Robotics Engineering	
Course Code: MRA-101 Contact Hours: L-3 T-0 P-2 Course Category: DCC	Credits: 4 Semester: 1

Introduction: Robotics engineering provides an overview of robot mechanisms, kinematics, dynamics, and intelligent controls.

Course Objectives:

- Research simple machines and the history of robotics;
- Students to be able to analyze Robot motions.
- Students learn Offline and online Robot Programming;
- The students are to be provided hands on practical exposure on topics covered in the course.

Pre-Requisites: NIL

Course Outcomes: Having successfully completed this course, the student will be able to

- Understand the mechanism of robot and its grippers.
- Analyse the kinematics of robot using DH representation.
- Analyse the differential motion and velocities of robot using jacobian.
- Analyse the dynamic analysis of forces using Lagrangian and Newtonian method.
- Understand the online and offline programming of robots.
- The practical sessions will improve visualization of the concepts taught in theory.

Pedagogy: Classroom teaching is supported by White board, black board, chalks, markers, projector and screen. The hand written notes, PowerPoint slides and assignments will be provided to the students and also mailed to them. The students can also raise their issues related to the course in the class and mail.

Contents:

UNIT I	11 Hours
Introduction: Brief History, Types of robots, Overview of robot subsystems, resolution, repeatability and accuracy, Degrees of freedom of robots, Robot configurations and concept of workspace, Mechanisms and transmission, End effectors and Different types of grippers, vacuum and other methods of gripping. Pneumatic, hydraulic and electrical actuators, applications of robots, specifications of different industrial robots.	
UNIT II	11 Hours
Kinematics of Robots: Transformation Matrices, Inverse transformation matrices, Forward and Inverse kinematic equation for position and orientation, Denavit-Hartenberg representation of robot, inverse kinematic solution for articulated robot, Numericals. **Differential Motions and velocities:** Jacobian, Differential motions of a frame,	

Differential motion between frames, Calculation of the Jacobian, Inverse Jacobian, Numericals.		
UNIT III		10 Hours
Dynamic analysis of Force: Lagrangian and Newtonian mechanics, Dynamic equations form multiple –DOF Robots, Static force analysis of Robots, Transformation of forces and moments between coordinate frames, Numericals. **Trajectory Planning**: Basics of Trajectory planning, Joint space trajectory planning, Cartesian Space trajectories, Numericals.		
UNIT IV		10 Hours
Robot Programming languages & systems: Introduction, the three levels of robot programming, requirements of a robot programming language, problems peculiar to robot programming languages. **Off-line programming systems**: Introduction, central issues in on-line and off-line programming. Programming examples**.**		
Text Books		
1.	Saha S K, “Introduction to Robotics”, TMH Publication, 2008.	
2.	Nagrath and Mittal, “Robotics and Control”, Tata McGraw-Hill, 2003.	
3.	Fu. K.S, Gonzalez, R.C., Lee, C.S.G, “Robotics, control, sensing, Vision and Intelligence”, McGraw Hill International, 1987.	
4.	Saeed B. Niku, “Introduction to Robotics analysis, Systems & Applications”, Pearson Education Singapore P. Ltd., 2002.	
5.	Spong and Vidhyasagar, “Robot Dynamics and Control”, John Wiley and sons, 2008.	
6.	Howie Choset, Kevin Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia	
7.	Kavraki and Sebastian Thurn, “Principles of Robot Motion: Theory, Algorithms, and Implementations”, Prentice Hall of India, 2005.	

Mechatronics Systems and Applications	
Course Code: MRA-103 Contact Hours: L-3 T-0 P-2 Course Category: DCC	Credits: 4 Semester: 1

Introduction: The basic aim of this course is to impart knowledge to the students that they can analyze how will a factory operation, which is being done manually be automated and further programming is taught to implement automation.

Course Objectives:

- Students to learn designing Industrial Automation;
- To gain knowledge about sensors and their interfacing;
- To learn PLC Programming.
- The students are to be provided hands on practical exposure on topics covered in the course.

Pre-Requisites: NIL

Course Outcomes: Having successfully completed this course, the student will be able to

- Develop pneumatic sequencing circuits;
- Electro-pneumatic circuits;
- Electronic sequencing problems;
- Do PLC programming;
- Understand working of transducers, sensors and signal conditioning.
- The practical sessions will improve visualization of the concepts taught in theory.

Pedagogy: Classroom teaching is supported by White board, black board, chalks, markers, projector and screen. The hand written notes, PowerPoint slides and assignments will be provided to the students and also mailed to them. The students can also raise their issues related to the course in the class and mail.

Contents:

UNIT I	11 Hours
Introduction: What is Mechatronics? Measurement System; Control Systems, Mechatronics Approach. **Actuators and Mechanisms:** Actuation Systems; Pneumatic and Hydraulic Systems; Process Control Valves; Rotary Actuators Pneumatic sequencing problems; **Mechanical Actuation Systems**: Kinematic Chains, Cams, Gears, Belt & chain drives;	
UNIT II	11 Hours
Electrical Actuation Systems: Electrical System, Mechanical Switches, Solid state switches, Solenoids, DC motors, AC Motors, Stepper Motors, Electro pneumatic sequencing problems;	

Sensors and Transducers: Performance Terminology; Displacement, Position, and proximity, velocity and motion, Force, Fluid Pressure, Liquid level, Temperature sensors, Flow Transducers, Optical Sensors & Transducers, Selection of Sensors, Mechanical / Electrical switches, Inputting data by switches.

Signal Conditioning: Signal Conditioning; Filtering Digital Signal; Multiplexers; Data Acquisition; Digital Signal Processing; Pulse Modulation; Data Presentation Systems.

UNIT III	10 Hours

Digital Logic: Logic gates, Boolean algebra, Karnaugh maps, Application of logic gates, sequential logic.

Microprocessors and Microcontrollers: Microcomputer Structure; microcontrollers; Applications.

Programmable Logic Controllers: PLC Structure, Input / Output Processing, Programming, Language (Ladder Diagram), Logic Functions, Latching, Sequencing, Timers, Internal Relays and Counters, Shift Registers, Master and Jump Controls, Jumps, Data Movement, Code Conversion, Ladder Circuits.

Input/output Systems: Interfacing, I/O addressing, Serial communications interface, Examples of interfacing.

UNIT IV	10 Hours

Modelling & System Response: Mathematical Models; Mechanical, Electrical, Hydraulic and Thermal Systems; Modelling of dynamic systems.

Mechatronic Case studies: Consumer Mechatronic Products, Surgical Equipment, Industrial Robot, Autonomous Guided Vehicles, printers, automated washing machine, Autofocus Camera.

Text Books

1.	Bolton W, “Mechatronics”, Pearson Education Ltd., 4th Edition.
2.	David G. Alciatore& Michael B. Histrand, “Introduction to Mechatronics”, Tata McGraw Hill, 2007.
3.	Shetty, Dedas, Kolk and Richard, “Mecharonics System Design”, PWS Pub, 1997.
4.	Mahalik, “Mechatronics Principles, Concept and Applications”, Tata McGaw Hill, 2003.
5.	Bishop, Ropert H., “Mechatronics Handbook”, CRC Press, 2002.
6.	Mahalik, “Mehatronics”, TMH, 2003.

Computer Aided Modelling and Analysis	
Course Code: MRA-105 Contact Hours: L-3 T-0 P-2 Course Category: DCC	Credits: 4 Semester: 1

Introduction: Computer Aided Design (CAD) is the most powerful tool in design and manufacturing industries with its reliability, flexibility, efficient and cost effectiveness. With the CAD one can easily visualize and see the final product at the design stage itself with the aid of computer. The final product can be modified easily according to the need of application.

Course Objectives: The general objectives of the course are to enable the students to

- Understand the basic fundamentals of computer aided design and manufacturing.
- To learn 2D &3D transformations of the basic entities like line, circle, ellipse etc.
- To understand the different geometric modeling techniques like solid modeling, surface modeling, feature based modeling etc. and to visualize how the components look like before its manufacturing or fabrication.
- To learn the part programming, importance of group technology, computer aided process planning, computer aided quality control.
- To learn the overall configuration and elements of computer integrated manufacturing systems.
- The students are to be provided hands on practical exposure on topics covered in the course.

Pre-Requisites: NIL

Course Outcomes: On completion of this course student should be able to:

- Integrate the role of graphic communication in the engineering design process
- Generate and interpret engineering technical drawings of parts and assemblies according to engineering design standards.
- Use CAD software to generate a computer model and technical drawing for a simple, well-defined part or assembly.
- The practical sessions will improve visualization of the concepts taught in theory.

Pedagogy: Classroom teaching is supported by White board, black board, chalks, markers, projector and screen. The hand written notes, PowerPoint slides and assignments will be provided to the students and also mailed to them. The students can also raise their issues related to the course in the class and mail.

Contents:

UNIT I	11 Hours
Introduction to CAD: Criteria for selection of CAD workstations, Shigle Design Process, Design criteria, Geometric modeling, entities, 2D & 3D Primitives. 2D & 3D Geometric **Transformations:** Translation, Scaling, Rotation, Reflection and Shearing, concatenation. **Graphics standards:** GKS IGES, PDES. Wireframe modeling: Curves: Curve representation. Analytic curves –lines, Circles, Ellipse, Conis. Synthetic curves –	

Cubic, Bezier, B-Spline, NURBS.		
UNIT II		11 Hours
Surface Modeling: Surface entities, Surface Representation. Analytic Surface –Plane Surface, Ruled Surface, Surface of Revolution, Tabulated Cylinder. Synthetic Surface-Cubic, Bezier, B-spline, Coons.		
UNIT III		10 Hours
Solid Modeling Techniques: Graph Based Model, Boolean Models, Instances, Cell Decomposition & Spatial –Occupancy Enumeration, Boundary Representation (B-rep) & Constructive Solid Geometry (CSG).		
UNIT IV		10 Hours
Advanced Modeling Concepts: Feature Based Modeling, Assembling Modeling, Behavioural Modeling, Conceptual Design & Top Down Design. Capabilities of Modeling & Analysis Packages such as solid works, Unigraphics, Ansys, Hypermesh. Computer Aided Design of mechanical parts and Interference Detection by Motion analysis.		
Text Books		
1.	Ibrahim Zeid, "CAD/CAM, Theory and Practice", McGraw Hill, 1998.	
2.	Foley, Van Dam, Feiner and Hughes, "Computer Graphics Principles and Practice", Addison –Wesley, 2000.	
3.	Martenson, E. Micheal, "Geometric Modelling", John Wiley & Sons, 1995.	
4.	Hill Jr, F.S., "Computer Graphics using open GL", Pearson Education, 2003.	

Automation in Manufacturing	
Course Code: MRA-107 Contact Hours: L-3 T-0 P-2 Course Category: DCC	Credits: 4 Semester: 1

Introduction: This is a basic introductory course on automation in Industry. A management course which concentrates on importance of automation, effect of automation of an organization, choosing the level of automation required and enlightens the students about costing involved and problems such as line balancing in an automated environment.

Course Objectives: The objectives of this course are

- To develop the understanding related to the need of automation in manufacturing systems.
- To familiarize with the potential benefits obtained with the implementation of automation at various levels in industry.
- Describe the basic concepts of automation in manufacturing systems.
- Acquire the fundamental concepts of automated flow lines and their analysis.
- Classify automated material handling, automated storage and retrieval systems.
- The students are to be provided hands on practical exposure on topics covered in the course.

Pre-Requisites: NIL

Course Outcomes: Having successfully completed this course, the student will be able to

- Identify the basic components required for manufacturing systems automation.
- Intend an automated material handling and inspection systems.
- Design and analyze an automated manufacturing system.
- The practical sessions will improve visualization of the concepts taught in theory.

Pedagogy: Classroom teaching is supported by White board, black board, chalks, markers, projector and screen. The hand written notes, PowerPoint slides and assignments will be provided to the students and also mailed to them. The students can also raise their issues related to the course in the class and mail.

Contents:

UNIT I	11 Hours
Introduction: Definition of automation, Types of production, Functions of Manufacturing, Organization and Information Processing in Manufacturing, Production concepts and Mathematical Models, Automation Strategies. **Fixed Automation:** Automated Flow lines, Methods of Workpart Transport, Transfer Mechanism - Continuous transfer, intermittent transfer, Indexing mechanism, Operator-Paced Free Transfer Machine, Buffer Storage, Control Functions, Automation for Machining Operations, Design and Fabrication Considerations. **Analysis of Automated Flow Lines:** General Terminology and Analysis, Analysis of Transfer Lines without Storage, Partial Automation, Automated Flow Lines with Storage Buffers.	

UNIT II	11 Hours
Assembly Systems and Line Balancing: The Assembly Process, Assembly Systems, Manual Assembly Lines, The Line Balancing Problem, Methods of Line Balancing, Computerized Line Balancing Methods, Other ways to improve the Line Balancing, Flexible Manual Assembly Lines. **Automated Assembly Systems:** Design for Automated Assembly, Types of Automated Assembly Systems, Vibratory bowl feeder and Non-vibratory bowl feeder, Part Orienting Systems, Feed tracks, Escapements and part placing mechanism, Analysis of Multi-station Assembly Machines, Analysis of a Single Station Assembly Machine	
UNIT III	10 Hours
Automated Materials Handling: The material handling function, Types of Material Handling Equipment, Analysis for Material Handling Systems, Design of the System, Conveyor Systems, Automated Guided Vehicle Systems. **Automated Storage Systems:** Storage System Performance, Automated Storage/Retrieval Systems, Carousel Storage Systems, Work-in-process Storage, Interfacing Handling and Storage with Manufacturing.	
UNIT IV	10 Hours
Automated Inspection and Testing: Inspection and testing, Statistical Quality Control, Automated Inspection Principles and Methods, Sensor Technologies for Automated Inspection, Coordinate Measuring Machines, Other Contact Inspection Methods, Machine Vision, Other optical Inspection Methods. **Modeling Automated Manufacturing Systems:** Role of Performance Modeling, Performance Measures**,** **Performance Modeling Tools:** Simulation Models, Analytical Models. **The Future Automated Factory:** Trends in Manufacturing, The Future Automated Factory, Human Workers in the Future Automated Factory, The social impact.	

Text Books	
1.	Automation, Production Systems, and Computer-Integrated Manufacturing by Mikell P. Groover, Prentice Hall.
2.	Fundamentals of Modern Manufacturing: Materials, Processes, and Systems by Mikell P. Groover, John Wiley & Sons

Pneumatics and Hydraulic Control	
Course Code: MRA-102 Contact Hours: L-3 T-0 P-2 Course Category: DCC	Credits: 4 Semester: 2

Introduction: This course allows students to develop the knowledge and understanding of the operational and maintenance requirements of pneumatic and hydraulic systems.

Course Objectives: The objectives of this course are:

- To introduce the industrial hydraulics and pneumatics, their parts, functions and their structure.
- To give the required information about hydraulics and pneumatics and to teach the fundamentals of hydraulic and pneumatic circuit design.
- To provide exposure to the basics of Hydraulic and Pneumatic and principles of development of circuits for various engineering applications.
- The students are to be provided hands on practical exposure on topics covered in the course.

Pre-Requisites: NIL

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

- Choose hydraulic and pneumatic elements and demonstrate the applicability of fluid power systems for engineering applications.
- Design customized circuits in hydraulics, pneumatics and servo systems for various industrial needs
- The practical sessions will improve visualization of the concepts taught in theory.

Pedagogy: Classroom teaching is supported by White board, black board, chalks, markers, projector and screen. The hand written notes, PowerPoint slides and assignments will be provided to the students and also mailed to them. The students can also raise their issues related to the course in the class and mail.

Contents:

UNIT I	11 Hours
Advantages and Disadvantages of Fluid control, Types of Hydraulic Fluids, physical, chemical and thermal properties of hydraulic fluids, selection of hydraulic fluid, fluid flow fundamentals **Hydraulic Pumps and Motors:** Basic Types and constructions, ideal pump and motor analysis, Performance curves and parameters,	
UNIT II	11 Hours
Hydraulic Control Valves: Valve configurations, general valve analysis, critical centre, open centre, three way spool valve analysis and Flapper valve analysis, pressure control valves, single and two stage pressure control valves, flow control valves, introduction to electro hydraulic valves.	

Hydraulic Power Elements: Valve controlled motor, valve controlled piston, three way valve controlled piston, and pump controlled motor, pressure transients in power elements.

UNIT III	10 Hours

Characteristics of Pneumatics, Applications of Pneumatics, Basic Pneumatic elements, Steady flow of Ideal gases, orifice and nozzle calculations, capillary flow, flow of real gases, linear flow equations in Orifices and Nozzles.

Steady state analysis of pneumatic components: Multiple restriction and volume calculations, sensing chambers, valves, Single acting actuators.

UNIT IV	10 Hours

Transients in elementary pneumatic systems: Linear dynamics-linear pneumatic spring rate, linear dynamics of a variable volume of gas, Pneumatic transmission lines, linear dynamics in single acting actuators.

Applications in industrial process controls: On-Off pneumatic feedback systems, feedback control of proportional gain, derivative action, integral action, Design of a Pneumatic Pressure Regulator.

Text Books

1.	Herbert E. Merritt, “Hydraulic Control Systems”, John Wiley & Sons, 2005.
2.	B.W. Anderson, “The Analysis and Design of Pneumatic Systems”, Wiley, 1980.
3.	A.B. Goodwin, “Fluid Power Systems”, Macmillan, 1989.
4.	Anthony Esposito, “Fluid power with applications”, Prentice Hall, 7th Edition, 2002.
5.	Arthur Akers, Max Gassman, Richard Smith, “Hydraulic Power System Analysis”, Taylor and Francis Group, 2006.
6.	John Pippenger& Tyler Hicks, “Industrial Hydraulics”, 3rd edition McGraw Hill, 1980.

Computer Integrated Manufacturing	
Course Code: MRA-104 Contact Hours: L-3 T-0 P-2 Course Category: DCC	Credits: 4 Semester: 2

Introduction: Today computer integrated manufacturing systems are widely used in industries. This course develops capability in students to demonstrate and use of CIM in fabrication industry. Students can demonstrate and use automated assembly lines, group technology, Flexible manufacturing systems for welding, material handling and identification technology. Students can utilize various automated inspection systems/instruments in fabrication industries. Students can prepare planning and scheduling of process equipment fabrication using various CAPP software.

Course Objectives: The objectives of this course are

- To expose the student to the different types of manufacturing available today such as the Special manufacturing System, the Manufacturing Cell, and the Flexible Manufacturing System (FMS).
- To learn the fundamentals of computer assisted numerical control programming and programming languages,
- To learn the concepts of Computer Integrated Manufacturing and Management System and automated flowlines,
- To learn the guidelines and criteria for implementing CAD/CAM Systems and associated software for design, Manufacturing, and a common CAD/CAM data base organized to serve both design and manufacturing
- To discuss current research trends and possible future development.
- The students are to be provided hands on practical exposure on topics covered in the course.

Pre-Requisites: NIL

Course Outcomes: Having successfully completed this course, the student will

- Have sound knowledge of Flexible Manufacturing systems parts and functioning.
- Be able to perform solve analytical problems on the subject.
- Be able to define the real world modern manufacturing process steps.
- Analyze and design sequence of operations and selection of system parts for optimum flexibility.
- The practical sessions will improve visualization of the concepts taught in theory.

Pedagogy: Classroom teaching is supported by White board, black board, chalks, markers, projector and screen. The hand written notes, PowerPoint slides and assignments will be provided to the students and also mailed to them. The students can also raise their issues related to the course in the class and mail.

Contents:

UNIT I	11 Hours
Introduction to CIM The meaning of Manufacturing, Types of Manufacturing; Basic Concepts of CIM: CIM Definition, Elements of CIM, CIM wheel, concept or technology, Evolution of CIM, Benefits of CIM, Needs of CIM: Hardware and software. Fundamentals of Communication: Communications Matrix. Product Development Cycle, Concurrent Engineering: Definition, Sequential Engineering Versus Concurrent Engineering, Benefits of Concurrent Engineering, Characteristics of concurrent Engineering, Framework for integration of Life-cycle phases in CE, Concurrent Engineering Techniques, Integrated Product Development (IPD), Product Life-Cycle Management (PLM), Collaborative Product Development.	
UNIT II	11 Hours
CIM database and database management systems: Introduction, Manufacturing Data: Types, sources; Database Terminology, Database requirements, Database models, Database Management System, DBMS Architecture, Query Language, Structural Query Language (SQL): Basic structure, Data definition Language (Create, Alter, Drop, Truncate, View), Data Manipulation Language (store, retrieve, update, delete). Illustration of Creating and Manipulating a Manufacturing Database. SQL as a Knowledge Base Query Language. Features of commercial DBMS: Oracle, My SQL, SQL Access, Sybase, DB2. Product Data Management (PDM), Advantages of PDM.	
UNIT III	10 Hours
CIM Technology and Systems Product Design: Needs of the market, Design and Engineering, The design Process, Design for Manufacturability (DFM): Component Design, Design for Assembly. Computer-Aided Process Planning: Basic Steps in developing a process plan, Variant and Generative Process Planning, Feature Recognition in Computer-Aided Process Planning. Material Requirements Planning (MRP), Manufacturing Resource Planning (MRP –II), Cellular Manufacturing: Design of Cellular Manufacturing Systems, Cell Formation Approaches: Machine–Component Group Analysis, Similarity Coefficients-Based Approaches. Evaluation of Cell Design. Shop-floor Control: Data Logging and Acquisition, Automated Data Collection, Programmable Logic Controllers, Sensor Technology. Flexible Manufacturing Systems: Physical Components of an FMS. Types of Flexibility, Layout Considerations: Linear Single Machine Layout, Circular Machine Layout, Cluster Machine Layout, Loop Layout; Operational Problems of FMS. FMS benefits.	
UNIT IV	10 Hours
Enterprise Wide Integration in CIM and CIM Models: Introduction to Networking, Principles of Networking, Network Terminology, Types of Networks: LAN, MAN, WAN; Selection of Network Technology: Communication medium, Network Topology, Medium access control Methods, Signaling methods; Network Architectures and Protocols: OSI Model, MAP & TOP, TCP/IP, Network Interconnection and Devices,	

Network Performance. Framework for Enterprise-wide Integration. CIM Models: ESPRIT-CIM OSA Model, NIST-AMRF Model, Siemens Model of CIM, Digital Equipment Corporation Model, IBM Concept of CIM. Future Trends in Manufacturing Systems Lean Manufacturing: Definition, Principles of Lean Manufacturing, Characteristics of Lean Manufacturing, Value of Product, Continuous Improvement, Focus on Waste, Relationship of Waste to Profit, Four Functions of Lean Production, Performance Measures, The Supply Chain, Benefits of Lean Manufacturing. Introduction to Agile and Web Based Manufacturing systems.	
Text Books	
1.	S.Kant Vajpayee, "Principles of Computer Integrated Manufacturing", Prentice-Hall India, 2007.
2.	Nanua Singh: "Systems Approach to Computer Integrated Design and Manufacturing"- John Wiley, 1995.
3.	P.Radhakrishnan, S.Subramanyam, "CAD/CAM/CIM", New Age International, 2009.
4.	Alavudeen, Venkateshwaran, "Computer Integrated Manufacturing", Prentice-Hall India, 2008.

Microcontroller & Applications	
Course Code: MRA-106 Contact Hours: L-3 T-0 P-2 Course Category: DCC	Credits: 4 Semester: 2

Introduction: The 8051 Microcontroller is one of the most popular general-purpose microcontrollers especially designed for embedded systems. The first version of this single chip microcontroller came in 1980s, and since then it has been being used for embedded systems especially in robotics. It a small chip based on an architecture with support for embedded applications, such as measuring device, security systems, robotics, remote control applications, scroll message display, etc. 8051 Microcontroller course is essential to understand the complexity involved in designing of embedded systems.

Course Objectives: The objectives of this course are -

- Give an understanding about the concepts and basic architecture of 8051
- Provide an overview of difference between microprocessor and micro controller
- Provide background knowledge and core expertise in microcontroller
- Study the architecture and addressing modes of 8051
- Impart knowledge about assembly language programs of 8051
- Help understand the importance of different peripheral devices & their interfacing to 8051
- Impart knowledge of different types of external interfaces including LEDS, LCD, Keypad Matrix, Switches & Seven segment display

- The students are to be provided hands on practical exposure on topics covered in the course.

Pre-Requisites: NIL

Course Outcomes: Having completed this course student will be able to:

- Gain comprehensive knowledge about architecture and addressing modes of 8051
- Write assembly language program in 8051 for various embedded system applications
- Implement the middle level programming and interfacing concepts in 8051
- Use external interfaces in various embedded system projects
- Create the memory interfacing techniques with 8051
- Create the IO interfacing techniques with 8051
- The practical sessions will improve visualization of the concepts taught in theory.

Pedagogy: Classroom teaching is supported by White board, black board, chalks, markers, projector and screen. The hand written notes, PowerPoint slides and assignments will be provided to the students and also mailed to them. The students can also raise their issues related to the course in the class and mail.

Contents:

UNIT I	11 Hours
Binary data representation: decimal system, binary system, octal system, hexadecimal system, binary coded decimal system, decimal conversion, decimal to Hexadecimal, binary addition and subtraction, binary multiplication and division, binary coded decimal	

addition, signed numbers, twos complement arithmetic, hexadecimal arithmetic, digital logic gates, MCS51 Micro controller –difference between micro controller and microprocessor, criteria for choosing a microcontroller, internal architecture of MCS51 microcontroller and its family.		
UNIT II		11 Hours
8051 assembly language programming: instruction set-arithmetic, logical, data transfer branching and Flag manipulation Instructions, addressing modes, 8051 timer/counter, serial communication programming, interrupts structure, interrupt programming, usage of C programming to 8051 family.		
UNIT III		10 Hours
Real word interfacing: Analog to Digital converter, Digital to Analog converter, Mechanical switches, keypads, LEDs, seven segment display, LCDs, keyboard, DC motor, stepper motor, PWM, External Memory Interface.		
UNIT IV		10 Hours
Microcontroller Applications: C programming of Podium timer, microcontroller based menu card, chimney sentinel, counting cars, anonymous voting, efficient lighting using microcontroller, I2C interface with serial EPROM, reading a PWM waveform using microcontroller, 8051 based pick and place robot.		
Text Books		
1.	Mazidi, "The 8051 micro controller and embedded system", Pearson education , 2002	
2.	Han-way Huang, "Using the MCS-51 microcontroller", Oxford University Press, 2009.	
3.	Ajay V Deshmukh, "Microcontrollers (Tuning and applications)", The McGraw Hill publications, 2007.	
4.	Parab, Shekale, Kamat& Naik, "Exploring C for Micro controllers: A hands on approach", Springer Verlag Publications, 2007.	
5.	Kenneth Hintz and Daniel Tabak, "Microcontrollers architecture, Implementation and programming", TMH, 2005	
6.	A. K. Stiffler, "Design with microprocessors for Mechanical Engineers", McGraw Hill, 1992	

Modern Control Theory	
Course Code: MRA-108 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 2

Introduction: This course provides the fundamentals in modern control theory - centred around the so-called state space methods - as a continuation of classical control theory taught in Linear Control Theory. Emphasis is placed on the treatment of such concepts as controllability and observability, pole allocation, the realization problem, observers, and linear quadratic optimal regulators.

Course Objectives: The objectives of this course are to:

- Provide a basic understanding of the concepts and techniques involved in designing control schemes for dynamic systems.
- Develop the ability to generate state-space models for dynamic systems described by:–time histories,–transfer functions, or–sets of differential or difference equations.
- Be able to determine solutions to these state equations by a variety of methods.
- Develop the ability to determine various properties of these systems including controllability, observability, and stability.
- Develop the ability to design feedback controllers for specified eigenvalues based on state space methods.
- Develop the ability to design state observers based on state-space methods and other methods.

Pre-Requisites: NIL

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

- Have an exposure to state space representation of dynamic systems and analysis.
- Analyse dynamic systems for their stability and performance.
- Design controllers (such as Proportional-Integral-Derivative) based on stability and performance requirements.

Pedagogy: Classroom teaching is supported by White board, black board, chalks, markers, projector and screen. The hand written notes, PowerPoint slides and assignments will be provided to the students and also mailed to them. The students can also raise their issues related to the course in the class and mail.

Contents:

UNIT I	11 Hours
Digital Control System configuration, Basic discrete time signals, time domain models for discrete time systems, transfer function models, stability on z plane, z domain description of continuous time systems, implementation of digital controllers, stepper motor and its control, synchro error detector pair, servo motors and their control, position control systems, z transforms	

UNIT II	11 Hours
Vectors and matrices, state variable representation, conversion of state variable models to transfer function and vice versa, Eigen values and Eigen vectors, solution of state equations: forced and unforced systems, controllability and observe ability, multi variable systems, state variable analysis of digital control systems	
UNIT III	10 Hours
State variable feedback structure, pole placement design using state feedback, state feedback with integral control, observer-based state feedback control, digital control using state feedback, optimal control systems, optimal digital control	
UNIT IV	10 Hours
Non-Linear systems: Linear approximations, common nonlinearities in control systems, describing function method for stability analysis, concepts of phase plane analysis, lyapunov stability analysis, linear quadratic optimal control through lyapunov equation	

Text Books

1.	M. Gopal, “Digital control and state variable methods”, TMH, 2008.
2.	M. Gopal, “Control systems: Principles and design”, TMH, 2002.
3.	K. Ogata, “Control Theory”, PHI, 4th Edition, 2009.

MEMS and Microsystems for Automation	
Course Code: MRA-110 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 2

Introduction: Micro-electro-mechanical systems, or MEMS, is an emerging area with applications to a variety of engineering fields such as mechanical, electrical, aerospace and bioengineering. This course is an introductory course and forms the first part of a 2-series MEMS course at SDSU. This introductory part concentrates in educating students the manufacturing techniques (micromachining), materials, mask layout, and multi-physics simulation of MEMS.

Course Objectives: The objectives of this course are to

- Provide basic knowledge on overview of MEMS (Micro electro Mechanical System) and various fabrication techniques.
- Enable students to design, analysis, fabrication and testing the MEMS based components.
- To introduce the fundamental concept of MEMS & Microsystem and their relevance to current industry/scientific needs

Pre-Requisites: NIL

Course Outcomes: Having completed this course student will be able to:

- Understand MEMS-specific design issues and constraints
- Perform Dynamics and modeling of Microsystems
- Perform applications of microsensors and micro-actuators

Pedagogy: Classroom teaching is supported by White board, black board, chalks, markers, projector and screen. The hand written notes, PowerPoint slides and assignments will be provided to the students and also mailed to them. The students can also raise their issues related to the course in the class and mail.

Contents:

UNIT I	11 Hours
Introduction to MEMS & Microsystems, Introduction to Micro sensors, Evaluation of MEMS, Micro sensors, Market survey, application of MEMS, MEMS Materials, MEMS materials properties, microelectronic technology for MEMS, micromachining technology for MEMS	
UNIT II	11 Hours
Micromachining process, Etch stop techniques and microstructure, surface and quartz Micromachining, Fabrication of micro machined microstructure, Micro stereolithography MEMS micro sensors, thermal micro machined micro sensors,	

Mechanical MEMS, Pressure and flow sensor, Micro machined flow sensors, MEMS inertial sensors.		
UNIT III		10 Hours
Micro machined micro accelerometers for MEMS, MEMS accelerometers for avionics, Temperature drift and damping analysis, Piezoresistive accelerometer technology, MEMS capacitive accelerometer, MEMS capacitive accelerometer process		
UNIT IV		10 Hours
MEMS gyro sensor, MEMS for space application, Polymer MEMS & carbon nano tubes (CNT), Wafer bonding & packaging of MEMS, Interface electronics for MEMS, MEMS for biomedical applications (Bio-MEMS)		
Text Books		
1.	Tai-Ran Hsu, "MEMS and Microsystems: Design and Manufacture", McGraw-Hill, 2002.	
2.	Ghodssi, Reza; Lin, Pinyen (Eds.), "MEMS Materials and Processes Handbook", Springer, 2011.	
3.	Mohamed Gad-el-Hak, "MEMS: Introduction and Fundamentals", Taylor and Francis, 2005.	
4.	Jan Korvink and Oliver Paul, "MEMS: A Practical Guide to Design, Analysis and Applications", 2005.	

Applications of AI in Automation	
Course Code: MRA-112 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 2

Introduction: Includes an introduction to artificial intelligence as well as current trends and characterization of knowledge-based systems. Search, knowledge representation schemes, production systems, and expert systems will be examined. Additional areas include knowledge discovery and neural learning.

Course Objectives:

- To understand the basic concept of artificial intelligence and expert system and their applications in manufacturing system for decision making
- The students are to be provided hands on practical exposure on topics covered in the course.

Pre-Requisites: NIL

Course Outcomes: On Completion of the course the student will be able to

- Apply artificial intelligence techniques, including search heuristics, knowledge representation, planning and reasoning.
- Describe the key components of the artificial intelligence (AI) field.
- Explain and solve problems by applying a suitable search method.
- Compare minimax search and alpha-beta pruning in game playing.
- Describe and list the key aspects of planning in artificial intelligence
- The practical sessions will improve visualization of the concepts taught in theory.

Pedagogy: Classroom teaching is supported by White board, black board, chalks, markers, projector and screen. The hand written notes, PowerPoint slides and assignments will be provided to the students and also mailed to them. The students can also raise their issues related to the course in the class and mail.

Contents:

UNIT I	11 Hours
Scope of AI: Robotics, Machine Learning, Intelligent Machines, Expert Systems, Gamestheorem proving, natural language processing, vision and speech processing, expert system, AI techniques-search knowledge, abstraction. Intelligent Agents: Autonomy, Properties, Environments, Taxonomy, Mobile Agents, Architectures-Reactive, Hybrid& Mobile Architecture. Robotics: Taxonomy, Hard & Soft Robots, Natural Sensing Control, Perception with sensors, Actuation with Effectors, Movement Planning, Robot Programming Languages.	
UNIT II	11 Hours
Machine Learning: Machine Learning Algorithms, Supervised learning, unsupervised learning, Markov Model, Nearest Neighbor classification-kNN, Knowledge Representation: Predicate Logic: Unification, Modus Ponens, Modus Tolens, Resolution	

in Predicate Logic, Conflict Resolution Forward Chaining, Backward chaining, Declarative and Procedural Representation, Rule based Systems.	
UNIT III	10 Hours
Rule Based Systems, Inference Systems, Problem Solving (Blind): State Space search; production system, depth-first, breadth-first search. Heuristic search, Hill climbing, best-first search, branch and bound, Problem reduction, Constraint Satisfaction End	
UNIT IV	10 Hours
Expert System: Need and justification for expert System, Knowledge acquisition, Architecture of Expert Systems. Case Studies: Intelligent Air Condition, Sugar Mill Boiler, Salmon Cutting Machine.	
Text Books	

1.	Jones M. T “Artificial Intelligence –A systems Approach”, Firewall Media, Infinity Science Press, 2008.
2.	Luger G.F. “Artificial Intelligence –Structures and Strategies for Complex Problem Solving”, Pearson Education, 5thEdition, 2010.
3.	Russel S. & Norvig P. “Artificial Intelligence –A Modern Approach”, Second Edition 2013.
4.	Schalkoff R., “Intelligent Systems -Principles, Paradigms & Pragmatics” Jones &Bartlet Learning, First Indian Edition 2011

Instrumentation and Control Engineering	
Course Code: MRA-114 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 2

Introduction: This course attempts to cross that bridge between control systems theory and control systems practice. The department considers it significant because of the importance of automation, control and instrumentation (collectively called instrumentation in the region) to the industrial processes which are the flagships of the Caribbean economies and to the burgeoning group of small manufacturing concerns. The instrumentation area is also of particular importance in supporting regional manufacturers who compete internationally; this competition requires greater focus on quality assurance and control which, in turn requires ever competent expertise in instrumentation technology

Course Objectives:

- The course focuses on imparting the principles of measurement which includes the working mechanism of various sensors and devices, that are in use to measure the important physical variables of various mechatronics systems.
- The students are to be provided hands on practical exposure on topics covered in the course.

Pre-Requisites: NIL

Course Outcomes: After undergoing the course the student can

- Understanding of measurement systems and their working.
- Select appropriate device for the measurement of parameters like temperature, pressure, speed, stress, humidity, flow velocity etc., and justify its use through characteristics and performance.
- Have an understanding of LabVIEW software and Modular Programming
- The practical sessions will improve visualization of the concepts taught in theory.

Pedagogy: Classroom teaching is supported by White board, black board, chalks, markers, projector and screen. The hand written notes, PowerPoint slides and assignments will be provided to the students and also mailed to them. The students can also raise their issues related to the course in the class and mail.

Contents:

UNIT I	11 Hours
Generalized Instrumentation system, Measurement systems, control system, Features of personal computers, PC_Based Instrumentation Systems, Data Acquisition systems, PC interfaces. Signal Conditioning and Op Amp circuits.	
UNIT II	11 Hours

Principles of Data acquisition and Interfacing Sampling concepts, D/A converter, A/D converters, Data Acquisition Configurations, Expansion, Buses, Parallel port, Plug-in Boards, Data Acquisition using GPIB, Data Acquisition serial interfaces, Network Data Acquisition.

UNIT III	10 Hours

Application Examples in Measurement and Control PC based data -Acquisition systems -Industrial process measurements, like flow temperature, pressure, and level PC based instruments development system. **Sensors and Actuators** Temperature sensor, Displacement Sensors, Pressure Sensors, Flow sensors, Actuators.

UNIT IV	10 Hours

Introduction to LabVIEW: Software environment, front panel, block diagram, palettes, loops, structures and tunnels, arrays, clusters, plotting data. **Modular Programming:** Modular programming in LabVIEW, creating an icon, building connector pane, displaying sub Vis (virtual instruments) and express Vis as icons or expandable nodes, creating sub VIs from sections of VIs, opening and editing sub VIs, placing sub Vis on block diagrams, creating stand alone applications.

Text Books

1.	Ahson, S.I. “Microprocessors with applications in process control”, Tata McGraw-Hill Publishing Company Limited,1984
2.	Jerome, PHI Virtual Instrumentation using Lab VIEW, Jovitha, ISBN 978-81-203-40305, 2010.

Reference Books

1.	George Barney C. “Intelligent Instrumentation”, Prentice Hall of India Pvt. Ltd., 1998
2.	Krishna Kanth “Computer based industrial control”, Prentice Hall. 1997
3.	Sergio Franco, “Design with operational amplifiers and analog integrated circutis”, TATA McGraw-Hill2002
4.	S. K. Singh, “Industrial Instrumentation and Control”, TATA McGraw-Hill. 2004
5.	N. Mathivanan, “PC-Based Instrumentation”, PHI, 2009

Higher Numerical Techniques	
Course Code: MRA-116 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 2

Introduction: Numerical Methods give insight into problems we cannot otherwise solve. These methods provide us the way to solve problem when exact methods fails or unable to produce the desirable results.

Course Objectives: The objectives of this course are

- To provide suitable and effective methods called Numerical Methods, for obtaining approximate representative numerical results of the problems.
- To solve higher level problems in the field of Applied Mathematics, Theoretical Physics and Engineering which requires computing of numerical results using certain raw data.
- To solve complex mathematical problems using only simple arithmetic operations. The approach involves formulation of mathematical models of physical situations that can be solved with arithmetic operations.
- To facilitate deeper numerical computing.
- The students are to be provided hands on practical exposure on topics covered in the course.

Pre-Requisites: NIL

Course Outcomes :
Having completed this course students will be able to:

- Go deeper into understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems
- Apply numerical methods to obtain approximate solutions to complex mathematical problems.
- Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solution of differential equations for complex cases.
- The practical sessions will improve visualization of the concepts taught in theory with focus on projects.

Pedagogy: Classroom teaching is supported by White board, black board, chalks, markers, projector and screen. The hand written notes, PowerPoint slides and assignments will be provided to the students and also mailed to them. The students can also raise their issues related to the course in the class and mail.

Contents:

UNIT I	11 Hours
Rounding, Chopping, Error analysis, Condition and instability, rate and order of convergence of iterative schemes. Non-Linear Equations: Direct iteration method,	

Bisection, Secant, Regula-Falsi method and Newton Raphson method for single variable, convergence analysis of Newton's and Secant method, simultaneous nonlinear equations with two variables-Newton-Raphson method.	
UNIT II	11 Hours
System of Linear equations: Gauss-elimination method (using Pivoting strategies), Gauss-Jacobi and Gauss-Seidel Iteration method. Power and Jacobi method for eigen-values and eigen-vectors. **Interpolation:** Difference operators, Finite differences, Newton's, Stirling's and Bessel's interpolation formula	
UNIT III	10 Hours
Gauss interpolation method, Lagrange interpolation and Newton's divided difference interpolation formula with error analysis. **Numerical differentiation and integration:** Newton-Cotes quadrature formulae (with error) and Gauss - Legendre quadrature formulae, Trapezoidal, Simpson's one-third and three-eighth rule.	
UNIT IV	10 Hours
Differential Equations: Solution of initial value problems using Euler's, modified Euler's, Runge-Kutta method for first and second order differential equations. Milne's and Adam's Bashforth predictor- corrector methods.	

Text Books

1.	Chapra, Steven C., and Raymond P. Canale. Numerical methods for engineers. Boston: McGraw-Hill Higher Education, 2010.
2.	Jain M.K., Iyengar, S.R.K., and Jain, R.K. Numerical Methods for Scientific and Engineering Computation, New Age International,2003.
3.	Gerald C.F and Wheatley P.O., Applied Numerical Analysis, Pearson Education. 2011,Eighth Edition.
4.	Grewal B. S., Numerical Methods in Engineering and Science, KhannaPublishers.

Reference Books

1.	Sastry S., Introductory Methods of Numerical Analysis, PHI Pvt. Ltd., 2012, FifthEdition.
2.	Conte, S.D and Carl D. Boor, Elementary Numerical Analysis: An Algorithmic approach, Tata McGraw Hill, New York,2005.
3.	Jain R.K., Iyengar S. R. K., Advanced Engineering Mathematics, Narosa Publishing House, 2011, ThirdEdition.

Advanced digital signal processing	
Course Code: MRA-118 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 2

Introduction: This course surveys recent advances in signal processing concepts, especially those related to the acquisition, formation, processing, analysis, and visualization of images, videos, and similar multidimensional signals. This course begins by reviewing representations and applications of digital signals and images, including common tasks involving such signals. Successive lectures will feature discussions of recent research papers in these areas, and activities applying and reproducing their results.

Course Objectives:

- The student comprehends mathematical description and modelling of discrete time random signals.
- The student is conversant with important theorems and algorithms.
- The student learns relevant figures of merit such as power, energy, bias and consistency.
- The student is familiar with estimation, prediction and filtering concepts and techniques.

Pre-Requisites: NIL

Course Outcomes: After the completion of this course, students will be able to

- Formulate time domain and frequency domain description of Wide Sense Stationary process in terms of matrix algebra and relate to linear algebra concepts.
- State Parseval's theorem, W-K theorem, principle of orthogonality, spectral factorization theorem, Widrow-Hoff LMS algorithm and Shannon's sampling theorem, and define linear prediction, linear estimation, sample auto-correlation, periodogram, bias and consistency.
- Explain various noise types, Yule-Walker algorithm, parametric and non-parametric methods, Wiener and Kalman filtering, LMS and RMS algorithms, Levinson Durbin algorithm, adaptive noise cancellation and adaptive echo cancellation, speed verses convergence issues, channel equalization, sampling rate change, sub band coding and wavelet transform.
- Calculate mean, variance, auto-correlation and PSD for WSS stochastic processes, and derive prediction error criterion, Wiener-Hoff equations, Parseval'stheorem-K theorem and normal equations.
- Design AR, MA, ARMA models, Weiner filter, anti-aliasing and anti-imaging filters, and develop FIR adaptive filter and polyphase filter structures.
- Simulate spectral estimation algorithms and basic models on computing platform.

Pedagogy: Classroom teaching is supported by White board, black board, chalks, markers, projector and screen. The hand written notes, PowerPoint slides and assignments will be provided to the students and also mailed to them. The students can also raise their issues related to the course in the class and mail.

Contents:

UNIT I	11 Hours
Review DSP: Discrete Fourier Transform, linear filtering method based on the DFT, FFT at radix2. Digital filter design FIR and IIR (Butterworth and Chebyshev). Introduction -Decimation, Interpolation Sampling rate conversion by rational factor	
UNIT II	11 Hours
Linear Prediction and Optimum Linear Filters: Representation of a stationary random process, forward and backward linear prediction, solution of normal equations (levinson-durbin),lattice structure, Wiener –Hopf equation for filtering and prediction	
UNIT III	10 Hours
System Modeling and Identification: Adaptive systems -definitions and characteristics -applications -properties-examples -adaptive linear combiner-input signal and weight vectors -performance function -gradient and minimum mean square error -introduction to filtering-smoothing and prediction -linear optimum filtering -orthogonality -wiener	
UNIT IV	10 Hours
Adaptive Filtering Algorithms: Least Mean Squares (LMS) LMS algorithm -convergence of weight vector -properties, and Recursive Least square (RLS) algorithms and their convergence performance, Application of adaptive filters	

Text Books	
1.	Proakis, Rader, Ling, Nikias, “Advanced Digital Signal Processing”, Macmillan Publishing House, 1992.
2.	Alexander “Adaptive Signal Processing Theory and Applications” Springer Verlag, 1986.
3.	S.K.Mitra,“DigitalSignalProcessing,AComputerBasedapproach,”TataMc-GrawHill
4.	Tarun Kumar Rawat, “Digital Signal Processing,” Oxford University Press.
Reference Books	
1.	Widrow, Stearns “Adaptive Signal Processing”, Pearson Education, 1985.
5.	Vaseghi, “Advanced Digital Signal Processing and Noise Reduction”, Wiley, 2000.

Advanced Finite element analysis	
Course Code: MRA-120 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 2

Introduction: The Finite Element Method (FEM) is widely used in industry for analysing and modelling structures and continua, whose physical behaviour is described by ordinary and partial differential equations. The FEM is particularly useful for engineering problems that are too complicated to be solved by classical analytical methods.

Course Objectives: The objectives of this course are

- To introduce advanced element used in FE analysis.
- To introduce nonlinear analysis of structure.
- To introduce formulation of dynamic problems in FEM
- To build the ability to model and to solve complex problems in engineering

Pre-Requisites: NIL

Course Outcomes: Having successfully completed this course, the student will

- Possess a good understanding of the theoretical basis of the weighted residual Finite Element Method.
- Be able to implement the Galerkin residual weak formulation into the Finite Element Method for the solution of Ordinary and Partial Differential Equations, using mathematical software such as Maple.
- Be able to use the commercial Finite Element package ANSYS to build Finite Element models and solve a selected range of engineering problems.
- Be able to validate a Finite Element model using a range of techniques.
- Be able to communicate effectively in writing to report (both textually and graphically) the method used, the implementation and the numerical results obtained.
- Be able to discuss the accuracy of the Finite Element solutions.

Pedagogy: Classroom teaching is supported by White board, black board, chalks, markers, projector and screen. The hand written notes, PowerPoint slides and assignments will be provided to the students and also mailed to them. The students can also raise their issues related to the course in the class and mail.

Contents:

UNIT I	11 Hours
Introduction to FEM, basic concepts, historical back ground, applications of FEM, general description, comparison of FEM with other methods, variational approach, Glerkin's Methods. Co-ordinates, basic element shapes, interpolation function, Virtual energy principle, Rayleigh – Ritz method, properties of stiffness matrix, treatment of boundary conditions, solution of system of equations, shape functions and characteristics, Basic	

equations of elasticity, strain- displacement relations.		
UNIT II		11 Hours
1-D Structural Problems: Axial bar element – stiffness matrix, load vector, temperature effects, Quadratic shape functions and problems.Analysis of Trusses: Plane Trusses and Space Truss elements and problems Analysis of BECAD/CAM: Hermite shape functions – stiffness matrix – Load vector – Problems.		
UNIT III		10 Hours
2-D Problems: CST, LST, force terms, Stiffness matrix and load vectors, boundary conditions, Isoparametric elements – quadrilateral element, shape functions – Numerical Integration. Finite element modeling of Axi-symmetric solids subjected to Axi-symmetric loading with triangular elements. 3-D Problems: Tetrahedron element – Jacobian matrix – Stiffness matrix.		
UNIT IV		10 Hours
Scalar Field Problems: 1-D Heat conduction-Slabs – fins – 2-D heat conduction problems – Introduction to Torsional problems. Dynamic considerations, Dynamic equations – consistent mass matrix – Eigen Values, Eigen vector, natural frequencies – mode shapes – modal analysis.		
Text Books		
1.	Finite Element Methods: Basic Concepts and applications, Alavala, PHI.	
2.	Finite Element Method – Zincowitz / McGraw Hill	
3.	The Finite Element Methods in Engineering / SS Rao / Pergamon.	
4.	Introduction to Finite Elements in Engineering, Chandrupatla, Ashok and Belegundu, Prentice – Hall	
5.	Introduction to Fininte element analysis- S.Md. Jalaludeen, Anuradha Publications, print2012	
6.	A First Course in the Finite Element Method/Daryl L Logan/Cengage Learning/5th Edition	
7.	Finite Element Method – Krishna Murthy / TMH	
8.	Finite Element Analysis – Bathe / PHI	

Neural Network and Fuzzy Logic	
Course Code: MRA-122 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 2

Introduction: This course introduces students to neural networks and fuzzy theory from an engineering perspective. This is a hands-on subject where students are given integrated exposure to professional practice. These areas include identification and control of dynamic systems, neural networks and fuzzy systems can be implemented as model-free estimators and/or controllers. As trainable dynamic systems, these intelligent control systems can learn from experience with numerical and linguistic sample data.

Course Objectives: The main objectives of this course are

- Introduce students to the various neural network and fuzzy systems models.
- Reveal different applications of these models to solve engineering and other problems.
- Introduce the theory and applications of artificial neural network and fuzzy systems to engineering applications with emphasis on image processing and control.
- Discuss neural networks and fuzzy systems, architectures, algorithms and applications, including Back-propagation, BAM, Hopfield network, Competitive Learning, ART, SOFM, Fuzzy inference methods and expert systems.

Pre-Requisites: NIL

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

- Comprehend the concepts of feed forward neural networks.
- Analyze the various feedback networks.
- Understand the concept of fuzziness involved in various systems and fuzzy set theory.
- Comprehend the fuzzy logic control and adaptive fuzzy logic and to design the fuzzy control using genetic algorithm.
- Analyze the application of fuzzy logic control to real time systems.

Pedagogy: Classroom teaching is supported by White board, black board, chalks, markers, projector and screen. The hand written notes, PowerPoint slides and assignments will be provided to the students and also mailed to them. The students can also raise their issues related to the course in the class and mail.

Contents:

UNIT I	11 Hours
Network: History, Overview Of Biological Neuro-System, Mathematical Models Of Neurons, ANN architecture, Learning Rules, Learning Paradigms-Supervised,	

Unsupervised and Reinforcement Learning, ANN training Algorithms-perceptions, Training rules, , Back Propagation Algorithm, K Means clustering, Probabilistic Neural Network, Multilayer Perception Model, Hopfield Networks, Associative Memories, Applications of Artificial Neural Networks.	
UNIT II	11 Hours
FUZZY LOGIC: Introduction to fuzzy logic, Classical and fuzzy sets: Overview of Classical Sets, Membership Function and Fuzzy rule Generation. Operation on Fuzzy Sets: Compliment, Intersection, Unions, Combinations of Operations, Aggregation Operations Fuzzy Arithmetic: Fuzzy numbers, Linguistic variables, arithmetic operations on Intervals & Numbers, Lattice of Fuzzy Numbers, Fuzzy Equations.	
UNIT III	10 Hours
Fuzzy Logic: Classical Logic, Multivalued logics, Fuzzy Propositions, Fuzzy Qualifiers, Linguistic Hedges. Uncertainty based Information: Information& Uncertainty, Nonspecificity of Fuzzy & Crisp Sets, and Fuzziness of Fuzzy Sets.	
UNIT IV	10 Hours
Introduction of Neuro-Fuzzy Systems, Architecture of Neuro Fuzzy Networks. Application of Fuzzy Logic & Neural Networks in Intelligent Machine Design.	

Text Books

1.	Lee H.H., “First Course on Fuzzy Theory & Application”, Springer Publications, 2005.
2.	Yen J. & Langari R., “Fuzzy Logic—Intelligence Control & Information”, Pearson Education Asia, 1999.
3.	Ross T.J., “Fuzzy Logic with Engineering Applications”, Wiley India, 2011
4.	Haykins S., “Neural Networks”, Pearson Education, 2009
5.	Kumar S., “Neural Networks”, Tata Mc GrawHill Publications, 2004.
6.	Lee H.H., “First Course on Fuzzy Theory & Application”, Springer Publications, 2005.
7.	Yen J. &Langari R., “Fuzzy Logic—Intelligence Control & Information”, Pearson Education Asia, 1999.
8.	Ross T.J., “Fuzzy Logic with Engineering Applications”, Wiley India, 2011

Optimization for Engineering	
Course Code: MRA-124 Contact Hours: L-3 T-1 P-0 Course Category: DEC	Credits: 4 Semester: 2

Introduction: Optimization is the process of obtaining the best result under given circumstances. This course covers theory and applications for optimization in engineering.

Course Objectives: The aim of this course is to introduce the fundamental concepts of engineering optimization techniques.

- To understand the theory of optimization methods and algorithms developed for solving various types of optimization problems
- To develop and promote research interest in applying optimization techniques in problems of Engineering and Technology
- To apply the mathematical results and numerical techniques of optimization theory to concrete Engineering problems

Pre-Requisites: NIL

Course Outcomes: Having successfully completed this course, the student will be able to

- Formulate optimization problems
- Understand and apply the concept of optimality criteria for various type of optimization problems
- Solve various constrained and unconstrained problems in single variable as well as multivariable

Pedagogy: Classroom teaching is supported by White board, black board, chalks, markers, projector and screen. The hand written notes, PowerPoint slides and assignments will be provided to the students and also mailed to them. The students can also raise their issues related to the course in the class and mail.

Contents:

UNIT I	11 Hours
Mathematical Background: Historical Development; Engineering applications of Optimization; Objective function; Constraints and Constraint surface; Formulation of designproblems as mathematical programming problems; Classification of optimization problemsbased on nature of constraints, objective functions; Optimization techniques –classical and advanced techniques. **Convex sets and Convex Cones**-Introduction and preliminary definition -Convex sets and properties -Convex Hulls -Extreme point -Separation and support of convex sets -Convex Polytopes and Polyhedra -Convex cones -Convex andconcave functions -Basic Properties-Differentiable convex functions -Generalization of convex functions Hessian matrix formulation; Eigen values; Kuhn-Tucker Conditions; Examples	

UNIT II	11 Hours
Dynamic Programming: Sequential optimization; Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and the principle of optimality; Recursive equations –Forward and backward recursions; Computational procedurein dynamic programming (DP); Discrete versus continuous dynamic programming; Multiple state variables; curse of dimensionality in DP.Integer linear programming:Concept of cutting plane method; Mixed integer programming; Solution algorithms; Examples.	
UNIT III	10 Hours
Nonlinear Programming: Minimization and maximization of convex functions -Local &Global optimum –Convergence -Speed ofconvergence unconstrained optimization: One dimensional minimization --Gradient methods -Steepest descent method **Geometric Programming:** Introduction, Unconstrained minimization problems, solution of unconstrained problem from arithmetic-geometric inequality point of view, Generalized polynomial optimization, Applications of geometric problems	
UNIT IV	10 Hours
Novel methods for Optimization: Introduction to simulated annealing, selection of simulatedannealing parameters, simulated annealing algorithm; Genetic Algorithm (GA), Design of GA, Key concepts of GA, Examples of simulated algorithm, genetic annealing and Neural Network method.	

Text Books

9.	David G Luenberger, “Linear and Non-Linear Programming”, 2nd Ed, Addison-Wesley, 2008.
10.	S.S. Rao, “Engineering Optimization; Theory and Practice”; Revised 3rd Edition, New Age International Publishers, New Delhi, 2009.
11.	S.M. Sinha, “Mathematical programming: Theory and Methods”, Elsevier, 2006.
12.	Hillier and Lieberman, “Introduction to Operations Research”, McGraw-Hill, 8th edition, 2005.
13.	Saul I Gass, “Linear programming”, McGraw-Hill, 5th edition, 2005.
14.	Bazarra M.S., Sherali H.D. & Shetty C.M., “Nonlinear Programming Theory and Algorithms”, John Wiley, New York, 1979.
15.	Kalyanmoy Deb, “Optimization for Engineering: Design-Algorithms and Examples”, PHI, 2012.

Modelling and Simulation for Automation	
Course Code: MRA-126 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 2

Introduction: Modelling and Simulation is the use of models to develop data as a basis for making managerial or technical decisions.

Course Objectives: The objectives of this course are to

- Define the basics of simulation modelling and replicating the practical situations in organizations
- Generate random numbers and random variates using different techniques.
- Develop simulation model using heuristic methods.
- Analysis of Simulation models using input analyzer, and output analyser
- Explain Verification and Validation of simulation model.
- The students are to be provided hands on practical exposure on topics covered in the course.

Pre-Requisites: NIL

Course Outcomes: Having successfully completed this course, the student will be able to

- Understand Modelling & Simulation concepts
- Understand and apply the concepts of M&S to develop their own M&S applications
- The practical sessions will improve visualization of the concepts taught in theory.

Pedagogy: Classroom teaching is supported by White board, black board, chalks, markers, projector and screen. The hand written notes, PowerPoint slides and assignments will be provided to the students and also mailed to them. The students can also raise their issues related to the course in the class and mail.

Contents:

UNIT I	11 Hours
System Modeling: Concept of System and environment, Stochastic activities, Continuous and discrete systems, Types of Models, Principles of modeling, System studies and analysis, Advantages and disadvantages of simulation, Decision making with simulation, Numericals.	
UNIT II	11 Hours
System Simulation: Techniques of simulation, Monte Carlo method, Experimental nature of simulation, Numerical computation techniques, Distributed lag models, Cobweb models Continuous system models, Analog and Hybrid simulation, Feedback systems, Computers in simulation studies, Simulation software packages. System Dynamics: Exponential Growth and Decay models, Logistic curves, System dynamics diagrams, Time delay	

representation, Examples.	
UNIT III	10 Hours
Probability Concepts in Simulation: Stochastic variables, discrete and continuous probability functions, Random numbers, Methods of generation of Random numbers, Queuing disciplines, Measures of queues, Mathematical solutions of queuing problems, server utilization and Grade of service. Simulation software: Comparison of simulation packages with programming languages, classification of simulation software, Description of a general purpose simulation package- Design of scenario and modules, dialog box, database, animation, plots and output, interfacing with other software, summary of results. Examples with MATLAB/ AWESIM / ARENA.	
UNIT IV	10 Hours
Analysis of Simulation output: Importance of the variance of the sample mean, Procedure for estimating mean and variance, Subinterval method, Replication Method, Regenerative method; Variance reduction techniques, Start up policies, Stopping rules, Statistical inferences, Design of experiments. Simulation of Manufacturing Systems: Objective of Simulation in Manufacturing, Modeling system randomness, A simulation case study of manufacturing system.	

Text Books

1.	Geoffrey Gordon, "System Simulation", Prentice Hall India.
2.	Robert E. Shannon, "System Simulation: The Art and Science", Prentice Hall India.
3.	Charles M Close and Dean K. Frederick Houghton Mifflin, "Modelling and Analysis of Dynamic Systems:, TMH, 1993.
4.	Allan Carrie, "Simulation of manufacturing", John Wiley & Sons, 1988. 2003.