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 1	T 0	P 3	C 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 3	T 0	P 0	C 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 3	T 0	P 0	C 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.

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

Course Objectives:

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

Course Outcomes:

The Student will be able to

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

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

Module 1: Introduction (7 hrs)
Process Control Systems and Structure in the Food Industry – Process Control Methods – Robotics in the food industry – Automation – Specification for a food sector robot – future trends.

Module 2: Sensors and Automation (8 hrs)
Sensors for automated food process control – Special Considerations – Measurement Methods – Device Integration – Applications - Machine Vision- Optical Sensors – SCADA in food industry.

Module 3: Gripper Technology (8 hrs)
Gripper Challenges in food industry – Gripping Physics – Pinching and enclosing grippers – Penetrating Grippers – Suction Grippers – Surface Effect Grippers –Selection of appropriate gripping mechanism.

Module 4: Sensor Networks and Intelligent Quality Control Systems (8 hrs)
Wireless sensor networks – applications in agriculture and food production – future trends – intelligent control systems using fuzzy logic.

Module 5: Advanced Methods for control of food processes (7 hrs)
Introduction – Case Study of Bio conversion in a batch fed reactor – Design of PID Controller for fed batch process – Real time optimization.

Module 6: Applications (7 hrs)
Case Study – Bulk sorting – Food chilling and processing – meat processing – poultry industry –sea food processing – confectionary -

Text Books:

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

Reference Books:

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

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

Course Objectives:

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

Course Outcomes:

The Student will be able to

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

Module 1: Introduction to Neural Networks (7 hrs)
Differences between Biological and Artificial Neural Networks - Typical Architecture, Common Activation Functions, McCulloch - Pitts Neuron, Simple Neural Nets for Pattern Classification, Linear Separability - Hebb Net, Perceptron, Adaline, Madaline - Architecture, algorithm, and Simple Applications.

Module 2: Neural Network Applications (8 hrs)

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

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

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

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

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

Module 5: Membership Functions (8 hrs)

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

Module 6: Applications (7 hrs)

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

Text Books:

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

Reference Books:

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

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

Course Objectives:

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

Course Outcomes:

The Student will be able to

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

Module 1: The 8051 Architecture (8 hrs)

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

Module 2: Instruction Set and Programming (8 hrs)

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

Module 3: Memory and I/O Interfacing: (7 hrs)
Memory and I/O expansion buses - control signals - memory wait states. Interfacing of peripheral devices such as General Purpose I/O - ADC - DAC - timers - counters - memory devices. External Communication Interface (8 Hours) Synchronous and Asynchronous Communication. RS232 - SPI - I2C. Introduction and interfacing to protocols like Blue-tooth and Zig-bee.
Module 4: High Performance RISC Architecture: (8 hrs)
ARM 9 RISC architecture merits and demerits – The programmer's model of ARM Architecture – 3- stage pipeline ARM organization - 3-stage pipeline ARM organization – ARM instruction execution – Salient features of ARM instruction set
Module 5: High Performance Microcontroller Architectures: (8 hrs)
Introduction to the Cortex-M Processor Family - ARM 'Cortex-M4' architecture for microcontrollers – Thumb 2 instruction technology – Internal Registers - Nested Vectored Interrupt controller - Memory map - Interrupts and exception handling – Applications of Cotex-M4 architecture
Module 6: Applications: (6 hrs)
LED – LCD and keyboard interfacing. Stepper motor interfacing – DC Motor interfacing – sensor interfacing.

Text Books:

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

Reference Books:

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

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

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

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

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

ROBOTICS AND AUTOMATION

LIST OF COURSES

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

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

Course Objectives:
To impart knowledge on
1. Phase diagrams and alloys
2. Electric, Mechanical and Magnetic properties of materials
3. Advanced Materials used in engineering applications

Course Outcomes:
At the end of this course, students will demonstrate the ability to
1. Describe the various phase diagrams and their applications
2. Explain the applications of Ferrous alloys
3. Discuss about the electrical properties of materials
4. Summarize the mechanical properties of materials and their measurement
5. Differentiate magnetic, dielectric and superconducting properties of materials
6. Describe the application of modern engineering materials

Module 1: Introduction: (6 Hours)
Historical perspective-Classification-Atomic Structure and Inter atomic Bonding –Structure of Crystalline solids- Phase diagrams

Module 2: Ferrous Alloys: (9 Hours)
The iron-carbon equilibrium diagram - phases, invariant reactions - microstructure of slowly cooled steels - eutectoid steel, hypo and hypereutectoid steels - effect of alloying elements on the Fe-C system - diffusion in solids - Fick's laws - phase transformations - T-T-T-diagram for eutectoid steel – pearlitic, baintic and martensitic transformations - tempering of martensite – steels – stainless steels – cast irons.

Module 3: Electrical Properties:(9 Hours)
Conducting materials-quantum free electron theory -Fermi Dirac Statistics-Band theory of solids - the density of states. Dielectrics - types of polarization-measurement of dielectric Permittivity - Loss factor- Dielectric loss mechanisms. Magnetostriction. Electron ballistics- materials for thermionic emission electron guns-electron gun for electron beam machining-electric discharge plasma - EDM machining.

Module 4: Mechanical Properties: (8 Hours)
Tensile test - plastic deformation mechanisms - slip and twinning - role of dislocations in slip - strengthening methods - strain hardening - refinement of the grain size - solid solution strengthening - precipitation hardening - creep resistance - creep curves - mechanisms of creep - creep-resistant materials - fracture - the Griffith criterion - critical stress intensity factor and its determination - fatigue failure - fatigue tests - methods of increasing fatigue life - hardness - Rockwell and Brinell hardness - Knoop and Vickers microhardness.

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

Text Books

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

Reference Books

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

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

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

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

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

Text Books:

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

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

Reference Books:

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

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

Course Objective:

To impart knowledge on

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

Course Outcomes:

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

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

Module 1: Introduction: (8 Hours)

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

Module 2: Time Domain Analysis: (8 Hours)

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

Module 3: State Space Analysis: (8 Hours)

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

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

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

Module 5: System Stability: (8 Hours)

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

Module 6: Frequency Domain Analysis: (5 Hours)

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

Text books:

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

Reference Books:

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

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

Course Objectives:

To impart knowledge on

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

Course Outcomes:

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

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

Electrical Machines

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

Control Systems:

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

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

Course Objectives:

To impart knowledge on

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

Course Outcomes:

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

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

Module 1: Operational Amplifier Characteristics:(8 Hours)
Functional Block Diagram – Circuit symbol, Pin Configuration – The ideal OPAMP - Open loop gain, Inverting and Non-inverting amplifiers, Voltage follower, Differential amplifier, CMRR, slew rate – DC Characteristics - AC Characteristics.
Module 2: Linear Applications Of Op-Amp: (8 Hours)
Summing amplifier, Subtractor, Integrator and Differentiator – Analog PID Controllers -V-I and I-V converters, Sinusoidal oscillators - Active filters: Design of low pass and high pass filters**,** Instrumentation Amplifiers, Charge Amplifiers.
Module 3: Nonlinear Applications Of Op-Amp :(7 Hours)
Comparator – Regenerative comparator, Zero crossing detector, Window detector, Sample and hold circuit, Rectifiers, Clipper and Clamper, Logarithmic and Exponential amplifiers, Multiplier and Divider, Square and Triangular waveform generators
Module 4: Special Function ICs(8 Hours)
Block diagram of 723 general purpose voltage regulator- Fixed and adjustable three terminal regulators -555 Timer Functional block diagram and description – Monostable and Astable operation, Applications, 566 Voltage Controlled Oscillator. PLL Functional Block diagram – Principle of operation, Applications: Frequency synthesis, DC Motor speed control.
Module 5: A-D And D-A Converters: **(7 Hours)**
DAC/ADC performance characteristics – Digital to Analog Converters: Binary weighted and R-2R Ladder types – Analog to digital converters: Continuous, Counter ramp, Successive approximation, ADC specifications, resolution, accuracy, linearity, offset and quantization errors, sample rate and aliasing, line drivers and receivers, high power output drivers and devices, multi-channel ADCs, internal microcontroller ADCs,
Module 6: Interfacing and Data Acquisition Systems: (7 Hours)
Grounding Conflict, Ground Loops, Cross Talk, Shielded Wiring, Isolation, Linearization, Circuit protection, Impedance Matching, Parameters of Data Acquisition Systems such as dynamic range, calibration, bandwidth, processor throughput, time-based measurements and jitter-System Architecture, Case Studies

Text Books:

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

Reference Books:

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

18RO2006	SENSORS AND PROTOCOLS FOR INSTRUMENATION	L 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.