**M.Tech Robotics**  
**Curriculum 2013 – 2014**  
**For students admitted from the academic year 2013 – 2014**

### Course Mapping

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of Courses</th>
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<tr>
<td></td>
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<tr>
<td>Core courses</td>
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<tr>
<td>Optional / Elective Courses</td>
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<td>Supportive courses</td>
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<tr>
<td>Interdisciplinary elective</td>
<td>1 course of 3 credits to be taken in I or II or III semester</td>
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<tr>
<td>Seminar</td>
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<tr>
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**Total number of credits to be earned for the award of degree**  
71

### Core courses

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### Optional / Elective Courses (Program Electives)

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**Supportive courses**

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**CONTACT HOUR/CREDIT:**

L: Lecture Hours per week  
T: Tutorial Hours per week  
P: Practical Hours per week  
C: Credit
ME2301    FUNDAMENTALS OF ROBOTIC SYSTEMS  

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Total Contact Hours-75

Prerequisites

Nil

PURPOSE
To enlighten the students about the fundamentals of robotic systems.

INSTRUCTIONAL OBJECTIVES
At the end of this course the student should be able to understand

1. The basics of robot
2. End effectors and robot controls
3. Robot Transformations and Sensors
4. Robot cell design and applications
5. Micro/Nano robotic systems

UNIT I-INTRODUCTION (9 hours)

UNIT II-END EFFECTORS AND ROBOT CONTROLS (10 hours)
Mechanical grippers-Slider crank mechanism, Screw type, Rotary actuators, cam type-Magnetic grippers-Vacuum grippers-Air operated grippers-Gripper force analysis-Gripper design-Simple problems-Robot controls-Point to point control, Continuous path control, Intelligent robot-Control system for robot joint-Control actions-Feedback devices-Encoder, Resolver, LVDT-Motion Interpolations-Adaptive control.

UNIT III-ROBOT TRANSFORMATIONS AND SENSORS (8 hours)
UNIT IV-ROBOT CELL DESIGN AND APPLICATIONS (9 hours)


UNIT V-MICRO/NANO ROBOTICS SYSTEM (9 hours)

Micro/Nanorobotics system overview-Scaling effect-Top down and bottom up approach-Actuators of Micro/Nano robotics system-Nanorobot communication techniques-Fabrication of micro/nano grippers-Wall climbing micro robot working principles-Biomimetic robot-Swarm robot-Nanorobot in targeted drug delivery system.

PRACTICAL (30 hours)

REFERENCES

ME2302  MICROCONTROLLER AND ITS APPLICATION IN ROBOTICS

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Total Contact Hours-75

Prerequisites
Nil

PURPOSE
To familiarize the students with the fundamentals of microcontroller based system design.

INSTRUCTIONAL OBJECTIVES
Upon successful completion of the course the students will be able to understand and apply

1. 8051 Microcontroller based system.
2. Programming of microcontroller in real time applications
3. Communication with external devices
4. Basics of PIC microcontroller

UNIT I-INTRODUCTION TO 8051 MICROCONTROLLER (9 hours)
Data representation- decimal system, binary system, hexadecimal system. Binary to decimal conversion, decimal to Hexadecimal, binary addition and subtraction, MCS51 Micro controller: internal architecture, pin description, addressing modes. Difference between microcontroller and microprocessor, criteria for choosing a microcontroller

UNIT II-8051 PROGRAMMING (9 hours)
Instruction set-arithmetic, logical, data transfer, branching and Flag manipulation Instructions. 8051 assembly language programming- Timers, Interrupts, I/O ports, Interfacing I/O Devices, Serial Communication, Introduction to C programming in 8051,introduction to RTOS.

UNIT III-PERIPHERAL INTERFACING (9 hours)
Real world interfacing- Analog to Digital converter, Digital to Analog converter, Mechanical switches, LEDs, seven segment display, keypads, LCDs, DC motor, stepper motor, PWM, External Memory Interface.

UNIT IV-PIC MICROCONTROLLER (9 hours)
Architecture, memory organization - addressing modes. Instruction set - PIC programming in Assembly & C- I/O port, Data Conversion, RAM & ROM
allocation, Timer programming. Interfacing concepts - I²C, SSP bus operations

UNIT V-MICROCONTROLLER IN ROBOTICS (9 hours)
Case Studies –Home security system, Tic tac toe, Micro-mouse, Soccer playing robot, Unmanned Ariel vehicles, Smart card application

PRACTICAL (30 hours)

REFERENCES

<table>
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<tr>
<th>ME2303</th>
<th>DRIVES AND CONTROL SYSTEMS FOR ROBOTS</th>
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Purposes
To impart knowledge about various drive systems and its selection for particular applications.

INSTRUCTIONAL OBJECTIVES
At the end of this course the student should be able to understand
1. Various types of drive systems.
2. The selection of drive system for a particular application.
3. Accurate positioning of the robot end effectors with error compensation by servo control.
UNIT I-ROBOT DRIVE MECHANISM (8 hours)
Objectives, motivation, open loop control, closed loop control with velocity and position feedback. Types of drive systems. Functions of drive system. Lead Screws, Ball Screws, Chain & linkage drives, Belt drives, Gear drives, Precision gear boxes, Harmonic drives, Cyclo speed reducers.

UNIT II-HYDRAULIC DRIVES (8 hours)
Introduction, Requirements, Hydraulic piston and transfer valve, hydraulic circuit incorporating control amplifier, hydraulic fluid considerations, hydraulic actuators Rotary and linear actuators. Hydraulic components in robots.

UNIT III-PNEUMATIC DRIVES (8 hours)
Introduction, Advantages, pistons-Linear Pistons, Rotary pistons, Motors-Flapper motor, Geared motor, Components used in pneumatic control. Pneumatic proportional controller, pneumatically controlled prismatic joint.

UNIT IV-ELECTRIC DRIVES (9 hours)
Introduction, Types, DC electric motor, AC electric motor, stepper motors, half step mode operation, micro step mode. Types of stepper motors, Direct drive actuator.

UNIT V-SERVO SYSTEMS FOR ROBOT CONTROL (12 hours)
General aspects of robot control. Basic control techniques, mathematical modeling of robot servos, error responses and steady state errors in robot servos, feed back and feed forward compensations, hydraulic position servo, computer controlled servo system for robot applications, selection of robot drive systems.

PRACTICAL (30 hours)

REFERENCES

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PURPOSE
To study CAD/CAM applications in the field of Mechanical Engineering.

INSTRUCTIONAL OBJECTIVES
At the end of this course the student should be able to understand
1. The basics of CAD modeling
2. Numerical control machine operation and automation
3. Concepts of GT, FMS, AGV’s, AS / RS systems
4. Various planning systems and process monitoring

UNIT I-GEOMETRIC MODELLING (9 hours)
Types of mathematical representation of curves, wire frame models wire frame entities parametric representation of synthetic curves hermite cubic splines Bezier curves B-splines rational curves.

UNIT II-SURFACE MODELING (9 hours)
Mathematical representation surfaces, Surface model, Surface entities surface representation, Parametric representation of surfaces, plane surface, rule surface, surface of revolution, Tabulated Cylinder.

SOLID MODELLING-3D
Solid modeling, Solid Representation, Boundary Representation (Brep), Constructive Solid Geometry (CSG)
UNIT III-AUTOMATION AND NUMERICAL CONTROL  (9 hours)

UNIT IV-GROUP TECHNOLOGY AND FLEXIBLE MANUFACTURING SYSTEMS  (9 hours)

UNIT V-MANUFACTURING PLANNING SYSTEMS AND PROCESS CONTROL  (9 hours)
CAPP - Computer Integrated production planning systems –MRP – Capacity planning – Shop Floor control factory Data collection systems – Computer process interface types of computer process control – process monitoring, Supervisory computer control.

REFERENCES
4. S.R.Deb, “Robotic technology and Flexible automation”.
PURPOSE
To impart knowledge about kinematic and dynamic analysis of robot manipulators.

INSTRUCTIONAL OBJECTIVES
To Learn
1. To control both the position and orientation of the tool in the three dimensional space.
2. The relationship between the joint variables and the position and the orientation of the tool.
3. Planning trajectories for the tool to follow on order to perform meaningful tasks.
4. To precisely control the high speed motion of the system.

UNIT I-INTRODUCTION (9 hours)
Introduction, position and orientation of objects, objects coordinate frame Rotation matrix, Euler angles Roll, pitch and yaw angles coordinate Transformations, Joint variables and position of end effector, Dot and cross products, coordinate frames, Rotations, Homogeneous coordinates.

UNIT II-DIRECT KINEMATICS (8 hours)
Link coordinates D-H Representation, The ARM equation. Direct kinematic analysis for Four axis, SCARA Robot and three, five and six axis Articulated Robots.

UNIT III-INVERSE KINEMATICS (9 hours)
The inverse kinematics problem, General properties of solutions. Tool configuration, Inverse kinematics of four axis SCARA robot and three and five axis, Articulated robot.

UNIT IV-WORKSPACE ANALYSIS AND TRAJECTORY PLANNING (9 hours)
Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations, Joint
space technique - continuous path motion, Interpolated motion, straight line motion and Cartesian space technique in trajectory planning.

**UNIT V-MANIPULATOR DYNAMICS** (10 hours)

**PRACTICAL (30 hours)**

**REFERENCES**
ME2306  ROBOT PROGRAMMING  
Total Contact Hours-75  
Prerequisites  
Nil

PURPOSE
To enlighten the students about the use of robot programming for various applications.

INSTRUCTIONAL OBJECTIVES
At the end of this course the student should be able to understand the
1. Basics of Robot programming
2. VAL language applications
3. RAPID language applications
4. Practical study of virtual robot software
5. VAL-II and AML language

UNIT I-BASICS OF ROBOT PROGRAMMING (10 hours)
Robot programming-Introduction-Types- Flex Pendant- Lead through programming, Coordinate systems of Robot, Robot controller- major components, functions-Wrist Mechanism-Interpolation-Interlock commands-Operating mode of robot, Jogging-Types, Robot specifications- Motion commands, end effectors and sensors commands.

UNIT II-VAL LANGUAGE (9 hours)
Robot Languages-Classifications, Structures- VAL language commands- motion control, hand control, program control, pick and place applications, palletizing applications using VAL, Robot welding application using VAL program-WAIT, SIGNAL and DELAY command for communications using simple applications.

UNIT III-RAPID LANGUAGE (9 hours)
RAPID language basic commands- Motion Instructions-Pick and place operation using Industrial robot- manual mode, automatic mode, subroutine command based programming. Movemaster command language-Introduction, syntax, simple problems.

UNIT IV-PRACTICAL STUDY OF VIRTUAL ROBOT (9 hours)
Robot cycle time analysis-Multiple robot and machine Interference-Process chart-Simple problems-Virtual robotics, Robot studio online software-Introduction, Jogging, components, work planning, program modules, input
and output signals-Singularities-Collision detection-Repeatability measurement of robot-Robot economics.

UNIT V-VAL-II AND AML (8 hours)
VAL-II programming-basic commands, applications- Simple problem using conditional statements-Simple pick and place applications-Production rate calculations using robot. AML Language-General description, elements and functions, Statements, constants and variables-Program control statements-Operating systems, Motion, Sensor commands-Data processing.

PRACTICAL (30 hours)

REFERENCES
7. www.wpi.edu
ELECTIVE COURSES

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**Prerequisites**
Nil

**PURPOSE**
To familiarize the students in the area of stress, strain and deformation for a 3D problems.

**INSTRUCTIONAL OBJECTIVES**
Upon successful completion of the course the students will be able to solve practical problems involving Unsymmetrical bending, stress in flat plates, Torsion of noncircular sections and contact stresses.

**UNIT I-INTRODUCTION**
(9 hours)
Stress-strain relations and general equations of elasticity in Cartesian, polar and spherical co-ordinates equations of equilibrium - compatibility - boundary conditions - representation of 3-dimentinal stress of tensor - generalized Hooke’s law - St.Venant’s principle - plane strain - plane stress - Airy’s stress function - SHEAR CENTRE - Location of shear center for various sections - shear flow.

**UNIT II-UNSYMETRICAL BENDING**
(9 hours)
Stress and deflections in beams subjected to unsymmetrical loading - kern of a section - CURVED FLEXURAL MEMBERS - circumferential and radial stresses - deflections - curved beam with restrained ends - closed ring subjected to concentrated loading and uniform load - chain links and crane hooks.

**UNIT III-STRESS IN FLAT PLATES**
(9 hours)
Stresses in circular and rectangular plates due to various types of loading and end conditions - buckling of plates.

**UNIT IV-TORSION OF NON-CIRCULAR SECTIONS**
(9 hours)
Torsion of rectangular cross section - St. Venant’s theory - elastic membrane analogy - Prandtl’s stress function - torsional stress in hollow thin-walled tubes - STRESSES DUE TO ROTATION - Radial and tangential stresses in solid disc and ring of uniform thickness and varying thickness - allowable speeds.
UNIT V-THEORY OF CONTACT STRESSES (9 hours)
Methods of computing contact stresses - deflection of bodies in points and line contact - applications.

REFERENCES

<table>
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<th>NEURAL NETWORKS, GAs AND ITS APPLICATIONS</th>
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PREREQUISITES
Nil

PURPOSE
To study about the modern tools Neural Networks and Genetic algorithms and its applications to Mechanical Engineering.

INSTRUCTIONAL OBJECTIVES
1. Basic concepts of Genetic Algorithms
2. Application of GAs to Mechanical Engineering
3. Advances in Genetic Algorithms
4. Basic concepts of Neural Networks and applications of GAs to Neural networks
5. Applications of GAs and Neural networks to Mechanical Engineering

UNIT I-INTRODUCTION AND CONCEPT OF GENETIC ALGORITHMS (9 hours)
GAs - Robustness of Traditional Optimization Techniques - Distinctiveness of GAs from Traditional Optimization producers - Mathematical foundation
of GAs Similarity Templates - Working of Schema Process - Minimal Deceptive Problem - Similarity Templates as Hyper planes.

**UNIT II-IMPLEMENTATION OF GAs AND ADVANCED TECHNIQUES IN GENETIC SEARCH** (9 hours)
Data Structures - Reproduction, Crossover and Mutation - Mapping objective functions to Fitness From - Fitness Scaling - Multiparameter, Mapped, Fixed Point Coding - Computer Implementation - Evolution of Dominance, Diploidy and Abeyance - Inversion and other reordering operators - Multi objective optimization - Knowledge based Techniques - GAs and Parallel Processors.

**UNIT III-GENETIC BASED MACHINE LEARNING** (9 hours)

**UNIT IV-NEURAL NETWORKS AND APPLICATION OF GAs TO NEURAL NETWORKS** (9 hours)
Fundamentals of Neural Networks - Biological Basis - Features of Artificial Neural Networks - Back Propagation Training - Modular Neural Networks - Fitness Function - Application of GAs to Neural Networks - Use of Genetic Algorithms to Neural Networks - Use of Genetic Algorithms in the Design of Neural Networks.

**UNIT V-APPLICATIONS** (9 hours)
GAs applications in Pattern Recognition - Function Optimization - Improvements in Basic Technique - Optimization of Pipeline System - Multi model and Multi objective Optimization - Nonlinear Optimization.

**REFERENCES**
ME2122  RAPID PROTOTYPING AND TOOLING

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Total Contact Hours-45

Prerequisites
Nil

PURPOSE
To study the modern prototyping tool Rapid prototyping, its types and applications.

INSTRUCTIONAL OBJECTIVES
1. To familiarize the basics of RPT
2. The various process in RP
3. The principles of Rapid tooling and reverse Engineering

UNIT I-INTRODUCTION (9 hours)
Definitions, evolution, CAD for RPT. Product design and rapid product development. The cost and effects of design changes during conceptual modeling, detail designing, prototyping, manufacturing and product release. Fundamentals of RPT technologies, various CAD issues for RPT. RPT and its role in modern manufacturing mechanical design. 3D solid modeling software and their role in RPT. Creation of STL or SLA file from a 3D solid model.

UNIT II-LIQUID AND POWDER BASED RP PROCESSES (9 hours)
Liquid based process: Principles of STL and typical processes such as the SLA process, solid ground curing and others - Powder based process: Principles and typical processes such as selective laser sintering and some 3D printing processes.

UNIT III-SOLID BASED RP PROCESSES (9 hours)
Principles and typical processes such as fused deposition modeling laminated object modeling and others.

UNIT IV-RAPID TOOLING (9 hours)
Principles and typical processes for quick batch production of plastic and metal parts though quick tooling.

UNIT V-REVERSE ENGINEERING (9 hours)
3D scanning, 3D digitizing and Data fitting,. High speed machining-Hardware and software - Applications: Evaluation, bench marking and various case studies.
REFERENCES

UNIT I-HISTORICAL DEVELOPMENT OF PROGRAMMING (9 hours)
Procedural programming – Structural programming – object oriented programming – windows programming- event driven programming – conceptual comparison.

UNIT II-WINDOWS PROGRAMMING (9 hours)
Overview of windows programming – data types – resources –controls – interfaces – dynamic link libraries – SDK (Software development kit tools) – Context help
UNIT III-VISUAL BASIC PROGRAMMING (9 hours)

UNIT IV-VISUAL C++ PROGRAMMING (9 hours)

UNIT V-CASE STUDIES (9 hours)
Application to Mechanical Engineering problems - Mini Project

REFERENCES
5. Plewolds, “Windows Programming”

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PURPOSE
To emphasis the importance of group technology and cellular manufacturing systems and their significance & impact in manufacturing areas.

INSTRUCTIONAL OBJECTIVES
At the end of this course the student should be able to understand
1. Basics of Group technology
2. Concepts and applications of Cellular manufacturing systems
3. Traditional and non-traditional approaches of Problem solving
4. Implementation of CMS
3. Performance measurement and Human and economical aspects of CMS.
UNIT I-INTRODUCTION TO GROUP TECHNOLOGY   (7 hours)
Limitations of traditional manufacturing systems, Group technology - design attributes, manufacturing attributes, part families, characteristics and design of groups, PFA, FFA, benefits of GT and issues in GT.

UNIT II-CELLULAR MANUFACTURING   (8 hours)
Introduction, types of manufacturing cell, Design of cellular manufacturing systems, determination of best cell arrangement, key machine concept. Cell formation approach- Machine component group analysis, similarity coefficient based approach, exceptional parts and bottleneck machines

UNIT III-PLANNING AND DESIGN OF CELLULAR MANUFACTURING SYSTEM   (10 hours)

UNIT IV-IMPLEMENTATION OF GT/CMS   (10 hours)
Inter and Intra cell layout, cost and non-cost based models, establishing a team approach, Managerial structure and groups, batch sequencing and sizing, life cycle issues in GT/CMS.

UNIT V-PERFORMANCE MEASUREMENT AND CONTROL   (10 hours)
Measuring CMS performance - Parametric analysis - PBC in GT/CMS, cell loading, GT and MRP - framework. economics of GT/ Human aspects of GT/CMS.

REFERENCES
To study the principles of optimization and various techniques which can be used for solving Mechanical Engineering optimization applications.

INSTRUCTIONAL OBJECTIVES

To study the following optimization techniques:

1. Evolutionary Algorithms
2. Genetic Algorithms
3. Modern optimization techniques
4. Search Algorithms

UNIT I - INTRODUCTION TO OPTIMIZATION ALGORITHMS

(9 hours)

UNIT II - GENETIC ALGORITHMS AND GENETIC PROGRAMMING

(9 hours)

UNIT III - MODERN OPTIMIZATION TECHNIQUES

(9 hours)
Ant Colony Optimization- Areas of Application - River Formation Dynamics Particle Swarm Optimization - Areas of Application Hill Climbing - Areas of Application - Multi-Objective Hill Climbing - Problems in Hill Climbing -
Hill Climbing with Random Restarts – GRASP - Raindrop Method, Random Optimization

UNIT IV-MODERN OPTIMIZATION TECHNIQUES (9 hours)
Simulated Annealing- Temperature Scheduling- Multi-Objective Simulated Annealing, Extremal Optimization, Tabu Search, Memetic and Hybrid Algorithms, Downhill Simplex (Nelder and Mead)

UNIT V-SEARCH ALGORITHMS (9 hours)

REFERENCES

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<th>ME2216</th>
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PURPOSE
To enlighten the students about the fundamentals of design of experiment Techniques

INSTRUCTIONAL OBJECTIVES
At the end of this course the student should be able to understand the
1. Introduction about design of experiments
2. Response surface design
3. Factorial design
4. Taguchi design
5. ANOVA analysis

UNIT I-INTRODUCTION (9 hours)
Design of experiments-Introduction, factor constraints, Interaction terms, Number of runs, enter data, analyze the data, level of factors, Custom designs-Introductions, examples, Screening design creation-Statistical Software introduction, demo using simple case studies.

UNIT II-RESPONSE SURFACE DESIGN (9 hours)
Response surface design-Introduction, creation, Central Composite Design, Box Behnken design, Contour profile of response surface plot, Design table, analyze the data, using Statistical software simple case study examples-Evolutionary operation, Experiment with random factor-Simple case studies.

UNIT III-FACTORIAL DESIGN (9 hours)
Basic definition, principles and advantages-Creating, Blocking in a factorial design, responses and factors, Simple case studies, 2-level fractional factorial design, Mixture design-Introduction, optimal mixture design, Simplex centroid design-examples, $2^k$ Factorial design, linear Regression analysis-error prediction, Full factorial design-Simple Case studies.

UNIT IV-TAGUCHI DESIGN (9 hours)
Creating Taguchi design approach, Orthogonal array, S/N Ratio, Smaller is better, nominal is better and Larger is better, with simple case studies, analyze the data-Factor effect diagram, Levels of parameters, Confirmation test-Augmented design, simple case study problems.

UNIT V-ANOVA ANALYSIS (9 hours)
Experimentation with single factor-Analysis of Variance-Sum of square-Determining sample size-Model adequacy checking-Regression approach-least square method-Non parametric method-Simple problems.

REFERENCES

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Total Contact Hours - 45

Prerequisite
Nil

PURPOSE
To impart basic knowledge of robot vision, image processing and its applications.

INSTRUCTIONAL OBJECTIVES
To make the student to understand
1. Basic principle of image acquisition and imaging components
2. Fundamentals of image processing and image enhancement
3. Object recognition and feature detection
4. Thinning and propagation algorithm
5. Various application of robot

UNIT I - IMAGE ACQUISITION AND IMAGING COMPONENTS
(9 hours)
The Nature of Vision- Robot vision – Need, Applications - image acquisition –illumination techniques- Point sensor, line sensor, planar sensor, camera transfer characteristic, Raster scan, Image capture time, volume sensors, Image representation, picture coding techniques.

UNIT II - ELEMENTS OF IMAGE PROCESSING TECHNIQUES
(12 hours)

UNIT III - OBJECT RECOGNITION AND FEATURE EXTRACTION
(9 hours)
Image segmentation- Edge linking-Boundary detection-Region growing-
Region splitting and merging- Boundary Descriptors-Freeman chain code-
Regional Descriptors- recognition-structural methods- Recognition
procedure, mahalanobic procedure

UNIT IV-COLLISON FRONTS ALGORITHM (6 hours)
Introduction, skeleton of objects. Gradients, propagation, Definitions,
propagation algorithm, Thinning Algorithm, Skeleton lengths of Top most
objects.

UNIT V-ROBOT VISION APPLICATION (9 hours)
Case study-Automated Navigation guidance by vision system – vision based
depalletizing- line tracking-. Automatic part Recognition. Image processing
techniques implementation through Image Processing software-
MATLAB/OPENCV

REFERENCES
1. P.A. Janaki Raman, Robotics and Image Processing an Introduction,
2. Richard D. Klafter, Thomas .A, Chri Elewski, Michael Negin, Robotics
3. Mikell P Groover & Nicholas G Odrey, Mitchel Weiss, Roger N Nagel,
   Ashish Dutta, Industrial Robotics, Technology programming and
5. Bijay K. Ghosh, Ning Xi, T.J. Tarn, Control in Robotics and Automation
6. S.R. Deb, Robotics Technology and flexible automation, Tata McGraw-
   Hill Education., 2009.
7. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, “Robotics – Control Sensing,
ROBOTIC SIMULATION

Prerequisites
Nil

UNIT I-INTRODUCTION (8 hours)
Robotics systems, Robot movements, Quality of simulation, types of simulation, Robot applications, Robotics simulation displays. Simulation notation, Auto lisp functions. Features, Command syntax, writing design functions.

UNIT II-ROBOTIC PRINCIPLES (8 hours)
Straight lines, Angles and optimal moves circular interpolation, Robotic functions Geometrical commands, Edit commands. Selecting robot views, standard Robot part, using the parts in a simulation.

UNIT III-ROBOTICS SIMULATION (10 hours)
Simulation packages, Loading the simulation, Simulation editors, delay, Resume commands. Slide commands, program flow control. Robot motion control, Analysis of robot elements, Robotic linkages.

UNIT IV-ROBOTIC MOTION (9 hours)
Solids construction, Solid animation. Types of motion, velocity and acceleration, Types of simulation motion Harmonic motion, parabolic motion, uniform motion velocity and acceleration analysis for robots.

UNIT V-ROBOT DESIGN (10 hours)
REFERENCES

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<th>ME2313</th>
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Prerequisites
Nil

PURPOSE
To provide knowledge of sensors used in Robotics

INSTRUCTIONAL OBJECTIVES
To make the student to understand
1. The basics and the latest technology of sensors used in robotics.
2. The different sensing variables
3. Robot vision system
4. Robot programming

UNIT I-INTRODUCTION (4 hours)
An Introduction to sensors and Transducers, History and definitions, Smart Sensing, AI sensing, Need of sensors in Robotics.
UNIT II-SENSORS IN ROBOTICS  (10 hours)
Position sensors – optical, non-optical, Velocity sensors, Accelerometers, Proximity Sensors – Contact, non-contact, Range Sensing, touch and Slip Sensors, Force and Torque Sensors.

UNIT III-MISCELLANEOUS SENSORS IN ROBOTICS  (11 hours)

UNIT IV-VISION SENSORS IN ROBOTICS (10 hours)
Robot Control through Vision sensors, Robot vision locating position, Robot guidance with vision system, End effector camera Sensor.

UNIT V-MULTISENSOR CONTROLLED ROBOT ASSEMBLY  (10 hours)

REFERENCES
UNIT I-INTRODUCTION  (6 hours)
Introduction – History, Definition of AI, Emulation of human cognitive process, Intelligent agents – The concept of rationality, the nature of environments, the structure of agents.

UNIT II-SEARCH METHODS  (12 hours)

UNIT III-ROBOTICS  (10 hours)

UNIT IV-PROGRAMMING AND LOGICS IN ARTIFICIAL INTELLIGENCE  (10 hours)
LISP and other programming languages – Introduction to LISP, Syntax and numerical function, LISP and PROLOG distinction, input, output and local
variables, interaction and recursion, property list and arrays alternative languages, formalized symbolic logics – properties of WERS, non-deductive inference methods.

UNIT V - EXPERT SYSTEM


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PURPOSE
To expose the students with latest material handling system used in industry.

INSTRUCTIONAL OBJECTIVES
To study the
1. Basics of material handling system.
2. Various material handling equipment used in industry.
3. AGV’s AS/RS system, conveyor systems.
4. Application of Robotics in material handling

UNIT I - INTRODUCTION
Material Handling – Functions, Types, analysis, Importance & Scope, Principles, - Part feeding device – types of material handling system – Unit material movement & Unit loads – Receiving, Shipping, inprocess handling – bulk handling equipment & methods.
UNIT II-MATERIAL HANDLING EQUIPMENT (9 hours)
Industrial trucks, lifting device, monorails, manipulators, conveyors, storage systems, elevators, racks, bins, pallets, cranes – Automation of material handling – mechanization of part handling.

UNIT III-AUTOMATED GUIDED VEHICLE SYSTEM (9 hours)

UNIT IV-STORAGE SYSTEM (9 hours)
Conveyor systems – types, Quantitative relationship & analysis – Automated storage system, performance – AS/RS system – Basic components, types, controls, features, applications, Quantitative analysis – carousel storage system – applications.

UNIT V-ROBOTICS IN MATERIAL HANDLING (9 hours)

REFERENCES
7. Measwani .N.V & Mehta .A.C., Advances in material handling equipment
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<th>ME2316</th>
<th>ROBOT ECONOMICS</th>
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**PURPOSE**
To learn various economic and social aspects of Robotics and its installation procedure.

**INSTRUCTIONAL OBJECTIVES**
To learn

1. The various costs and potential benefits associated with the robot installation.
2. Several methods for analyzing these factors to determine economic merits of the project.
3. The logical sequences of the procedures to implement the robotic installation and social issues, applications.

**UNIT I-ROBOT COMPONENTS AND THEIRS SELECTION** *(8 hours)*
Power supply, movement and drive systems, sensors, end effector and grippers, Control techniques, Characteristics and factor considered for selection.

**UNIT II-ECONOMIC ANALYSIS FOR ROBOTICS** *(9 hours)*
Economic analysis for robotics. Economic analysis, basic data required methods of Economic analysis, subsequent uses of robot, Difference in production rates, other factors Robot project analysis form.

**UNIT III-IMPLEMENTING ROBOTICS** *(10 hours)*
Familiarization with robotics technology, plant survey to identify potential applications, Selection of the best applications, Selection of a robot, Detailed economic analysis, planning and installation.

**UNIT IV-SOCIAL ISSUES** *(8 hours)*
Safety in Robotics, Training, Maintenance, Quality improvement, productivity and capital formation, Robotics and labour. Education and training, international impacts, future applications.
UNIT V-ROBOTICS TECHNOLOGY OF THE FUTURE  (10 hours)
Robot intelligence, Advanced Sensors, Capabilities, Tele robotics, Mechanical design Features, Mobility, locomotion and Navigation. The universal Hand Systems Integration and Networking. Robots in RPT.

REFERENCES

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<th>ME2317</th>
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Prerequisites
Nil

(The students are expected to write computer programs in C or C++ to automate machine elements design principles)

PURPOSE
To study how computers can be used to automate machine element design.

INSTRUCTIONAL OBJECTIVES
To know the fundamentals of design and write programs in C or C++ to automate the design of shafts, power transmission systems (belts and gears), gear boxes, clutches and brakes for automobiles, machine tools and material handling equipments.

UNIT I-INTRODUCTION  (9 hours)
Phases of design – properties of engineering materials – standardization and interchangeability of machine elements – Classes of fit, selecting tolerances, accumulation and non-accumulation of tolerance - Tolerance stack up stress concentration – Theories of failure.
UNIT II-SHAFT (9 hours)
Design of shaft for different application – Design for rigidity – Integrated
design of shaft, key and bearing practical shaft Design using computer.

UNIT III-BELT DRIVES AND GEAR (9 hours)
Design of belt drives - Principle of gear tooth action – Gear correction - Gear
tooth failure modes – Stress and loads – component design of spur, helical,
bevel and worm gears, practical component design of gears using computer.

UNIT IV-GEAR BOXES (9 hours)
Integrated design of speed reducer and multi speed gear boxes - Housing,
Bearing, Shaft, Capacity of lubricant, Gasket.

UNIT V-CLUTCHES AND BRAKES (9 hours)
Integrated design of automobile components: Clutches – Dynamic and
thermal aspects of vehicle braking – Integrated design of brakes for machine
tools, automobiles and mechanical handling equipments.

REFERENCES
ME2318 MANUFACTURING SYSTEM SIMULATION

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Total Contact Hours-45

Prerequisite
Nil

PURPOSE
To highlight the basic concepts and procedure for simulation of Manufacturing systems

INSTRUCTIONAL OBJECTIVES
To familiarise

1. Basics of simulation and its types
2. Techniques for generation of random numbers
3. Design and evaluation of simulation experiments
4. Simulation languages
5. Concepts and simulation of discrete events

UNIT I - INTRODUCTION (6 hours)
Systems – discrete and continuous systems, general systems theory, models of systems - variety of modeling approach, concept of simulation, simulation as a decision making tool, types of simulation, Principle of computer modeling- Monte Carlo simulation, Nature of computer modeling, limitations of simulation, area of application.

UNIT II - RANDOM NUMBER GENERATION (9 hours)
Techniques for generating random numbers- mid square method, mid product method, constant multiplier technique, additive congruential method, linear congruential method. Tests for random numbers- Kolmogorov-Smirnov test, the Chi-square test.

UNIT III - DESIGN AND EVALUATION OF SIMULATION EXPERIMENTS (10 hours)
Problem formulation, data collection and reduction, time flow mechanism, key variables, logic flow charts, starting condition, run size, experimental design consideration, output analysis, verification and validation of simulation models.

UNIT IV - SIMULATION LANGUAGES (10 hours)
Comparison and selection of simulation languages, study of any one simulation language
UNIT V - DISCRETE EVENT SIMULATION (10 hours)

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AIM
To provide knowledge on principle, constructional features, programming, tooling and work holding devices in CNC machine tools.

OBJECTIVE
Upon completion of this subject, student will be able to
1. Understand of CNC machine tools and machining centres
2. Describe constructional features of CNC machine tools
3. Explain drives and tooling systems used in CNC machine tools
4. Understand feedback and adaptive control of CNC machines
5. Write simple programs for CNC turning and machining centres

UNIT I - INTRODUCTION TO CNC MACHINE TOOLS (6 hours)
Evolution of CNC Technology, principles, features, advantages, applications, CNC and DNC concept, classification of CNC Machines – turning centre,
machining centre-features and applications, Automatic tool changers and Multiple pallet system, types of control systems, CNC controllers, characteristics, interpolators.

**UNIT II-STRUCTURE OF CNC MACHINE TOOL**  
(10 hours)  
CNC Machine building, structural details, configuration and design, guide ways –Friction, Anti friction and other types of guide ways, elements used to convert the rotary motion to a linear motion – Screw and nut, recirculating ball screw, rack and pinion, spindle assembly, torque transmission elements – gears, timing belts, flexible couplings, Bearings. Swarf removal and safety considerations.

**UNIT III-DRIVES AND TOOLING SYSTEMS**  
(9 hours)  
Spindle drives – DC shunt motor, 3 phase AC induction motor, feed drives – stepper motor, servo principle, DC and AC servomotors, Open loop and closed loop control, Tooling requirements for turning and machining centres, Introduction to cutting tool materials – Carbides, Ceramics, CBN, PCD– inserts, classification- qualified, semi qualified and preset tooling, coolant fed tooling system, work holding devices for rotating and fixed work parts, modular fixtures.

**UNIT IV-FEEDBACK SYSTEMS AND ADAPTIVE CONTROL**  
(10 hours)  

**UNIT V-CNC PROGRAMMING**  
(10 hours)  
Coordinate system, structure of a part program, G & M Codes, tool length compensation, cutter radius and tool nose radius compensation, do loops, subroutines, canned cycles, mirror image, parametric programming, machining cycles, programming for machining centre and turning centre generation of CNC codes from CAM packages. Basics of APT
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**Total Contact Hours-45**

**Prerequisites**
Nil

**PURPOSE**
To study the basic principles and applications of the engineering analysis tool Finite Element Analysis.

**INSTRUCTIONAL OBJECTIVES**

1. Introduction to Engineering Analysis tool FEA its application in Linear static Analysis and 2D problems
2. Study of Finite Element modeling and simulation Techniques
3. Use of FEA in structural vibration and thermal Analysis
4. Study of Finite Element Software - ANSYS

**UNIT I-INTRODUCTION (9 hours)**
UNIT II-1-D LINEAR STATIC ANALYSIS  (9 hours)
Bar and Beam elements, local and global coordinate system, transformation of coordinate systems, element stress. Analysis of truss. Natural coordinate system, Interpolation polynomial, Isoparametric elements and Numerical integration -Gaussian quadrature approach-simple problems in 1-D.

UNIT III-FINITE ELEMENT ANALYSIS OF TWO DIMENSIONAL PROBLEMS  (9 hours)
Review of the basic theory in 2-D elasticity, plane stress, 2-D problems using Constant Strain Triangles (CST), isoparametric representation, element matrices, stress calculations. Finite element modeling and simulation techniques-symmetry, Nature of FE solutions, error, convergence, adaptivity, substructures (super elements) in FEA.

UNIT IV-STRUCTURAL VIBRATION AND DYNAMIC ANALYSIS  (9 hours)
Review of basic dynamic equations, Hamilton’s principle, element mass matrices, free vibration (normal mode) analysis, Eigen values and Eigen vectors. Introduction to transient response analysis.

UNIT V-THERMAL ANALYSIS  (9 hours)
Review of basic equations of heat transfer, steady state one dimensional heat conduction, governing equations, boundary conditions, element characteristics-Simple problems in 1-D.
Practical: - 2-D, 3-D problems, introduction to transient heat transfer, simple problems using ANSYS.

REFERENCES

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PURPOSE
To enable the students to understand the basic principles of CIM and its elements.

INSTRUCTIONAL OBJECTIVES
To familiarize
1. The basic components of CIM and its hardware and software
2. CAD/CAM and its integration with CIM
3. FMS and its applications
4. Principles of computer aided process planning, JIT and GT
5. Different monitoring systems used in CIM
6. Computer Aided Quality Control and FIS

UNIT I-INTRODUCTION TO CIM (9 hours)
Manufacturing - Types, Manufacturing Systems, CIM Definition, CIM wheel, CIM components, Evolution of CIM, needs of CIM, Benefits of CIM, basic components of NC system, NC motion control system, applications of NC, advantages and disadvantages of NC, computer Numerical control, advantages of CNC, functions of CNC, Direct Numerical Control, components of a DNC system, functions of DNC, advantages of DNC.

UNIT II-CAD (9 hours)
Development of computers, CIM Hardware & Software, Data-Manufacturing data, types, sources, Structure of data models, Data base and DBMS-requirement, RDBMS, SQL, Computer Aided Design - benefits, Graphic Standards, Interfaces, CAD software, Integration of CAD/CAM/CIM.
UNIT III-Flexible Manufacturing Systems (9 hours)
FMS concept, Components of FMS, FMS Layouts, FMS planning and implementation, Tool Management systems-Tool monitoring, Work holding devices- Modular fixuring, flexible fixturing., flexibility, quantitative analysis of flexibility, application and benefits of FMS, automated material handling system –AGVs, Guidance methods, AS/RS.

UNIT IV-Automated Process Planning (9 hours)

UNIT V-Monitoring and Quality Control (9 hours)
Types of production monitoring system, process control & strategies, Direct digital control - Supervisory computer control - computer aided quality control - objectives of CAQC, QC and CIM, contact, non contact inspection methods, CMM and Flexible Inspection systems. Integration of CAQC with CIM.

REFERENCES
### ME2322 NANO ROBOTICS

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**Total Contact Hours-45**

**Prerequisites**

Nil

**PURPOSE**

To enlighten the students about nanorobot working principle and applications

**INSTRUCTIONAL OBJECTIVES**

At the end of this course the student should be able to understand the

1. Basics of nano robotics system
2. Micro/Nano Sensors
3. Micro/Nano Actuators
4. Micro/Nano Manipulators
5. Micro/Nano Robotics manufacturing and control techniques

**UNIT I-INTRODUCTION**

(9 hours)

Micro/Nano-Robotic system components, Products-Scaling effects in the physical parameters -Micro/Nano-Robotic System examples around the world-wall climbing micro robot, Micro mechanical flying robot-Design, fabrication, characterization of micro gripper- Introduction to nanomanipulation, control and applications-Bottom up and Top down approach.

**UNIT II-MICRO/NANO SENSORS**

(9 hours)


**UNIT III-MICRO/NANO ACTUATORS**

(9 hours)

Micro robot actuation- Piezoelectric Actuators - Bending Type - Unimorph and Bimorphs - Stack Type – Piezotubes - Thin-Film Type - Surface Acoustic Waves - Electrostatic, Thermal, Ultrasonic, Magnetostrictive actuators ,Shape memory alloy actuators - Polymer Actuators - Dielectric Elastomers - Carbon Nanotube (CNT) Actuators - Biomolecular Motors.

**UNIT IV-MICRO/NANO MANIPULATORS**

(9 hours)

SPM Probes and Micro/Nanogrippers -Atomic Manipulation using STM, non-contact AFM, nanoassembly, Direct self-assembly - Optical Tweezers

UNIT V - MANUFACTURING TECHNIQUES, NANO-ROBOT DESIGN (9 hours)

REFERENCES
### ME2323 COMPUTER GRAPHICS

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**Total Contact Hours-45**

**Prerequisites**

Nil

**PURPOSE**

To study how various graphics images can be created on the computer and its representation standards.

**INSTRUCTIONAL OBJECTIVES**

The students can understand the following:

1. Basics of computer Graphics like drawing line, arc etc.
2. Drawing of spline curves
3. Creation of surfaces
4. Algorithms for 3D viewing
5. Available drawing standards

### UNIT I-INTRODUCTION (9 hours)


### UNIT II-SPECIAL CURVES (9 hours)

Curve representation – Bezier, cubic spline, B-spline, rational.

### UNIT III-SURFACES (9 hours)

Surface modeling techniques: Coons patch, Bi-cubic patch, Bezier and B-spline surfaces.

### UNIT IV-THREE DIMENSIONAL COMPUTER GRAPHICS (9 hours)

Volume modeling: boundary representation, CSG, hybrid - viewing transformations – techniques for visual realism: clipping, hidden line removal, algorithms for shading and rendering.

### UNIT V-GRAPHICS STANDARDS & FUNDAMENTALS OF COMMUNICATIONS (9 hours)


**REFERENCES**

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<tr>
<th>ME2324</th>
<th>OPTIMIZATION IN ENGINEERING DESIGN</th>
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**Prerequisites**
Nil

**PURPOSE**
To study the principles of optimization and various techniques which can be used for Mechanical Engineering optimization along with applications.

**INSTRUCTIONAL OBJECTIVES**
1. Principles of optimization and its need.
2. Various conventional optimization techniques
3. Solving multivariable problems
4. Solving problems using Unconventional optimization techniques
5. Applications of optimization to design of machine elements
UNIT I-INTRODUCTION (9 hours)

UNIT II-CLASSICAL OPTIMIZATION TECHNIQUES (9 hours)

UNIT III-MULTIVARIABLE – UNCONSTRAINED AND CONSTRAINED OPTIMIZATION (9 hours)

UNIT IV-NON–TRADITIONAL OPTIMIZATION TECHNIQUES (9 hours)
Genetic Algorithms - Simulated Annealing - Tabu search methods.

UNIT V-OPTIMUM DESIGN OF MACHINE ELEMENTS (9 hours)

REFERENCES
SUPPORTIVE COURSES

<table>
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<tr>
<th>MA2006</th>
<th>COMPUTATIONAL METHODS IN ENGINEERING</th>
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Total contact hours – 45
Prerequisite
Nil

PURPOSE
To develop analytical capability and to impart knowledge in Mathematical and Statistical methods and their applications in Engineering and Technology and to apply these concepts in engineering problems they would come across.

INSTRUCTIONAL OBJECTIVES
At the end of the course, Students should be able to understand Mathematical and Statistical concepts and apply the concepts in solving the engineering problems.

UNIT I INITIAL AND BOUNDARY VALUE PROBLEMS
Classification of Linear differential equation - solution of initial and boundary value problems. Laplace transform methods for one - dimensional wave equation - Displacements in a string. Fourier series methods for one dimensional wave equation and one - dimensional heat conduction problems.

UNIT II PROBABILITY
Basic definition, conditional, Probability, Baye's theorem - Binomial, Poisson, Normal, Exponential, Rectangular, Gamma Distributions. Moment generating function, random variables, two dimensional random variables.

UNIT III PRINCIPLE OF LEAST SQUARES
Fitting of Straight line and parabola - Correlation - Linear multiple and partial correlation - Linear regression - Multiple regression.

UNIT IV SAMPLING DISTRIBUTIONS
Tests based on t-distribution, chi-square and F-distributions - Analysis of variance - One-way and two-way classifications.

UNIT V TIME SERIES ANALYSIS
Significance of time series analysis - Components of Time series - Secular trend - Graphical method - Semi-average method - Method of Moving

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REFERENCES


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<th>MA2007</th>
<th>APPLIED MATHEMATICS FOR MECHANICAL ENGINEERS</th>
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PURPOSE
To develop analytical capability and to impart knowledge in Mathematical and Statistical methods and their applications in Engineering and Technology and to apply these concepts in engineering problems they would come across.

INSTRUCTIONAL OBJECTIVES
At the end of the course, Students should be able to understand Mathematical and Statistical concepts and apply the concepts in solving the engineering problems.

UNIT I TRANSFORM METHODS ( 9 hours)
Laplace transform methods for one-dimensional wave equation - Displacements in a string - Longitudinal vibrations of an elastic bar - Fourier transform methods for one-dimensional heat conduction problems in infinite and semi-infinite rod.

UNIT II ELLIPTIC EQUATIONS (9 hours)
Laplace equation - Fourier transform methods for Laplace equation - Solution of Poisson equation by Fourier transform method.
UNIT III CALCULUS OF VARIATIONS  (9 hours)
Variation and its properties - Euler's equation - Functionals dependent on first and higher order derivatives - Functionals dependent on functions of several independent variables - Some applications - Direct methods - Ritz methods.

UNIT IV NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS  (9 hours)
Numerical Solution of Partial Differential Equations - Solution of Laplace’s and Poisson equation on a rectangular region by Liebmann’s method - Diffusion equation by the explicit and Crank Nicholson implicit methods - Solution of wave equation by explicit scheme.

UNIT V REGRESSION METHODS  (9 hours)
Principle of least squares - Correlation - Multiple and Partial correlation - Linear and non-linear regression - Multiple linear regression.

REFERENCES
1. Sankara Rao K., Introduction to Partial Differential Equations, 4th printing, PHI, New Delhi, April 2003
ME2391 MOBILE ROBOT 

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Total contact hours - 45

Prerequisite
Nil

PURPOSE
To familiarize the students with mobile robots, basic methods for achieving mobility and autonomy.

INSTRUCTIONAL OBJECTIVES
Upon successful completion of the course the students will be able to understand

1. Design and kinematic modeling of mobile robots
2. Basic control algorithms involved in mobile robots
3. Various sensors used for perception
4. The localization and mapping
5. Various algorithms in path planning and navigation

UNIT I-INTRODUCTION TO MOBILE ROBOTS (9 hours)

UNIT II-CONTROL OF MOBILE ROBOTS (9 hours)
Control theory - Control design basics, Cruise-Controllers, Performance Objectives. Simple robot – State space model, Linearization, LTI system, stability. PID control, basic control algorithms

UNIT III-PERCEPTION (9 hours)
Sensors for mobile robots – Classification, performance, uncertainty in sensors, wheel sensor, heading sensor, accelerometers, inertial measurement, motion sensor, range sensors. Vision sensor- Basics of computer vision, image processing techniques, feature extraction – image, range data location recognition.

UNIT IV-LOCALIZATION (9 hours)
Major challenges, localization based navigation. Belief representation, map representation, probabilistic Map. Examples of localization systems. Autonomous map building

UNIT V-PLANNING AND NAVIGATION (9 hours)

REFERENCES
3. Thrun, Burgard, Fox, Probabilistic Robotics, MIT Press, 2005

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Students have to present a minimum of three seminar papers on the topics of current interest. The evaluation will be based on the knowledge of the student on the subject of presentation, their communication abilities, the method of presentation, the way questions were answered and his attention to the other students' seminars.

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Students can register for this course only after earning at least 12 credits in the core courses of their study.

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Students can register for this course only after earning at least 16 credits in the core courses of their study. Students can enroll for this course only after completing Project Work-Phase I.