, acceleration sensors, force sensors, miscellaneous sensors. Introduction to actuators, pneumatic, hydraulic and electric actuators, characteristics and control, applications.		
MODULE: 3	**INDUSTRIAL ROBOT MANIPULATORS**	**8 Hours**

Introduction, serial robots and parallel robots, classification of serial chain manipulators, mapping, homogeneous transformation, end-effectors, introduction to forward and inverse kinematic analysis.		
MODULE: 4	**MOBILE ROBOTS**	**8 Hours**
Introduction, locomotion and its key issues, classification of mobile robots, wheeled mobile robots, wheel design, wheel geometry, stability, maneuverability, controllability, degrees of freedom, introduction to mobile robot kinematics, applications.		
MODULE: 5	**MODERN ROBOTIC SYSTEMS**	**7 Hours**
Introduction, intelligence and autonomy, collaborative robots, humanoid robots, aerial robots, underwater robots, surgical robots, space robots, intelligent vehicles.		
MODULE: 6	**APPLICATIONS OF ROBOTS**	**6 Hours**
Introduction, Industrial applications: object manipulation, assembly, spray painting, welding, palletizing and depalletizing. Medical Applications: Robot based surgery, rehabilitation and assistive applications. Inspection: surveillance using wheeled mobile robots and UAVs. Entertainment: social applications of humanoids and other robotic systems. Domestic applications: house hold robotic systems and applications in indoor environment.		
Total Lectures		**45 Hours**

Text Books:	
1.	Saeed B Niku, (2019), *Introduction to Robotics, analysis, control and applications*, Wiley Publications. ISBN: 978-1-119-52760-2
2.	M.P. Groover, (2012), *Industrial Robotics- Technology, Programming, and Applications*, Tata Mcgraw Hill Publications. ISBN-13: 978-1259006210
Reference Books:	
1.	Roland Seigwart, (2011), *Introduction to Autonomous Mobile Robots*, The MIT Press Cambridge. ISBN: 9780262015356
2.	R.K. Mittal and I.J. Nagrath, (2003), *Robotics and Control,* Tata Mcgraw Hill Publications. ISBN: 9780070482937
3.	Asitava Ghosal, (2006), *Robotics: Fundamental Concepts and Analysis*, The MIT Press Cambridge. ISBN: 978-0195673913
4.	Fu K.S, Gonzalez R.C., Lee C.S.G., (2008), *Fundamental of Robotics*, McGraw Hill Publication. ISBN: 9780070265103
5.	J.J Craig, *Introduction to Robotics: Mechanics and Control*, Prentice Hall Publication. ISBN: 9788131718360

Recommended by Board of Studies	
Approved by Academic Council	18th December 2021

Course Code	**INTRODUCTION TO INDUSTRIAL AUTOMATION**	**L**	**T**	**P**	**C**
21RO2013		3	0	0	3

Course Objectives:

Enable the student to:
1. gain knowledge in the basics of Industrial Automation
2. understand types of Automation done in industries
3. learn the theory of PLC and its Programming concepts.

Course Outcomes:

The student will be able to:
1. describe the different types of Industrial Automation
2. identify the Assembly Systems
3. develop techniques for automation in Material Handling
4. design Inspection systems for industries.
5. apply PLC architecture knowledge to select PLC for specific problems.
6. model applications using PLC

MODULE 1:	INTRODUCTION	7 Hours
Introduction: Definition, automation principles and strategies, scope of automation, socio-economic consideration, low-cost automation, Production concepts and automation strategies. Fixed Automation, Automated Flow Lines, Flexible Manufacturing for automation		
MODULE 2:	**SENSORS AND ACTUATORS**	**7 Hours**
Assembly Systems and Line Balancing, Assembly Process, Assembly Systems, Manual Assembly Lines, Methods of Line Balancing, Computerized Line Balancing Methods, Part Placement.		
MODULE 3:	**INDUSTRIAL ROBOT MANIPULATORS**	**7 Hours**
Material handling function, Types of Material Handling Equipment, Design, Conveyor Systems, Automated Guided Vehicle Systems.		
MODULE 4:	**AUTOMATED INSPECTION AND TESTING**	**8 Hours**
Statistical Quality Control, Automated Inspection Principles and Methods, Sensor Technologies for Automated Inspection, Coordinate Measuring Machines, Machine Vision.		
MODULE 5:	**PROGRAMMABLE LOGIC CONTROLLERS**	**8 Hours**
Programmable Logic Controllers (PLCs): Introduction, Definition & history of the PLC, PLC Architecture. PLC advantage & disadvantage, Processor Memory Organization, programming equipment, proper construction of PLC ladder diagrams, Program Scan Programming Devices.		
MODULE 6:	**INTRODUCTION TO PLC PROGRAMMING CONCEPTS**	**8 Hours**
The Binary Concept, developing circuits from Boolean Expression expressions, Producing the Boolean equation from given circuit, Hardwired logic versus programmed logic, writing a ladder logic program directly from a narrative description, Instruction addressing, Creating Ladder Diagrams from Process Control Descriptions		
Total Lectures		**45 Hours**

Text Books:

1.	Mikell P. Groover, (2015), *Automation, Production Systems and Computer-Integrated Manufacturing, Fourth edition*, Pearson Publishers. ISBN: 978-9332572492.
2.	Stephen J. Derby, (2004), *Design of Automatic Machinery, Special Indian Edition*, Marcel Decker. ISBN: 978-0824753696.

Reference Books:

1.	Groover M. P., (2012), *Industrial Robotics, Technology, Programming and Application*, McGraw Hill Book and Co. ISBN- 9781259006210.
2.	C. RayAsfahl, (2010), *Robots and manufacturing Automation*, John Wiley and Sons New York. ISBN: 978-0-471-55391-5
3.	StamatiosManesis, George Nikolakopoulas, (2018), *Introduction to Industrial Automation* CRC Press. ISBN: 978-1498705400
4.	John W Webb & Ronald A Reis, (2015), *Programmable logic controllers: Principles and Applications*, Prentice Hall India. ISBN13: 9780130416728

Recommended by Board of Studies	
Approved by Academic Council	18th December 2021

Course Code	AUTONOMOUS MOBILE ROBOTS	L	T	P	C
21RO3006		3	0	0	3

Course Objectives

Enable the student to:

1. learn concepts of Sensing and Controlling the Autonomous Mobile Robots
2. understand kinematics models of Mobile Robots
3. acquire knowledge in fundamentals of ROS

Course Outcomes

The student will be able to

1. classify and describe the various types of Mobile Robots 2. describe the kinematic models and manoeuvrability of Robots 3. identify the sensing elements and actuators used in mobile robots 4. create solutions to localize, plan and navigate the mobile robots using various techniques 5. develop path planning algorithm for Robot navigation 6. apply the concept of ROS for mobile robots in various applications		
MODULE: 1	**INTRODUCTION**	**5 Hours**
History of Robots – Autonomous Robots – Robot Arm Manipulators – Mobile Robots – Multi-Robot System and Swarms. 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. Mobile Robot Manoeuvrability: Degree of mobility - Degree of steerability. Mobile Robot Workspace - Degrees of freedom - Holonomic robots - Path and trajectory considerations.		
MODULE: 3	**PERCEPTION**	**8 Hours**
Sensors for Mobile Robots: Characterizing sensor performance - Representing uncertainty - Wheel/motor sensors - Heading sensors – Accelerometers – Inertial Measurement Unit (IMU) – GPS - 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.		
MODULE: 4	**MOBILE ROBOT LOCALIZATION**	**8 Hours**
Introduction to Map based localization-Markov Approach-Kalman Filter Approach. SLAM: The SLAM Problem-Monocular SLAM and beyond-Extended Kalman Filter SLAM.		
MODULE: 5	**PLANNING AND NAVIGATION**	**10 Hours**
Motion Planning – Representation and Configuration Space-Graph Search Methods-Collision Avoidance-Sampling based planning-Planning under motion constraints-Dijkstra's algorithm and the motion window.		
MODULE: 6	**ROS**	**7 Hours**
Introduction to ROS: Services, Actions and Nodes. Software representation of a Robot using Unified Robot Description Format (URDF) - ROS parameter server and adding real-world object representations to the simulation environment. Autonomous Navigation: Map creation with GMapping. Motion planning, pick and place behaviours using ROS MoveIt!		
Total Lectures		**45 Hours**

Reference Books	
1.	Nourbakhsh, I. R., Siegwart, R., Scaramuzza, D. (2011). *Introduction to Autonomous Mobile Robots*. United Kingdom: MIT Press.
2.	Eugene Kagan, Shvaib, Irad Ben-Gal, (2019) *Autonomous Mobile Robots and Multi-Robot Systems: Motion-Planning, Communication, and Swarming*. United Kingdom: Wiley.
3.	Burgard, W., Thrun, S., Fox, D., Arkin, R. C. (2005). *Probabilistic robotics*. Cambridge: MIT Press.
4.	Newman, W. (2017). *A Systematic Approach to Learning Robot Programming with ROS*. United States: CRC Press.
5.	AnisKoubaa, (2018) *Robot Operating System (ROS): The Complete Reference (Volume 1-4)*. Germany: Springer International Publishing.

Recommended by Board of Studies	
Approved by Academic Council	18th December 2021

Course code	MATERIAL SCIENCE	L	T	P	C
22RO1001		**3**	**0**	**0**	**3**
Course Objective					

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 Outcome		
At the end of this course, students 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. Outline 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 -Time scale for phase change, T-T-T-diagram for eutectoid steel		
Module: 3	**Electrical Properties**	**9 Hrs**
Conducting materials-quantum free electron theory -Fermi Dirac Statistics-Band theory of solids - the density of states. Magneto striction. 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**
Concepts of stress and strain- Elastic deformation, plastic deformation, Hardness- Rockwell hardness test, Brinell Hardness test, Knoop and Vickers hardness test, Dislocation, Slip system, Deformation by twinning, Mechanism of strengthening materials- Grain size reduction, solid solution strengthening, strain hardening, Precipitation hardening, mechanisms of creep - creep-resistant materials - fracture - the Griffith criterion - - fatigue failure - fatigue tests - methods of increasing fatigue life		
Module: 5	**Magnetic, Dielectric and Superconducting Materials**	**8 Hrs**
Ferromagnetism – domain theory — 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-nano materials-physical properties and applications.		
	Total Lectures	**45**

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.

Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	**FUNDAMENTALS OF PYTHON PROGRAMMING FOR ROBOTICS**	**L**	**T**	**P**	**C**
22RO1002		**3**	**0**	**3**	**4.5**
Course Objective					

To impart knowledge on

1. Important libraries of Python, programming styles and idioms.
2. Core Python scripting elements such as variables and flow control structures.
3. Applications using Python for robotics.

Course Outcome

The student will be able to

1. Outline the structure and components of a Python program.
2. Describe loops and decision statements in Python.
3. Illustrate class inheritance in Python for reusability
4. Select lists, tuples, and dictionaries in Python programs.
5. Assess object-oriented programs with Python classes and GUI.
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 Classes and Graphical User Interfaces	8 Hours

Design with Classes- Objects and Classes, Data Modeling and Structuring Classes with Inheritance and Polymorphism. GUI-Based Programs

Module: 6	Micro Python	7 Hrs

Micro Python: Micro Python Hardware- Workflow-setting up Micro Python 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

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 Micro Python- Embedded Programming with Microntrollers & Python, O'Reilly, 2018.
Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	**BASIC ROBOTICS LABORATORY**	**L**	**T**	**P**	**C**
22RO1003		0	0	2	1

Course Objective:

To impart knowledge on

1. Components of Robot Anatomy
2. Implementation of sensor and controller circuits for Robot design.
3. Robot Programming for specific applications.

Course Outcome:

The student will be able to

1. Identify the components of Robot
2. Perform simulation of sensor and actuator interfacing
3. Demonstrate the robot programming techniques
4. Design robot controllers
5. Develop simple Robotic applications
6. Build Robot Models using Lego Mindstorms

List of Experiments

1.	Hardware elements of Robot- Study
2.	Simulation of Sensor interfacing
3.	Simulation of Motor Control
4.	Robot Programming Techniques
5.	Real time interfacing of Sensors and actuators
6.	Design of Controllers
7.	Design of a Robot for Pick and Place Operations.
8.	Design of Line follower Robot
9.	Design of Obstacle Avoidance Robot
10.	Design of Wifi controlled Robot
11.	IoT based Robot Navigation
12.	Design and Programming of simple robots using Lego Mindstorms
Total Lectures	**48 Hours**

Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	**ELECTRICAL CIRCUIT ANALYSIS**	**L**	**T**	**P**	**C**
22RO2001		**3**	**1**	**0**	**4**

Course Objective

To impart knowledge on

1. Basics of electric circuits and networks
2. Network Theorems and their applications
3. Circuit Analysis using Laplace Transforms

Course Outcome

At the end of the course students will be able to

1. Identify the various circuit elements, and their characteristics.
2. Analyze the circuits using KVL, KCL, Mesh and Nodal analysis techniques and theorems.
3. Solve first order and second order differential equations to obtain the transient responses
4. Describe fundamental concepts used in single phase, three phase AC circuits and coupled circuits.
5. Apply Laplace transform techniques to examine the behavior of resonant circuits and tuned coupled circuits.
6. Derive the parameters of two port networks

Module: 1	**Mesh and Nodal Analysis**	**7 Hrs**

Analysis with dependent voltage source and current sources. Node and Mesh analysis. Concept of duality and dual networks		
Module: 2	**Network Theorems**	**10 Hrs**
Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum power transfer theorem, Reciprocity theorem, Compensation Theorem.		
Module: 3	**Solution of First Order and Second Order Networks**	**8 Hrs**
Solution of first order and second order differential equation for series and parallel R-L, R-C and R-L-C networks. Initial and final conditions in network elements. Forced and free responses, Time constants, Steady state and transient state responses.		
Module: 4	**Sinusoidal Steady State Analysis**	**11 Hrs**
Representation of Sine function as a rotating phasor, phasor diagrams, impedances and admittances. AC circuit analysis, Effective or RMS value, Average power and complex power. Three phase circuits-. Coupled circuits. Dot convention in coupled circuits, Ideal transformer.		
Module: 5	**Electric Circuit Analysis Using Laplace Transform**	**9 Hrs**
Review of Laplace Transform. Analysis of Electric Circuits using Laplace transform for standard inputs, Convolution integral, Inverse Laplace transform, Transformed network with initial condition. Transfer function representation. Poles and zeros.		
Module: 6	**Two Port network and Network Functions**	**15 Hrs**
Two port networks, terminal pairs, Relationship of two port variables, Impedance parameters, Admittance parameters, Transmission parameter and Hybrid Parameters.		
	Total Lectures	**60**

Text Books	
1.	William H. Hayt Jr, Jack E. Kemmerly and Steven M. Durbin, "Engineering Circuits Analysis", Tata McGraw Hill Publishing Company Limited, New Delhi, 8thEdition, 2013.
2.	Sudhakar A., Shyammohan S Palli, "Circuits & Networks: Analysis and Synthesis", Tata McGraw Hill Publishing Company Limited, New Delhi, 3rd Edition, 2006.
Reference Books	
1.	Joseph A. Edminister, Mahmood Nahri, "Electric Circuits", Schaum's series, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2010.
2.	Van Valkenburg M.E., "Network Analysis", Pearson Education India, 3rd Edition, 2015.
3.	Roy Choudhuri D., "Networks and Systems", New Age International Private Limited, 2nd Edition, 2013.
4.	Alexander C.K., Sadiku M.N.O., "Fundamentals of Electric Circuits", McGraw Hill Education Series, New York, 5th Edition, 2013
5.	Murthy K.V.V., Kamath M.S., "Basic Circuit Analysis", Jaico Publications, 1st Edition, 2002.

Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	**ELECTRICAL MACHINES AND DRIVES**	**L**	**T**	**P**	**C**
22RO2002		**3**	**0**	**0**	**3**

Course Objective

To impart knowledge on

1. Characteristics of DC and AC motors.
2. Selection of drive for a given application.
3. Speed control of DC and AC motor using Solid state converters.

Course Outcome

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

1. Describe the operating principles of DC and AC motors.
2. Classify the methods of speed control of DC and AC motors.
3. Summarize the factors for selection of drive, various load patterns and power rating.
4. Discuss the working of various power semiconductor devices.
5. Outline the working of various power converters and inverters.
6. Analyze the control of DC and AC motors with solid state power converters and inverters.

Module: 1	**Electric Motors**	**7 Hrs**

Introduction - Construction – Principle of operation – DC Motor (BLDC), Three Phase Induction Motor, Servo Motor, Stepper Motor, Synchronous Motor (PMSM), Reluctance Motor.		
Module: 2	**Speed Control**	**8 Hrs**
Speed control methods - DC Motor – Ward-Leonard system – three phase induction motor - Stator Voltage Control Method and V/F Method. Torque-speed characteristics - DC Motor (BLDC), Three Phase Induction Motor, Servo Motor, Stepper Motor, Synchronous Motor (PMSM), Reluctance Motor.		
Module: 3	**Starting, Braking And Applications**	**8 Hrs**
Starting and Electric Braking – DC Motor and 3-ph IM, Application in Robotics - DC Motor (PMBLDC), AC Motor (Three Phase Induction Motor), Servo Motor, Stepper Motors, Synchronous Motor (Permanent Magnet SM and Reluctance Motors) – Case Studies		
Module: 4	**Electric Drives**	**7 Hrs**
Block Diagram - classification of Electrical Drives – Selection & factors influencing the selection – closed loop control of drives – heating and cooling curve; classes of motor duty – determination of motor rating.		
Module: 5	**Power Semiconductor Devices And Power Electronic Converters**	**7 Hrs**
Power Semiconductor Devices - Basic structure and operation of MOSFET, IGBT, GTO and SCR; Power Electronic Converters – Basic structure and operation of Rectifier, chopper, AC Voltage Controller, Cyclo-converter ; Inverters – Basic structure and operation of VSI and CSI		
Module: 6	**Solid State Speed Control**	**8 Hrs**
DC Motor – Ward Leonard drive – Controlled Rectifier fed DC drive, Chopper fed DC drive; Three Phase Induction Motor – Voltage Source Inverter Control, Speed control of Brushless DC Motor Drive – Stepper Motor Drive - Solar and Battery Powered Drive – Basic Operation		
Total Lectures		**45**

Text Books	
1.	Gopal K. Dubey, “Fundamentals of Electric Drives”, Narosa Publications, New Delhi, 2nd Edition, 2002.
Reference Books	
1.	Pillai S.K., “A First course on Electrical Drives”, New Age International Private Limited, New Delhi, 1991.
2.	Vedam Subrahmanyam, “Electric Drives: Concept and Application”, Tata McGraw-Hill Education, 2nd Edition, 2011.
3.	Bhattacharya, “Electrical Machines”, Tata McGraw Hill Education, 2008.
4.	Kothari D.P., Nagrath I.J., “Electrical Machines”, Tata McGraw Hill Education India Private Limited, New Delhi, 3rd Edition, 2004.
5.	Sen P.C., “Principles of Electrical Machines and Power Electronics”, John Wiley Publications Private Limited, 3rd Edition, 2013.

Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course Code	**SENSOR SIGNAL CONDITIONING CIRCUITS**	**L**	**T**	**P**	**C**
22RO2003		3	0	0	3

Course Objectives:

To impart knowledge on
1. Linear and nonlinear applications of operational amplifiers
2. Concepts of waveform generation and introduce some special function ICs
3. Scope and applications of data converters.

Course Outcomes:

At the end of this course, students will be able to
1. Infer operational amplifiers' DC and AC characteristics.
2. Discuss the linear and non-linear applications for an op-amp.
3. Classify the working of multivibrators using the general-purpose op-amp and specific application IC 555.
4. Outline the functionalities of specific ICs such as voltage regulators and PLLs.
5. Demonstrate the working of data converters.
6. Summarize the techniques of IC fabrication

Module 1: OP-AMP Fundamentals and Characteristics (7 hrs)	
Introduction, DC Characteristics, Ideal Characteristics of Op. Amp, Inverting amplifier and Non-inverting amplifier, Adder, Subtractor and Adder-Subtractor, Slew rate and CMRR.	
Module 2: OP-AMP Applications (9 hrs)	
Instrumentation Amplifier, Design of differentiator and Integrator, Differential Amplifier, Rectifiers, Log Amplifier, Multiplier and Divider, Comparator – Schmitt Trigger.	
Module 3: OP-AMP in Multivibrators and Oscillators (8 hrs)	
Multivibrator- Introduction, Astable Multivibrator – Square Wave Generator, Monostable Multivibrator, Triangular Wave Generator. Oscillators- Barkhausen Criteria, RC phase shift Oscillator, Wein's Bridge oscillator. Voltage Regulator- 723 low voltage regulator.	
Module 4: OP-AMP in Filters (8 hrs)	
Filters- Introduction, Low pass filters- First order and second order filters, High pass filters, Band pass filters, Band Reject filters.	
Module 5: IC 555 Timer and Phase Locked Loop (7 hrs)	
555 Timer Functional diagram, Mono-stable operation and application, Astable operation and application and Schmitt trigger. PLL- basic principle and applications.	
Module 6: DAC, ADC and IC Fabrication (6 hrs)	
Digital to analog converters: weighted resistor/converter, R-2R Ladder, analog to digital converters: parallel comparator A/D converter, successive approximation A/D converter, counting A/D converter, dual slope A/D converter. Basic Planar processes, Fabrication of Bipolar Junction Transistor- Chemical Vapour deposition, sputtering, n-tub, p-tub and twin-tub CMOS process.	
Text Books:	
1. Roy Choudhury.D., Shail Jain, "Linear Integrated Circuits", New Age International Publications, 5th Edition, 2018.	
Reference Books:	
1. Gayakwad.A.R., "Op-Amps & Linear IC's", PHI, 4th Edition,2004 2. Robert F. Coughlin, Frederick F. Driscoll, "Operational Amplifiers & Linear Integrated 3. Circuits", PHI 6th Edition, 2001. 4. Sergio Franco, "Design with Operational Amplifier and Analog Integrated Circuits", TMH,3rd Edition, 2002.	
Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	SENSORS SIGNAL CONDITIONING CIRCUITS LABORATORY	L	T	P	C
22RO2004		0	0	2	1
Course Objective:					
To impart knowledge on 1. Characteristics of operational amplifier 2. Applications of operational amplifier 3. Sensor Interfacing and the concepts involved.					
Course Outcome:					
The student will be able to 1. Interpret the characteristics of Operational amplifier 2. Demonstrate the mathematical operations using operational Amplifier 3. Perform the timer based operations using operational Amplifier and timer circuits 4. Analyse the effect of ADC parameters in Sensor Interfacing 5. Develop practical circuits for measurement of Temperature, Vibration, Force and Torque 6. Design and develop practical circuits for measurement using Gyroscope, Load Cell					
List of Experiments					
1.	Design and Analysis of Inverting and Non Inverting Amplifier using Op-Amp.				
2.	Study of Adder, Subtractor using Op-Amp				
3.	Design and Analysis of Differentiator and Integrator using Op-Amp				
4.	Astable Multivibrator using Op-Amp				
5.	Design Monostable Multivibrator using timer				
6.	Design of Analog to Digital Converter				

7.	Tactile Sensor: Force, Torque and Gyroscope	
8.	Measurement of Vibration Sensor	
9.	LVDT and Load Cell	
10.	Temperature Sensor	
11.	Strain Gauge Measurement set up using Wheatstone Bridge Circuit	
12.	Piezoelectric Sensor	
	Total Lectures	**30 Hours**
Recommended by Board of Studies		
Approved by Academic Council	24th September 2022	

Course code	MICROCONTROLLERS AND EMBEDDED SYSTEMS LABORATORY	L	T	P	C
22RO2005		0	0	2	1

Course Objectives

Impart knowledge on

1. Programming Techniques of Microcontrollers.
2. Sensor application using Microcontrollers
3. Concepts of peripherals

Course Outcomes

The student will be able to

1. Develop an assembly language programs for mathematical operations
2. Illustrate standard real-time interfaces with embedded C programming
3. Demonstrate signal generation with Microcontroller.
4. Perform timer-based operation with Microcontroller.
5. Design an interfacing system for motor control.
6. Implement sensor interfacing applications using microcontroller

List of Experiments

1.	Arithmetic operations	
2.	Sorting of numbers	
3.	Interfacing of Timer circuits	
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	
	Total Lectures	**30 Hours**
Recommended by Board of Studies		
Approved by Academic Council	24th September 2022	

Course code	PROGRAMMING LOGIC CONTROLLER LABORATORY	L	T	P	C
22RO2006		0	0	2	1

Course Objectives

To impart knowledge on

1. Fundamentals of PLC Programming
2. PLC Programming using Ladder Diagram.
3. Implementation of PLC in industrial automation systems.

Course Outcomes

The student will be able to

1. Develop simple logic for controlling process parameters
2. Select the inputs and outputs of the industrial system
3. Implement the relay circuit connection for PLC
4. Demonstrate PLC Ladder Logic programs in the simulation environment
5. Design Star-Delta connections for PLC
6. Build PLC program for industrial processes.

List of Experiments

1.	Temperature Control using PLC
2.	Traffic Signal Control using PLC
3.	Conveyor Automation using PLC
4.	Water Tank Control using PLC
5.	Automatic Lift Control using PLC
6.	PLC Input and Output Control using PLC
7.	Study of Relay Module using PLC
8.	Star-Delta Module using PLC
9.	Door Open / Close Module using PLC
10.	Industrial Process Control using PLC
11.	Washing Machine Control using PLC
12.	Sensor Module Control using PLC
Total Lectures	**30 Hours**

Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	ROBOTICS LABORATORY	L	T	P	C
22RO2007		0	0	2	1

Course Objective:

To impart knowledge on

1. Virtual Robot Simulators
2. Analysis of Robot motion using forward and inverse kinematics
3. Robot Programming for various applications

Course Outcome:

The student will be able to

1. Develop robot applications using virtual simulators
2. Analyze Forward and Inverse Kinematics of Robot Manipulators
3. Perform workspace analysis for industrial robots using simulators.
4. Implement Robot Programs for various applications.
5. Perform path planning of autonomous vehicles
6. Interface vision systems with robotic systems

List of Experiments

1.	Design and develop a manufacturing cell using virtual robot simulator.
2.	Develop a TCP for Industrial Robot using Robot simulator.
3.	Develop a program for workspace analysis of Industrial Robot using Robot simulator.
4.	Simulation of Forward Kinematics of PUMA 560
5.	Simulation of Inverse Kinematics of PUMA 560
6.	Simulation of Forward Kinematics of Move master RM-501
7.	Develop robot program for pick and place application
8.	Develop robot program for material handling applications.
9.	Develop robot program for palletizing process.
10.	Develop a path planning programming for autonomous vehicles.
11.	Implement a vision based robotic system for colour sorting
12.	Build a Face recognition system interfaced with robot.
Total Lectures	**30 Hours**

Recommended by Board of Studies	

Approved by Academic Council	24th September 2022

Course code	VISION AND IMAGE PROCESSING LABORATORY	L	T	P	C
22RO2008		0	0	2	**1**

Course Objectives

To impart knowledge on

1. Basics of images, and software tools used to implement image processing.
2. Develop a balanced view of modern image processing studies between theoretical aspects and practical implementations.
3. Significance of Computer vision techniques on practical aspect.

Course Outcomes

The student will be able to

1. Apply the fundamentals of image processing.
2. Demonstrate various morphological techniques on an image.
3. Perform smoothing and sharpening of an image in spatial domain.
4. Design basic segmentation algorithms on gray scale images.
5. Develop suitable algorithm for compression and decompression techniques.
6. Implement different object recognition algorithm for machine vision.

List of Experiments

1.	Transformations of an image.
2.	Histogram mapping and equalization.
3.	Edge detection – use of Sobel, Prewitt and Roberts operators.
4.	Morphological operations on binary image.
5.	Image smoothing filters in spatial domain.
6.	Image sharpening filters in spatial domain.
7.	Image segmentation using Watershed transform.
8.	Perform image compression and decompression using JPEG.
9.	Study and Implement the KLT based face representation and recognition system.
10.	Object detection algorithm using vision system.

Total Lectures	**30 Hours**
Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	UNDERWATER ROBOTICS	L	T	P	C
22RA2009		**3**	**0**	**0**	**3**

Course Objective

To impart knowledge on

1. Fundamental concepts of underwater robots
2. Underwater Vehicle guidance and control
3. Scope and applications of underwater robots

Course Outcome

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

1. Relate the fundamentals of robotics to underwater vehicles
2. Illustrate the design aspects of sailing vessels
3. Outline the concepts of ROVs
4. Interpret the kinematic and dynamics of underwater vehicles
5. Summarize the fault detection and tolerance strategies of AUVs and ROVs.
6. Appraise the scope and research trends in the field of underwater robots.

Module: 1	**Introduction**	**7 Hrs**
Underwater Vehicles-Types, History of Undersea Technology, Modern day applications of Underwater Technology- Sensors-Actuation-Localization-AUV Control-Future Perspectives		
Module: 2	**Robotic Sailing**	**8 Hrs**
History and recent developments in robotic sailing – miniature sailing robot platform (MOOP)– autonomous sailing vessel – design, development and deployment		
Module: 3	**Submersibles**	**8 Hrs**

Unmanned submersibles- towed vehicles – Remotely Operable Vehicles (ROV) – The ROV business – Design theory and standards – control and simulation – design and stability -components of ROV.		
Module: 4	**Underwater Vehicle Guidance and Control**	**7 Hrs**
Modelling of marine vehicles – kinematics – rigid body dynamics – hydrodynamic forces and moments – equation of motion – stability and control of underwater vehicles		
Module: 5	**Fault Detection and Tolerance Strategies for AUVs and ROVs**	**8 Hrs**
Introduction-Experienced Failures, Fault Detection Schemes, Fault Tolerant Schemes, Case Studies		
Module: 6	**Scope and Case Studies**	**7 Hrs**
Research Trends, Application of Underwater Robots, Case Studies.		
	Total Lectures	**45**

Text Books	
1.	Gianluca Antonelli , "Underwater Robots", Springer, 2014.
2.	Sabiha A. Wadoo, Pushkin Kachroo, Autonomous underwater vehicles, modelling, control design and Simulation, CRC press, 2011
Reference Books	
1.	Robert D. Christ,Robert L. Wernli, Sr. The ROV Manual A User Guide for Remotely Operated Vehicles, Elsevier, second edition, 2014
2.	MATE - Marine Advanced Technology Education :: Inside the Textbook (marinetech.org)
3.	Alexander Schlaelfer and Ole Blaurock, Robotic sailing, Proceedings of the 4th International sailing conference, Springer, 2011
4.	Mae L. Seto, Marine Robot Autonomy, Springer, 2013
5.	Robert D. Christ,Robert L. Wernli, Sr. The ROV Manual A User Guide for Remotely Operated Vehicles, Elsevier, second edition, 2014

Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	AERIAL ROBOTICS	L	T	P	C
22RA2010		**3**	**0**	**0**	**3**

Course Objective

To impart knowledge on

1. Fundamental concepts of aerial robots
2. Flight Mechanics and Control
3. Linear control methods and safety systems

Course Outcome

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

1. Relate the fundamentals of robotics to UAV
2. Outline the concepts of flight mechanics
3. Illustrate various sensors in flight control
4. Interpret the kinematic and dynamics of flight operations
5. Summarize various linear control methods.
6. Identify the safety measures in UAV.

Module: 1	**Introduction**	**7 Hrs**
Introduction to UAV- Types- motors and propellers- blades and diameter- efficiency/thrust UAV materials- launching systems		
Module: 2	**Flight Mechanics**	**8 Hrs**
Modelling Presentation frames- geodetic coordinate system, north-east down frame, body based frame, kinematic modelling – fixed wing aircraft dynamic modelling- Aircraft performance		
Module: 3	**Flight Control**	**8 Hrs**
Architecture- auto pilot- sensors detected to the flight controllers- compass/magnetometer, pressure/barometer, GPS, camera types, video transmitter, radio communication		
Module: 4	**Flight Operations**	**7 Hrs**
Modelling of marine vehicles – kinematics – rigid body dynamics – hydrodynamic forces and moments – equation of motion – stability and control of underwater vehicles		
Module: 5	**Linear Control Methods**	**8 Hrs**

Properties of LTI Methods, direct approach, pole placement, Gain scheduling		
Module: 6	**Safety Systems**	**7 Hrs**
UAV piloting techniques, checklists, decision making, airport operations, UAS traffic management, emergency operations		
	Total Lectures	**45**

Text Books	
1.	Yasmina Bestaoui Sebbane, A First Course in Aerial Robots and Drones, CRC Press, 2022
2.	Omar D Lopez Mejia, Jaime Escobar, Aerial Robots - Aerodynamics, Control, and Applications, Intech 2017
Reference Books	
1.	Anibal Ollero, Bruno Siciliano, Aerial Robotic Manipulation Research, Development and Applications, Springer, 2019
2.	Kenzo Nonami, Farid Kendoul, Satoshi Suzuki, Autonomous Flying Robots: Unmanned Aerial Vehicles and Micro aerial Vehicles, Springer 2019.
3.	Yasmina Bestaoui Sebbane, Planning and Decision Making for Aerial Robots, Springer 2014.
4.	Ranjan Vepa, Nonlinear Control of Robots and Unmanned Aerial Vehicles: An Integrated Approach, CRC Press 2016.
5.	Bruno Siliano, Oussama Khatib, Springer Handbook of Robotics, Springer 2016.

Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course Code	ROBOTIC PROCESS AUTOMATION	L	T	P	C
22RO2011		3	0	0	3

Course Objectives:

To impart knowledge on
1. Fundamental concepts of RPA
2. Scope and applications of RPA
3. Programming techniques in RPA

Course Outcomes:

At the end of this course, students will be able to
1. Relate RPA, where it can be applied and how it's implemented.
2. Outline the different types of variables, Control Flow and data manipulation techniques.
3. Identify and understand Image, Text and Data Tables Automation.
4. Interpret how to handle the User Events and various types of Exceptions and strategies.
5. Illustrate the RPA interfacing aspects with E-mail Automation
6. Understand the Deployment of the Robot and to maintain the connection.

Module 1: Introduction to RPA (7 hrs)

RPA Foundations- History of RPA- The Benefits of RPA- The downsides of RPA -Consumer Willingness for Automation- The Workforce of the Future- RPA Skills-On-Premise Vs. the Cloud- Web Technology- Programming Languages and Low Code- OCR-Databases-APls- Al-Cognitive Automation.

Module 2: RPA Platforms (9 hrs)

Components of RPA- RPA Platforms-About Ui Path-The future of automation - Record and Play - Downloading and installing UiPath Studio -Learning Ui Path Studio- Task recorder .

Module 3: Sequence, Flowchart, and Control Flow (8 hrs)

Sequencing the workflow- Activities-Control flow, various types of loops, and decision making-Sequence and Flowchart-Step-by-step example using Sequence and Control flow-Data Manipulation-Variables and Scope-Collections-Arguments.

Module 4: Advanced Automation concepts and techniques: (8 hrs)

Introduction to Image and Text ,Automation, Image based automation, Keyboard based automation, Information Retrieval, Advanced Citrix Automation challenges, - Revisit recorder- Screen Scraping-Data Tables in RPA, Excel and Data Table basics, Data Manipulation in excel.

Module 5: Email Automation & PDF (7 hrs)

Extracting Data from PDF, Extracting a single piece of data, Anchors, Using anchors in PDF - Email Automation, Incoming Email automation, Sending Email automation

Module 6: Future Trends and Orchestrator (6 hrs)
Orchestrator: Tenants, Authentication, Users, Roles, Robots, Environments, Queues &Transactions, Schedules Emerging and Future Trends in : Artificial Intelligence, Machine Learning, Natural Language Processing, Computer Vision
Text Books:
1. Tom Taulli, "The Robotic Process Automation Handbook:A Guide to Implementing RPA Systems", Apress Publisher, 2020 . 2. Alok Mani Tripathi, "Learning Robotic Process Automation", Packt Publishing Release, 2018 .
Reference Books:
1. Nandan Mullakara, Arun Kumar Asokan, "Robotic Process Automation Projects: Build real-world RPA" Packt Publishing,2020. 2. Richard Murdoch, "Robotic Process Automation: Guide to Building Software Robots, 3. Automate Repetitive Tasks & Become An RPA Consultant" Kindle Edition,2018. 4. Srikanth Merianda, "Robotic Process Automation Tools, Process Automation and their 5. benefits: Understanding RPA and Intelligent Automation" Consulting Opportunity Holdings Llc; 1st edition 2018. 6. Vaibhav Srivastava, "Getting started with RPA using Automation Anywhere" BPB publication,2020. 7. Vaibhav Jain, "Crisper Learning" Independently Published,2018.

Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	**ADVANCED ROBOTICS LABORATORY**	**L**	**T**	**P**	**C**
22RO3001		0	0	4	2

Course Objective:

To impart knowledge on

1. The concepts of robotic manufacturing system and work cells
2. Robot programming and control
3. Autonomous Navigation Robots

Course Outcome:

The student will be able to

1. Develop kinematic models of industrial robot using simulation tools.
2. Demonstrate sensor ased motion planning system
3. Implement robot programming for localization and navigation
4. Solve practical issues involved in implementing a motion planner
5. Interface vision system with robotic arm to develop intelligent applications.
6. Perform Programming and Analysis of Simple Robots using ROS

List of Experiments

1.	Study of Motoman GP8 Industrial Robot
2.	Kinematic Modelling of Motoman GP8 Industrial Robot using Robo Analyzer
3.	Motoman GP8 Industrial Robot Programming
4.	Motion Planning of Motoman GP8 for Point-to-Point path and Continuous path applications
5.	Pick and Place application using Dobot Magician
6.	Vision Integrated Robot Motion using Dobot Magician
7.	Mobile Robot Localization using multi sensor fusion.
8.	Obstacle Avoidance using Vision sensor for QuanserQbot 2e
9.	Simultaneous Localization and Mapping using QuanserQbot 2e
10.	Robotic Operating System - Study
11.	Simulation of Tortoise Bot using ROS
12.	Autonomous Navigation Mobile Robot using ROS

Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

<table>
<tr><td>Course code</td><td colspan="2">ADVANCED SOFT ROBOTS FOR HEALTHCARE APPLICATIONS</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>22RA3002</td><td colspan="2"></td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Objective</td></tr>
<tr><td colspan="7">To impart knowledge on
1. Fundamental concepts of medical soft robots
2. Design and Development of soft wrist rehabilitation robot
3. Scope and applications of Medical robots</td></tr>
<tr><td colspan="7">Course Outcome</td></tr>
<tr><td colspan="7">At the end of this course, students will be able to
1. Relate the fundamentals of robotics to medical robots
2. Outline the concepts of soft robots in healthcare industry
3. Interpret the concepts of soft wrist rehabilitation robot
4. Illustrate the development of soft ankle rehabilitation robot
5. Summarize the design of soft ankle rehabilitation robot
6. Appraise the scope and research trends of soft robotics in healthcare.</td></tr>
<tr><td>Module: 1</td><td colspan="4">Introduction</td><td colspan="2">7 Hrs</td></tr>
<tr><td colspan="7">Healthcare requirements - Soft robots for healthcare applications - Definition of soft robots, Examples of soft robots for healthcare, Motivation of soft robots for healthcare – Critical issues in developing soft robots for healthcare – Acceptance of healthcare robots, Soft actuators, Modelling and control of soft actuators</td></tr>
<tr><td>Module: 2</td><td colspan="4">State of Art Soft Robots</td><td colspan="2">8 Hrs</td></tr>
<tr><td colspan="7">Rehabilitation robots for healthcare - Upper-limb rehabilitation exoskeletons, Gait rehabilitation exoskeletons, Ankle rehabilitation robots - Soft robots for healthcare - Soft robots for various applications, Soft robots for healthcare</td></tr>
<tr><td>Module: 3</td><td colspan="4">Soft wrist rehabilitation robot</td><td colspan="2">8 Hrs</td></tr>
<tr><td colspan="7">Introduction - Device design - Force and torque distribution - Control strategies - Pneumatic setup, Model-based control, Feedback-based control, Design Comparison - System integration and experiments – Software Architecture, Experiments</td></tr>
<tr><td>Module: 4</td><td colspan="4">Development of a soft ankle rehabilitation robot</td><td colspan="2">7 Hrs</td></tr>
<tr><td colspan="7">Ankle complex - Existing ankle rehabilitation robots - Design requirements of ankle rehabilitation robots - Ankle range of motion and torque, Robot flexibility - Conceptual design of the soft ankle rehabilitation robot</td></tr>
<tr><td>Module: 5</td><td colspan="4">Kinematics and Control of Soft Ankle Rehabilitation Robot</td><td colspan="2">8 Hrs</td></tr>
<tr><td colspan="7">Kinematics of the soft ankle rehabilitation robot - Dynamics of the soft ankle rehabilitation robot - Ankle force and torque, Inertial property of the moving unit, Force distribution, Festo fluidic muscle modelling, Construction of the soft ankle rehabilitation robot - Control of a soft ankle rehabilitation robot – Passive Training Control, Active Training Control</td></tr>
<tr><td>Module: 6</td><td colspan="4">Applications of Soft Robotics in Healthcare</td><td colspan="2">7 Hrs</td></tr>
<tr><td colspan="7">Design of Social Robots in hospitals – Fabric-based Soft Robotic Assistive Glove - Soft Robotic Sock for Ankle Rehabilitation - ARMAS Shoulder: A 2DOF Shoulder Exosleeve for Shoulder Rehabilitation</td></tr>
<tr><td colspan="5" align="right">Total Lectures</td><td colspan="2" align="right">45</td></tr>
<tr><td colspan="7">Text Books</td></tr>
<tr><td>1.</td><td colspan="6">S. Xie, M. Zhang and W. Meng, "Soft Robots for Healthcare Applications Design, modelling, and control", Published by The Institution of Engineering and Technology, London, United Kingdom, 2017.</td></tr>
<tr><td>2.</td><td colspan="6">Paula Gomes, "Medical robotics- Minimally Invasive surgery", Woodhead, 2012.</td></tr>
<tr><td colspan="7">Reference Books</td></tr>
<tr><td>1.</td><td colspan="6">Daniel Faust, “Medical Robots”, Rosen Publishers, 2016</td></tr>
<tr><td>2.</td><td colspan="6">VanjaBonzovic, “Medical Robotics”, I-tech Education publishing,Austria,2008</td></tr>
<tr><td>3.</td><td colspan="6">Jocelyne Troccaz, “Medical Robotics”, Wiley-ISTE, 2012</td></tr>
<tr><td>4.</td><td colspan="6">AchimSchweikard, Floris Ernst, “Medical Robotics”, Springer, 2015.</td></tr>
<tr><td colspan="2">Recommended by Board of Studies</td><td colspan="5"></td></tr>
<tr><td colspan="2">Approved by Academic Council</td><td colspan="5">24th September 2022</td></tr>
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Course code	ROBOT ECONOMICS	L	T	P	C
22RO3003		3	0	0	3

Course Objective

To impart knowledge on

1. The robot components and their systematic selection
2. Various economic and social aspects of Robotics and its installation procedure
3. The future robotics technology

Course Outcome

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

1. Recall the fundamentals of the robot configuration
2. Select the robot component for a given application
3. Outline the factors for economic analysis of robotics
4. Analyze the costs and potential benefits associated with the robot installation.
5. Explain the various social issues in Robotics.
6. Assess the future of the robotics technology

Module: 1	BASIC CONCEPTS OF ROBOTICS AND AUTOMATION	8 Hrs

Basic Concepts, Robot anatomy, Classification and Associated parameters, Automation concept and Need for Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions

Module: 2	ROBOT COMPONENTS AND THEIRS SELECTION	6 Hrs

Power supply, movement and drive systems, sensors, end effector and grippers, Control techniques, Characteristics and factor considered for selection.

Module: 3	ECONOMIC ANALYSIS FOR ROBOTICS	7 Hrs

Economic analysis, basic data required methods of Economic analysis, subsequent uses of robot, Difference in production rates, other factors, Robot project analysis form.

Module: 4	IMPLEMENTING ROBOTICS	8 Hrs

Familiarization with robotics technology, plant survey to identify potential applications, Selection of the best applications, Selection of a robot, Detailed economic analysis, planning and installation.

Module: 5	SOCIAL ISSUES	8 Hrs

Safety in Robotics, Training, Maintenance, Quality improvement, productivity and capital formation, Robotics and labour. Education and training, international impacts, future applications.

Module: 6	ROBOTICS TECHNOLOGY OF THE FUTURE	8 Hrs

Robot intelligence, Advanced Sensors, Capabilities, Tele robotics, Mechanical design Features, Mobility, locomotion and Navigation. The universal Hand Systems Integration and Networking. Robots in RPT.

Total Lectures **45 Hrs**

Text Books

1.	Mikell P .Groover & Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, “Industrial Robotics, Technology Programming and Applications”, McGraw Hill, 2012.

Reference Books

1.	Richard D. Klafter, Thomas .A, Chri Elewski, Michael Negin, “Robotics Engineering an Integrated Approach”, Phi Learning., 2009.
2.	Radhakrishnan .P, Srivatsavan .R, Mohan Ram .P.V and Radharamanan .R, CAD/CAM, “Robotics and factories of the future, Proceeding of the 14th International Conference on CAR and FOF”, 98 editors, Narosa Publishing house, 2003.
3.	Gonzalez Fu .K.S, Lee R.S, .C.S.G, “Robotics Control, Sensing Vision and Intelligence”, Tata McGraw Hill Education, 2008.
4.	John J. Craig, “Introduction to Robotics: Mechanics and Control”, by Pearson India, ISBN: 9788131718360, 8131718360. Edition: 3rd Edition, 2008.

Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	CYBERNETICS	L	T	P	C
22RO3004		3	0	0	3

Course Objective

To impart knowledge on

1. Fundamental concepts of Cybernetics
2. The framework activities of Cybernetics
3. Modeling Cybernetics Systems

Course Outcome

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

1. Explain the fundamentals of cybernetics in the design of systems
2. Interpret the feedback systems and the design process
3. Outline the concepts of Requisite Variety
4. Summarize the importance of conversation in cybernetics
5. Model cybernetic systems for real time problems
6. Build algorithms for design of systems

Module: 1	INTRODUCTION TO CYBERNETICS	7 Hrs

History and Overview of Cybernetics - Cybernetics in terms of interfaces, design, and living systems - Feedback and Control: Open and Closed loop - Artificial Intelligence vs Cybernetics - Information, entropy, information transmission, coding - a cybernetic view

Module: 2	FIRST-ORDER FEEDBACK SYSTEMS	8 Hrs

Feedback Graphs – Cybernetics as Steering - Goal of Regulator or Governor - Goal-Directed System—Behavioural View - Feedback: Formal Mechanism - Feedback: Mechanical Example - Feedback: Biological Example - First-order Feedback and Modelling Interfaces - First-order Feedback and the Design Process

Module: 3	REQUISITE VARIETY	8 Hrs

Requisite Variety as a Function of the System's Goal - Cost of Adding Variety and the Probability of a Disturbance - Requisite Variety: Formal Mechanism - Requisite Variety: Social Example - Mapping the Feedback: Formal Mechanism to Ashby's Communications Model

Module: 4	SECOND-ORDER FEEDBACK SYSTEMS	7 Hrs

Second-order Feedback: Formal Mechanism - Second-order Feedback: Electro-mechanical Example: Precision Farming - Second-order Feedback: Biological Example - Second-order Feedback: Social Example – Communication between two first order systems

Module: 5	CONVERSATION IN CYBERNETICS	8 Hrs

Model of Communication - Model of Agreement - 2nd-Order Cybernetics and Subjectivity - Observing the observing - Conversations about conversations – Interaction – Relationship – Conversation: Formal Mechanism - Conversation: Biological Example - Architecture of Conversation - Conversation for Understanding

Module: 6	MODELING CYBERNETIC SYSTEMS	7 Hrs

The system identification problem - Proportional, Integrative, Derivative (PID) control - Anticipatory and Adaptive control models - Hierarchical control models

	Total Lectures	**45 Hrs**

Reference Books

1.	Mobus, G.E., Kalton, M.C. (2015). Cybernetics: The Role of Information and Computation in Systems. In: Principles of Systems Science. Understanding Complex Systems. Springer, New York, N.
2.	Hugh Dubberly Paul Pangaro, "Introduction to Cybernetics and the Design of Systems Collected Models", 2010
3.	Nilsson, N. N.: Artificial Intelligence: A New Synthesis. Morgan Kaufmann Publ. San Francisco, 1998
4.	George E. Mobus, Michael C. Kalton, "Principles of Systems Science", Springer, 2015.

Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	REAL-TIME OPERATING SYSTEM	L	T	P	C
22RO3005		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 modeling Process based on range of OS features
3. Functionalities in commercial OS, application development using RTOS

Course Outcome

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

1. Recall the fundamental concepts of operating systems
2. Outline the concepts of RTOS
3. Summarize process management in RTOS
4. Categorize inter process communication techniques
5. Interpret memory management in RTOS
6. Develop real time application programs using RTOS

Module: 1	INTRODUCTION	7 Hrs

Introduction to Operating System: Computer Hardware Organization, BIOS and Boot Process, Multi-threading concepts, Processes, Threads, Scheduling

Module: 2	BASICS OF REAL-TIME CONCEPTS	8 Hrs

Terminology: RTOS concepts and definitions, real-time design issues, examples, Hardware Considerations: logic states, CPU, memory, I/O, Architectures, RTOS building blocks, Real-Time Kernel

Module: 3	PROCESS MANAGEMENT	8 Hrs

Concepts, scheduling, IPC, RPC, CPU Scheduling, scheduling criteria, scheduling algorithms Threads: Multi-threading models, threading issues, thread libraries, synchronization Mutex: creating, deleting, prioritizing mutex, mutex internals

Module: 4	INTER-PROCESS COMMUNICATION	7 Hrs

Messages, Buffers, mailboxes, queues, semaphores, deadlock, priority inversion

Module: 5	MEMORY MANAGEMENT	8 Hrs

Process stack management, run-time buffer size, swapping, overlays, block/page management, replacement algorithms, real-time garbage collection

Module: 6	CASE STUDIES	7 Hrs

Case study Linux POSIX system, RTLinux / RTAI, Windows system, Vxworks, uItron Kernel Design Issues: structure, process states, data structures, inter-task communication mechanism, Linux Scheduling

Total Lectures	**45 Hrs**

Reference Books

1. S J. J Labrosse, "MicroC/OS-II: The Real –Time Kernel", Newnes, 2002
2. Jane W. S. Liu, "Real-time systems", Prentice Hall, 2000.
3. W. Richard Stevens, "Advanced Programming in the UNIX® Environment", 2nd Edition, Pearson Education India, 2011.
4. Philips A. Laplante, "Real-Time System Design and Analysis", 3rd Edition, John Wley& Sons, 2004
5. Doug Abbott, "Linux for Embedded and Real-Time Applications", Newnes, 2nd Edition, 2011.

Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

Course code	ARTIFICIAL INTELLIGENCE IN ROBOTICS AND AUTOMATION	L	T	P	C
22RO3006		3	0	0	3

Course Objective

To impart knowledge on
1. The concept of Industrial Automation
2. Different intelligent search methods
3. Applications in Robotics and Automation

Course Outcome

The student will be able to
1. Summarize the basic concepts of AI
2. Compare the various intelligent search methods
3. Discuss the concepts of knowledge and reasoning
4. Categorize different forms of learning methods
5. Outline the ethical issues of AI
6. Apply concepts of AI for robotics and automation systems

Module: 1	INTRODUCTION	7 Hrs

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 Hrs

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

Module: 3	KNOWLEDGE AND REASONING	8 Hrs

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 Hrs

Overview of different forms of learning, Inductive learning, learning decision trees, computational learning theory, Applications: Robotics, Natural language processing.

Module: 5	ETHICS OF AI	8 Hrs

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 Hrs

Assembly, packaging, customer service, open source robotics, fraud prevention, brand management, software testing and development, human resource management.

Total Lectures	**45 Hrs**

Reference Books

1. Francis X Govers, “Aritifical Intelligence for Robotics”, Packt Publishing Ltd, 2018.
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. Rich and Knight, "Artificial Intelligence", 3rd Edition, Tata McGraw Hill, 2014

Recommended by Board of Studies	
Approved by Academic Council	24th September 2022

DEPARTMENT OF ROBOTICS ENGINEERING

LIST OF NEW COURSES

S. No	Course Code	Name of the Course	Hours per week L	T	P	Total Credits
1.	21RO2001	Introduction to Mechanical Systems	3	0	0	3
2.	21RO2002	Automatic Control Systems	3	1	0	4
3.	21RO2003	Sensor Signal Conditioning Circuits	3	0	0	3
4.	21RO2004	Robot Kinematics and Dynamics	3	0	0	3
5.	21RO2005	Robot Operating Systems	1	0	4	3
6.	21RO2006	Additive Manufacturing	3	0	0	3
7.	21RO2007	Mechatronic System Design	3	0	0	3
8.	21RO2008	Virtual Instrumentation	2	0	2	3
9.	21RO3001	Industrial Automation	3	0	0	3
10.	21RO3002	Mobile Robotics	3	0	0	3
11.	21RO3003	System Identification and Adaptive Control	3	0	0	3
12.	21RO3004	Advanced Virtual Instrumentation for Robotics	1	0	4	3
13.	21RO3005	Advanced Robot Operating System	3	0	0	3
14.	21RO3006	Autonomous Mobile Robots	3	0	0	3

Course code	INTRODUCTION TO MECHANICAL SYSTEMS	L	T	P	C
21RO2001		3	0	0	3

Course Objective

To impart knowledge on

1. Fundamental principles of mechanics
2. Motion characteristics of particles and rigid bodies
3. Kinematics of rigid bodies and introductory design process

Course Outcome

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

1. Recall the basic concepts of equilibrium of forces
2. Interpret the properties of engineered surfaces and volumes
3. Recognize the motion characteristics of particles using laws of motion
4. Describe the motion characteristics of rigid bodies
5. Identify the kinematic principles of simple mechanisms
6. Explain the elementary design process of the simple machine components

Module: 1 **Module 1: Statics of Particles: (8 Hours)**

Equilibrium of Particle: Introduction – Laws of mechanics – Forces on particles – Concurrent forces in a plane– Coplanar forces – Resolution of forces – Resultant of several concurrent forces – Free body diagram – Equilibrium of particles in space. Equilibrium of rigid bodies: Principle of transmissibility – Moment of a force – Varignon‘s theorem – Equivalent system of forces – Reduction of system of forces into single force and couple- Types of loads-Types of supports and their reactions – Equilibrium of rigid bodies in two dimensions

Module: 2 **Properties of Surfaces and Volumes (8 Hours)**

CENTROID: Definition of center of gravity, centroid of area, centroid of line, concept of line of symmetry, location of centroid by direct integration of rectangular, triangular, semi-circular and quarter circular areas, centroid of composite areas.
SECOND MOMENT OF AREA: Definition, parallel axis theorem, polar moment of area, radius of gyration, second moment of area by direct integration of a rectangular, triangular, circular, semi-circular and quarter-circular area. Second moment of composite area.

Module: 3 **Dynamics of Particles (8Hours)**

General Principle in dynamic, types of motion, Motion of projectile, motion of body projected horizontally and on inclined plane. – Relative motion, Newton’s second law of motion, D’Alembert‘s principle

Module: 4 **Dynamics of Rigid Bodies (8 Hours)**

Kinematics of rigid bodies – Translation and rotation of rigid bodies – Fixed axis rotation – General plane motion –Relative velocity in plane motion, Work energy Principle, work done by a varying force, Principle of Impulse momentum, Linear Impulse and momentum.

Module: 5	**Kinematics of Mechanisms (8 Hours)**
Kinematic link and its types, constrained motions, kinematic pair and its types, types of joints, kinematic chain, mechanism and machine, degree of freedom (Mobility), kutzbach and grubler's criterion. Four bar chain and its inversions, grashoff's law, slider crank chain and its inversions, double slider crank chain and its inversions, concept of equivalent linkage of mechanisms, introduction to straight line mechanisms, introduction to steering mechanisms.	
Module: 6	**Introduction & Design of Simple Machine Parts (5 Hours)**
Machine design, basic procedure of machine design, design of machine elements, selection of materials, standards and codes, modes of failure, factor of safety, theories of elastic failure. Design for strength and rigidity. Case studies of transmission shafts, square and flat keys, couplings, power screw	
	Total Lectures: 45

Text Books

1.	BasantAgrawal, C.M. Agrawal, "Basic Mechanical Engineering", Wiley India, 2008.
2.	Merial.J.L and Kraig.L.G, "Engineering Mechanics", John Wiley & Sons, 7th Edition, 2012

Reference Books

1.	Design of Machine Elements, by V. B. Bhandari, New Delhi: Tata McGraw–Hill Publishing Company Limited, 4th Edition, 2017.
2.	S. S. Rattan, Theory of Machines, Third Edition, McGraw Hill Education (India) Pvt. Ltd. New Delhi
3.	Merle C. Potter, Elaine Patricia Scott, Thermal Sciences: An Introduction to Thermodynamics, Fluid Mechanics, and Heat Transfer", Thomson Brookes, 2004.
4.	Dubey.N.H.," Engineering Mechanics – Statics and Dynamics", Tata McGrawHill Education Pvt. Ltd., 2013.
5.	Rajasekaran S and Sankarasubramanian G, "Engineering Mechanics – Statics and Dynamics", Vikas Publishing House Pvt Ltd, New Delhi, 2006.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**AUTOMATIC CONTROL SYSTEMS**	**L**	**T**	**P**	**C**
21RO2002		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 Controller Design to practical engineering problems.

Course Outcome

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. Investigate the stability of systems based on frequency domain by using different techniques.
6. Design Controllers for practical applications

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	**Frequency Domain Analysis: (8 Hours)**

Frequency domain specifications- 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: 4	**Stability Analysis in the Frequency Domain (8 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					
Module: 5	**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 - State Transition Matrix-Concepts of controllability and observability.					
Module: 6	**Controller Design (5 Hours)**				
P,PI, PD and PID Controllers-Controller Tuning-Adaptive Controllers- Intelligent Controllers-Case Studies.					
					Total Lectures: 45
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.	Design of Machine Elements, by V. B. Bhandari, New Delhi: Tata McGraw–Hill Publishing Company Limited, 4th Edition, 2017.				
2.	S. S. Rattan, Theory of Machines, Third Edition, McGraw Hill Education (India) Pvt. Ltd. New Delhi				
3.	Merle C. Potter, Elaine Patricia Scott, Thermal Sciences: An Introduction to Thermodynamics, Fluid Mechanics, and Heat Transfer", Thomson Brookes, 2004.				
4.	Dubey.N.H.," Engineering Mechanics – Statics and Dynamics", Tata McGrawHill Education Pvt. Ltd., 2013.				
5.	Rajput.R.K., "Basic Mechanical Engineering", Laxmi Publications, 2008.				
Recommended by Board of Studies					
Approved by Academic Council	25th September 2021				

Course Code	**SENSOR SIGNAL CONDITIONING CIRCUITS**	**L**	**T**	**P**	**C**
21RO2003		3	0	0	3
Course Objective					
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 Outcome					
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, Sensor Interfacing Issues in Robotic Systems.	
	Total Lectures:45
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
Reference Books	
1.	Bentley, John P. Principles of Measurement Systems, 4:th edition, Pearson/Prentice Hall, 2005.
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.
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**ROBOT KINEMATICS AND DYNAMICS**	**L**	**T**	**P**	**C**
21RO2004		3	0	0	3

Course Objective

To impart knowledge on

1. Mathematical concepts of Robot Kinematics
2. Differential motion and path planning
3. Fundamentals of Robot Dynamics

Course Outcome

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

1. Describe the mathematical concepts of kinematics
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. Analyse dynamics and force of robotic manipulators
6. Plan off-line Robot trajectories to meet desired End-Effector tasks

Module: 1	**Mathematical Fundamentals (8 Hours)**
Vector spaces, inner products, vector norms, orthogonality, Linear transformations, matrix multiplication, Coordinate transformations, rigid transformations, rotation matrices, Dot and cross products, Co-ordinate frames, Rotations, Homogeneous Coordinates	
Module: 2	**Introduction to Robot Kinematics: Position Analysis (8 Hours)**

Introduction, Robots as Mechanisms, Conventions, Matrix Representation, Representation of a Point in Space, Representation of a Vector in Space, Representation of a Frame at the Origin of a Fixed-Reference Frame, Representation of a Frame Relative to a Fixed Reference Frame, Representation of a Rigid Body	
Module: 3	**Forward and Inverse Kinematics of Robots (10 Hours)**
Forward and Inverse Kinematic Equations: Representation of Position and Orientation, Forward and Inverse Kinematic Equations, Euler Angles, Articulated Joints, Forward and Inverse Kinematic Equations: Position and Orientation, Denavit-Hartenberg Representation of Forward Kinematic Equations of Robots, The Inverse Kinematic Solution of Robots, General Solution for Articulated Robot Arms, Inverse Kinematic Programming of Robots.	
Module: 4	**Differential Motions and Velocities (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:(6 Hours)**
Introduction, Lagrangian mechanics, Effects of moments of Inertia, Dynamic equation for two axis planar articulated robot.	
Module: 6	**Trajectory Planning :(5 Hours)**
Trajectory planning, Pick and place operations, Continuous path motion, Interpolated motion, Straight-line motion.	
	Total Lectures: 45
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.
Reference Books	
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.
5.	Groover, “Industrial Robotics, Technology, Programming and Applications’’, Tata Mc GrawHill, 2008
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	ROBOT OPERATING SYSTEMS	L	T	P	C
21RO2005		1	0	4	3

Course Objective

To impart knowledge on

1. Introduce the basics of Robot Operating Systems and its architecture.
2. Provide knowledge on the simulation of robotics system
3. Understand the applications of ROS in real world complex applications

Course Outcome

At the end of this course, students will demonstrate the ability 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. Analyse the issues in hardware interfacing
6. Discuss about the applications of ROS

Module: 1	**Prerequisites of ROS: (8 hrs.)**
Learning Ubuntu Linux for ROS: GNU/Linux OS, Linux distribution, Ubuntu OS, UNIX commands, file system, File system security, changing access rights, frequently using Linux terminologies, Virtual Machine Software, Installation of Ubuntu OS on VM software, Introduction to programming language: C++ and python; git, GitHub.	

Module: 2	Introduction to Robot Operating System (8 hrs.)
Getting started with ROS: ROS Equation, Why use ROS? Installing ROS, ROS Architecture and concepts, ROS Filesystem, ROS Coding styles, IDE, ROS Hello World, ROS Turtlesim.	
Module: 3	**Understanding concepts of ROS (8 hrs.)**
Navigation through file system, Understanding of Nodes, topics, services, messages, bags, rosmaster, parameter server.	
Module: 4	**Programming with ROS (7 hrs.)**
ROS catkin workspace and package, ROS Client libraries: roscpp & rospy, roslaunch, Rviz, rqt, Learning ROS programming using TurtleSim: roscpp and rospy, Understanding ROS concepts using TurtleSim, Moving TurtleSim using ROS programming.	
Module: 5	**Modeling a robot in ROS using URDF (8 hrs.)**
Understanding Transformation and frames, Working with TF broadcaster and listener, Creating TF for your robot, Working with ROS TF tools, TurtleSim projects, Draw your caricature using TurtleSim, Object tracking using TurtleSim, Understanding URDF & xacro, Writing your own URDF and xacro, Visualizing your robot, Interacting with the robot model, Moving the robot model.	
Module: 6	**Simulating robot using Gazebo (7 hrs.)**
Introduction to Gazebo simulator, Getting started with Gazebo, Gazebo models and plugins, Spawning models into Gazebo, Interacting with a simulated robot, Working with Husky, Turtlebot3, and x-arm simulation, Visualizing robot sensor data in Rviz, Creating your own mobile robot and robot arm simulation, Visualizing robot in Rviz, Introduction to ROS controllers, Interacting with robot models, Moving robots using ROS programming.	
	Total Lectures: 45

Text Books	
1.	Lentin Joseph, “Robot Operating Systems (ROS) for Absolute Beginners, Apress, 2018
2.	YoonSeok Pyo, HanCheol Cho, RyuWoon Jung, TaeHoon Lim, “ROS Robot Programming, Published by ROBOTIS Co.,Ltd. 2017
	Quigley, Morgan and Gerkey, Brian and Smart, William D., “Programming Robots with ROS: A Practical Introduction to the Robot Operating System”, O'Reilly Media, 2015.
Reference Books	
1.	Jason M O'Kane, “A Gentle Introduction to ROS”, CreateSpace, 2013.
2.	Wyatt Newman, “A Systematic Approach to learning Robot Programming with ROS”, CRC Press, 2017.
3.	Patrick Gabriel, “ROS by Example: A do it yourself guide to Robot Operating System”, Lulu, 2012.
4.	Jason Cannon, “Linux for Beginners: An Introduction to the Linux Operating System and Command Line”
5.	Lentin Joseph, “Learning Robotics using Python” , Packt Publishing; 2nd Revised edition (June 27, 2018)

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	ADDITIVE MANUFACTURING	L	T	P	C
21RO2006		3	0	0	3

Course Objective

To impart knowledge on

1. Evolution of Additive Manufacturing and basic concepts
2. Selection of suitable process for Additive Manufacturing
3. Applications of Additive Manufacturing

Course Outcome

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

1. Describe the evolution and concepts of Additive Manufacturing (AM)
2. Classify Additive Manufacturing methods
3. Select suitable AM processes
4. Describe the applications of AM
5. Summarize the post processing of AM
6. Apply concepts of additive manufacturing in product development

Module: 1	**Introduction to Additive Manufacturing (AM) (7Hrs)**

Introduction to AM, AM evolution, Distinction between AM & CNC machining, Advantages of AM,	
Module: 2	**AM Process Chain and Classification (9 Hrs)**
Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, Machine setup, build , removal and clean up, post processing. Classification: Liquid polymer system, discrete particle system, molten material systems, solid sheet system.	
Module: 3	**Process selection (8 Hrs)**
Introduction, selection methods for a part, challenges of selection, example system for preliminary selection, production planning and control	
Module: 4	**AM Applications (9 Hrs)**
Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts, Re-manufacturing. Application examples for Aerospace, defense, automobile, Bio-medical and general engineering industries	
Module: 5	**Post Processing of AM Parts (7 Hrs)**
Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques.	
Module: 6	**Applications (5 Hrs)**
Introduction, new types of products and employment and digiproneurship	
	Total Lectures: 45 Hrs
Text Books	
1.	Ian Gibson, Davin Rosen, Brent Stucker “Additive Manufacturing Technologies, Springer, 2nd Ed, 2014.
2.	Ali K. Kamrani, Emand Abouel Nasr, “Rapid Prototyping: Theory & Practice”, Springer, 2006.
Reference Books	
1.	Chua C.K., Leong K.F. and LIM C.S Rapid prototyping: Principles an Applications, World Scientific publications, 3rdEd., 2010
2.	D.T. Pham and S.S. Dimov, “Rapid Manufacturing”, Springer, 2001
3.	Terry Wohlers, “ Wholers Report 2000”, Wohlers Associates, 2000
4.	Paul F. Jacobs, “ Rapid Prototyping and Manufacturing”–, ASME Press, 1996
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	MECHATRONIC SYSTEM DESIGN	L	T	P	C
21RO2007		3	0	0	3

Course Objective

To impart knowledge on

1. Fundamentals of Mechatronic Systems
2. Drives and Control Systems in Mechatronic Systems
3. Various applications of Mechatronic Systems

Course Outcome

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

1. Describe the fundamental components of mechatronic systems
2. Perform Reverse Engineering and CAD Modelling for various applications
3. Classify controls and drives used in mechatronic systems
4. Identify issues in real time interfacing
5. Summarize the application of mechatronic systems
6. Evaluate the application of data acquisition systems

Module: 1	**Mechatronics Systems And Design (8 Hrs)**
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	**Reverse Engineering and CAD Modelling (8 Hrs)**
Basic concept- Digitization techniques – Model Reconstruction – Data Processing for Rapid Prototyping: CAD model preparation, Data Requirements – geometric modeling techniques: Wire frame, surface and solid	

modeling – data formats - Data interfacing, Part orientation and support generation, Support structure design, Model Slicing and contour data organization, direct and adaptive slicing, Tool path generation	
Module: 3	**Control and Drives (8 Hrs)**
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: 4	**Real Time Interfacing (7 Hrs)**
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: 5	**Case Studies – I (7 Hrs)**
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 Hrs)**
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 Hrs)

Text Books	
1.	Bolton, “Mechatronics – Electronic Control Systems in Mechanical and Electrical Engineering”, Pearson Education Limited, ISBN – 9781292076683, 2015, Seventh Edition.
2.	Devdas Shetty, Richard A. Kolkm, “Mechatronics System Design”, Cengage Learning, ISBN – 9781439061992, 2010
Reference Books	
1.	Brian Morriss, “Automated Manufacturing Systems – Actuators Controls, Sensors and Robotics”, McGraw-Hill Inc., ISBN – 9780028023311, 1994
2.	Bradley, D. Dawson, N.C. Burd and A.J. Loader ,“Mechatronics: Electronics in products and Processes”, CRC Press, ISBN – 9780748757428, 1993.
3.	R. K. Rajput, "A Text Book of Mechatronics", 3rd Edition, Chand & Company – New Delhi, 3rd Edition, 2007.
4.	Dan Necsulescu, “Mechatronics”, Pearson Education Asia, 2009.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	VIRTUAL INSTRUMENTATION	L	T	P	C
21RO2008		2	0	2	3

Course Objective

To impart knowledge on

1. VI software and programming in VI.
2. Data Acquisition Systems and network interface concepts.
3. Analysis tools and developing programs for Industrial Applications

Course Outcome

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

1. Describe Virtual Instrument concepts.
2. Create a Virtual Instrument using graphical programming
3. Develop systems for real-time signal acquisition and analysis.
4. Apply concepts of network interface for data communication.
5. Implement and design data acquisition systems for practical applications.
6. Suggest solutions for automation and control applications using virtual instrumentation

Module: 1	**Over view Of Virtual Instrumentation (7 Hrs)**
Historical perspective, advantages, Block diagram and Architecture of a Virtual Instrument, Data Flow Techniques, Graphical programming in data flow, comparison with Conventional programming.	
Module: 2	**Introduction To LabVIEW (7 Hrs)**

Advantages of LabVIEW Software Environment-Creating and Saving VI-Controls and Indicators- Data types. Sub VI: Creating- Opening-Editing-Placing a Sub VI in a block- Creating a Stand Alone Application	
Module: 3	**Programming Techniques (8 Hrs)**
Loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, local and global variables, string and file I/O	
Module: 4	**Data Acquisition Basics (8 Hrs)**
Signals Handling and Classification – Signal Conditioning - Analog Interfacing (I/O) - Counters & Timers – Digital (I/O) - DAQ Hardware – DAQ Software Architecture - DAQ Assist	
Module: 5	**Common Instrument Interfaces (8 Hrs)**
GPIB-RS232-Handshaking- RS232/RS485 interfacing, VISA – IVI - PCMCIA – SCXI – VXI - Networking basics for office & Industrial applications	
Module: 6	**Applications (7 Hrs)**
Motion Control - Virtual Instrumentation and CAD Tool, Remote Front Panel LabVIEW Applications, Timed Loop Applications Client–Server Applications – Case Studies	
	Total Lectures (45 Hrs.)
Text Books	
1.	Dr. Sumathi. S and Prof. Surekha. P, "LabVIEW Based Advanced Instrumentation Systems", 2nd edition, 2007.
2.	Jovitha Jerome, "Virtual Instrumentation using LabVIEW", PHI Learning Pvt. Ltd, New Delhi, 2010.
Reference Books	
1.	Lisa .K, Wells and Jeffrey Travis, "LABVIEW for Everyone", Prentice Hall, 2009.
2.	Skolkoff, "Basic concepts of LABVIEW 4", PHI, 1998.
3.	Gupta. S, Gupta. J.P, "PC Interfacing for Data Acquisition and Process Control", ISA, 1994.
4.	Amy. L.T, "Automation System for Control and Data Acquisition", ISA, 1992.
5.	Gary W. Johnson, Richard Jennings, 'Lab-view Graphical Programming', McGraw Hill Professional Publishing, 2001.
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	**INDUSTRIAL AUTOMATION**	**L**	**T**	**P**	**C**
21RO3001		3	0	0	3

Course Objective:

To impart knowledge on

1. Analyze the concept of Industrial Automation
2. Learn the various automation concepts in Material Handling, Storage and Inspection systems
3. Explore the need of Automation in the Manufacturing Industries

Course Outcomes:

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

1. Describe the basics of Industrial Automation
2. Familiarize the concepts of Assembly systems and Line Balancing
3. Explain the concepts of Material Handling systems
4. Understand the in-depth concepts of Automated Storage and Retrieval System
5. Apply the concept to automate the industrial inspection
6. Create solutions to automate the industrial robotics

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

Introduction

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, 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, 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.		
Module: 6	**Industrial Applications**	**8 Hours**
Introduction to Flexible Manufacturing for automation -Conveyor system for Transferring Granular Material with Weight control – Food Industry: A Machine for Productionof Tzatziki Salad - Simple Robotic Arm for Pickupand Placement of Light Objects - Colour-Based Separation of Plastic Balls-Multiple bottle packing station – BarrelFilling System for Dry Bulk Material		
	Total Lectures	**45 Hours**

Reference Books

1. Mikell P. Groover, "Automation, Production Systems and Computer-Integrated Manufacturing", Fourth edition, Pearson Publishers, 2015.
2. StamatiosManesis, George Nikolakopoulas, 'Introduction to Industrial Automation" CRC Press, 2018.
3. Stephen J. Derby, "Design of Automatic Machinery", Special Indian Edition, Marcel Decker, New York, Yesdee publishing Pvt. Ltd, Chennai, 2004.
4. Groover M. P., "Industrial Robotics, Technology, Programming and Application", McGraw Hill Book and Co., 2012.
5. C.RayAsfahl, "Robots and manufacturing Automation", John Wiley and Sons New York, 1992.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course Code	**MOBILE ROBOTICS**	**L**	**T**	**P**	**C**
21RO3002		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 types of Mobile Robots

Course Outcomes

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

1. Classify and describe the various types of Mobile Robots, kinematics and dynamic analysis
2. Identify different sensor for mobile robots
3. Describe the actuators of Robots
4. Classify different localization and mapping of mobile robots
5. Create solutions to plan and navigate the mobile robots using various techniques
6. Apply the concept of mobile robots in various applications

Module: 1	**Mobile Robots: General Concepts, Kinematics and Dynamics**	**7 Hours**
General Concepts: Types of robots-Ground Robot Locomotion –Legged Locomotion –wheeled Locomotion – wheel types-Drive types –Mobile Robot Kinematics-Direct and Inverse Robot Kinematics- Robot Dynamic Modelling -Newton –Euler Dynamic model-Lagrange Dynamic model-Non-holonomic Robots.		
Module: 2	**Mobile Robot Sensors**	**7 Hours**
Sensor classification –sensor characteristics- position and velocity sensors-Distance sensors: Sonar, Laser, Infrared sensors-Robot vision-sensing: camera calibration-Image acquisition- Illumination-Imagine geometry,		

Preprocessing, Image segmentation-recognition-interpretation-other Robotic sensors- Force and tactile sensors-GPS		
Module: 3	**Mobile robot Actuators**	**7 Hours**
Electrical –stepper motor –DC motor- AC motors- servo motors-motion transmission with gears-harmonic drive- Hydraulic-pneumatic actuators-.		
Module: 4	**Mobile Robot Localization and Mapping**	**8 Hours**
General schematic for mobile robot localization-challenges of localization: noise and aliasing-localization based navigation versus programmed solutions-Belief Representation-		
Module: 5	**Mobile Robot Path, Motion and Task Planning**	**8 Hours**
Introduction – path planning of mobile robots-model based robot path planning-configuration space-Road Map path planning methods- cell decomposition- potential fields-vector field histogram-Mobile robot motion planning-mobile robot task planning-general issues-plan representation and generation		
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	25th September 2021

Course Code	**SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL**	**L**	**T**	**P**	**C**
21RO3003		3	0	0	3

Course Objective:

1. To impart the concepts of process modeling
2. To recall the various system identification techniques
3. Apply adaptive control schemes in various processes

Course Outcomes:

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

1. Classify the various models for identification
2. Identify the given process model
3. Validate the given model
4. Design adaptive control.
5. Apply the design of adaptive controllers for various industrial and real time applications
6. Discuss Case Studies on System identification for robotic systems.

Module: 1	**Models of LTI systems**	**7 Hours**
Linear Models - State space Models - OE model - Model sets, Structures and Identifiability - Models for Time - varying and Non - linear systems: Models with Nonlinearities – Nonlinear state - Space models - Black box models - Fuzzy models		
Module: 2	**Transient response and Correlation Analysis**	**7 Hours**
Frequency response analysis – Spectral Analysis – Least Square – Recursive Least Square –Forgetting factor - Maximum Likelihood – Instrumental Variable methods		
Module: 3	**Open and closed loop identification**	**7Hours**
Direct and indirect identification – Joint input output identification – Non - linear system identification – Wiener models – Power series expansions – State estimation techniques – Non linear identification using Neural Network and Fuzzy Logic- –		
Module: 4	**Adaptive Control**	**8 Hours**

Introduction – Uses – Auto tuning – Self Tuning Regulators (STR) – Model Reference Adaptive Control – Types of STR and MRAC – Different approaches to self- tuning regulators- Stochastic Adaptive control –Gin scheduling		
Module: 5	**Issues in Adaptive control**	**8 Hours**
Stability: Input and output error direct adaptive control, indirect adaptive control exponential parameter convergence -Convergence-Robustness: Heuristic analysis, averaging analysis of slow drift instability, methods for improving robustness		
Module: 6	**Case Studies**	**8 Hours**
Inverted pendulum- Robot arm-process control application: heat exchanger, Distillation column - Application to power system - Ship steering control		
	Total Lectures	**45 Hours**

Reference Books	
1	Karel J Keesman System Identification –An introduction, Springer-Verlag London Limited 2011
2	Narendra and Annasamy," Stable Adaptive Control Systems, Prentice Hall, Inc., 2005
3	Torsten Soderstrom, Petre Stoica, "System Identification", prentice Hall ` International (UK) Ltd,2000
4	William S Levine, " Control Hand Book" CRC Press, Jaico Publishing House, 2000.
5	Astrom and wittenmark Adaptive Control Second Edition", Addison - Wesley Publishing Company,2001
6	Lennart Ljung,System Identification Theory for the User", Prentice Hall, Inc., NJ, 1999.
Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course Code	ADVANCED VIRTUAL INSTRUMENTATION FOR ROBOTICS	L	T	P	C
21RO3004		1	0	4	3

Course Objective:

To impart knowledge on

1. Virtual instrumentation system and LabVIEW based Virtual Instrumentation.
2. Hardware and software involved programming techniques in VI.
3. Basics of Virtual Programming Techniques and its applications.

Course Outcomes:

The student will be able to

1. Describe the architecture of Virtual Instrumentation.
2. Classify the programming structure
3. Analyze DAC basics and Use Virtual Instrumentation for instrumentation and control
4. Identify a suitable interface for data acquisition
5. Apply simple programming using VI
6. Apply real time robotic programming with VI

Module: 1	**Introduction to Lab VIEW**	**4 Hours**
Block diagram and Architecture of a Virtual Instrument, Data Flow Techniques, Graphical programming in data flow, comparison with Conventional programming, Advantages of LabVIEW Software Environment-Creating and Saving VI-Controls and IndicatorsData types. Sub VI: Creating- Opening-Editing-Placing a Sub VI in a block- Creating a Stand Alone Application		
Module: 2	**Programming structure**	**6 Hours**
Loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, local and global variables, string and file I/O		
Module: 3	**Data Acquisition Basics**	**2 Hours**
Signals Handling and Classification – Signal Conditioning - Analog Interfacing (I/O) - Counters & Timers – Digital (I/O) - DAQ Hardware – DAQ Software Architecture - DAQ Assist		
Module: 4	**Common Instrument Interfaces**	**4 Hours**
GPIB-RS232-Handshaking- RS232/RS485 interfacing, VISA – IVI - PCMCIA – SCXI – VXI - Networking basics for office & Industrial applications		

Module: 5	Programming Techniques	2 Hours
Waveform Generators - Frequency Measurements Using Transition Duration Method- Analog Input and Output Interface Using NImyDAQ - Network Interface Using TCP/IP Functional Blocks -Real-Time Temperature Measurements by Interfacing Thermocouple | LM35 -Speed and Direction Control for a Stepper Motor-- Design and Analysis Analog of Filters Using NI-ELVIS Module -. Embedded Implementation of Digital Filters Using SPEEDY33 - Speed Control of DC Motor by Interfacing ARDUINO with LabVIEW -. Development of Digital Voltmeter Using MCB2300 Embedded Board		
Module: 6	**Robotic design with VI**	**3 Hours**
Robotics library with built-in connectivity to robotic sensors and actuators, foundational algorithms for intelligent operation and robust perception, and motion functions for making your robot or vehicle move. You can deploy your algorithms and control code to NI real-time embedded hardware		
	Total Lectures	**21 Hours**

Reference Books

1	Jovitha Jerome, "Virtual Instrumentation Using LabVIEW" Prentice Hall India Learning Private Limited, New Delhi 2020
2	JohnEssick, "Hands-On Introduction to LabVIEW for Scientists and Engineers", Oxford University Press,New York, 2nd Edition, 2010
3	Sanjay Gupta and Joseph John, " Virtual Instrumentation using LabVIEW", Tata McGraw – Hill Education India Private Limited, New Delhi, 2nd Edition, 2010.
4	Lab VIEW Basics: I & II Manual, National Instruments, 2005
5	Gary W Johnson, Richard Jennings, "LabVIEW Graphical Programming", McGraw-Hill Education, New York, 3rd Edition, 2001
6	NesimiErtugrul "LabVIEW for Electric Circuits, Machines, Drives, and Laboratories", Pearson Education, 2nd Edition, 2002

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course code	ADVANCED ROBOT OPERATING SYSTEMS	L	T	P	C
21RO3005		3	0	0	3

Course Objective:

To impart knowledge on

1. Basics of Robot Operating Systems and its architecture.
2. Provide knowledge on the simulation of robotics system like ROS perception
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. Analyse the issues in hardware interfacing
6. Able to program mobile robot and Industrial Robot

Module: 1	Introduction to Robot Operating System	7 Hours
Getting started with ROS: ROS Equation, Why use ROS? Installing ROS, ROS Architecture and concepts, ROS Filesystem, ROS Coding styles, IDE, ROS Hello World, ROS Turtlesim.Navigation through file system, Understanding of Nodes, topics, services, messages, bags, rosmaster, parameter server.		
Module: 2	**Programming with ROS**	**7 Hours**
ROS catkin workspace and package, ROS Client libraries: roscpp & rospy, roslaunch, Rviz, rqt, Learning ROS programming using TurtleSim: roscpp and rospy, Understanding ROS concepts using TurtleSim, Moving TurtleSim using ROS programming.		
Module: 3	**Advanced concept of URDF**	**7Hours**
Understanding Transformation and frames, Working with TF broadcaster and listener, Creating TF for your robot, Working with ROS TF tools, Understanding URDF &xacro, Writing your own URDF and xacro, Visualizing your robot, Interacting with the robot model, Moving the robot model, various tags in URDF, URDF/xacro for a mobile robot, URDF/xacro for a robotic arm		

Module: 4	ROS MoveIt!	8 Hours
Introduction to ROSMoveIt!, Configuring and fine tuning MoveIt! for any robot, Using different planners in MoveIt, Interfacing perception to MoveIt, Complex motion planning and pick-place, Programming using MoveIt! APIs		
Module: 5	**ROS Perception**	**8 Hours**
ROS interface of OpenCV and PCL, Creating ROS nodelets for working with PCL, 2D & 3D Object detection using ROS, YOLO Object detection using ROS, ROS-Perception projects		
Module: 6	**ROS in Real World Applications and Introduction to ROS 2**	**8 Hours**
Hardware Interface: Sensor Interfacing – Sensor Drivers for ROS – Actuator Interfacing – Motor Drivers for ROS, Understanding core concepts of ROS 2, Migrating from ROS 1 to ROS 2, ROS 2 concepts, ROS 2 programming, ROS 2 simulation in Gazebo		
	Total Lectures	**45 Hours**

Reference Books

1	YoonSeokPyo, HanCheol Cho, RyuWoon Jung, TaeHoon Lim, "ROS Robot Programming, Published by ROBOTIS Co.,Ltd. 2017
2	Quigley, Morgan and Gerkey, Brian and Smart, William D., "Programming Robots with ROS: A Practical Introduction to the Robot Operating System", O'Reilly Media, 2015.
3	Wyatt Newman, "A Systematic Approach to learning Robot Programming with ROS", CRC Press, 2017.
4	Patrick Gabriel, "ROS by Example: A do it yourself guide to Robot Operating System", Lulu, 2012.
5	AnisKoubaa, "Robot Operating System (ROS) – The Complete Reference (Vol.1 to 4), Springer, 2018.
6	Lentin Joseph, Robot Operating System for Absolute Beginners, Apress, 2018

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

Course Code	AUTONOMOUS MOBILE ROBOTS	L	T	P	C
21RO3006		3	0	0	3

Course Objectives

To impart knowledge on

1. Concepts of Sensing and Controlling the Autonomous Mobile Robots
2. Kinematics models of Mobile Robots
3. Fundamentals of ROS

Course Outcomes

The student will be able to

1. Classify and describe the various types of Mobile Robots
2. Describe the kinematic models and manoeuvrability of Robots
3. Identify the sensing elements and actuators used in mobile robots
4. Create solutions to localize, plan and navigate the mobile robots using various techniques
5. Develop path planning algorithm for Robot Navigation
6. Apply the concept of ROS for mobile robots in various applications

Module: 1	Introduction	5 Hours
History of Robots – Autonomous Robots – Robot Arm Manipulators – Mobile Robots – Multi-Robot System and Swarms. 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. Mobile Robot Manoeuvrability: Degree of mobility - Degree of steerability. Mobile Robot Workspace - Degrees of freedom - Holonomic robots - Path and trajectory considerations.		
Module: 3	**Perception**	**8 Hours**
Sensors for Mobile Robots: Characterizing sensor performance - Representing uncertainty - Wheel/motor sensors - Heading sensors – Accelerometers – Inertial Measurement Unit (IMU) – GPS - 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.		
Module: 4	**Mobile Robot Localization**	**8 Hours**

Introduction to Map based localization-Markov Approach-Kalman Filter Approach. SLAM: The SLAM Problem-Monocular SLAM and beyond-Extended Kalman Filter SLAM		
Module: 5	**Planning and Navigation**	**10 Hours**
Motion Planning – Representation and Configuration Space-Graph Search Methods-Collision Avoidance-Sampling based planning-Planning under motion constraints-Dijkstra's algorithm and the motion window.		
Module: 6	**ROS**	**7 Hours**
Introduction to ROS: Services, Actions and Nodes. Software representation of a Robot using Unified Robot Description Format (URDF) - ROS parameter server and adding real-world object representations to the simulation environment. Autonomous Navigation: Map creation with GMapping. Motion planning, pick and place behaviours using ROS MoveIt!		
	Total Lectures	**45 Hours**

Reference Books

1. Roland Siegwart, Illah Reza Nourbakhsh and Davide Scaramuzza, "Introduction to Autonomous Mobile Robots", Second Edition, MIT Press, 2011.
2. Eugene Kagan, Shvaib, Irad Ben-Gal, "Autonomous Mobile Robots and Multi-Robot Systems Motion-Planning, Communication and Swarming", Wiley publication, 2019.
3. Sebastian Thrun , Wolfram Burgard, Dieter Fox , "Probabilistic Robotics", MIT Press, 2006
4. Wyatt Newman, "A Systematic Approach to learning Robot Programming with ROS", CRC Press, 2017.
5. AnisKoubaa, "Robot Operating System (ROS) – The Complete Reference (Vol.1 to 4), Springer, 2018.

Recommended by Board of Studies	
Approved by Academic Council	25th September 2021

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 3	T 0	P 0	C 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 0	T 0	P 2	C 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 3	T 0	P 0	C 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 3	T 0	P 0	C 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 3	T 0	P 0	C 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 3	T 0	P 0	C 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 3	T 0	P 0	C 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.