SCHEME OF EXAMINATION

&

DETAILED SYLLABUS

FOR

MASTER OF TECHNOLOGY
[Robotics and Automation]

REGULAR PROGRAMME

Offered by MAE Dept.

Indira Gandhi Delhi Technical University for Women
(Established by Govt. of Delhi vide Act 09 of 2012)
(Formerly Indira Gandhi Institute of Technology) Kashmere Gate Delhi-110006

M.Tech (Robotics and Automation)

First Semester (First Year)

S. No	Subject Code	Subject Name	L-T-P	Credits	Category
1	MRA - 101	Robotics Engineering	3-0-2	4	**DCC**
2	MRA - 103	Mechatronics Systems and Applications	3-0-2	4	**DCC**
3	MRA - 105	Computer Aided Modeling and Analysis	3-0-2	4	**DCC**
4	MRA - 107	Automation in Manufacturing	3-0-2	4	**DCC**
5	ROC - 101	Research Methodology	3-0-0	3	**ROC**
6	GEC - 101	Generic Open Elective	2-0-0 /1-1-0 /0-0-4	2	**GEC**
		Total		21	

Second Semester (First Year)

S. No	Subject Code	Subject Name	L-T-P	Credits	Category
1	MRA - 102	Pneumatic and Hydraulic Controls	3-0-2	4	**DCC**
2	MRA- 104	Computer Integrated Manufacturing	3-0-2	4	**DCC**
3	MRA -106	Microcontroller &Applications	3-0-2	4	**DCC**
4	MRA -1xx	**Department Elective I**	3-0-2	4	**DEC**
5	MRA -1yy	**Department Elective II**	3-0-2	4	**DEC**
6	ROC -102	Research Ethics	3-0-0	3	**ROC**
		Total		23	

Third Semester (Second Year)

S. No	Subject Code	Subject Name	L-T-P	Credits	Category
1	MRA -201	Advanced Robotics	3-0-2	4	**DCC**

2	MRA -2xx	**Department Elective III**	3-0-2 / 3-1-0	4	**DEC**
3	MRA -2yy	**Department Elective IV**	3-0-2 / 3-1-0	4	**DEC**
4	MRA -251	Dissertation – I / Project Work	-	8	**DCC**
5	MRA -253	Industrial Training / Project	-	1	**DCC**
6	GEC -201	Generic Open Elective	2-0-0 /1-1-0 /0-0-4	2	**GEC**
		Total		23	

Fourth Semester (Second Year)

S. No	Subject Code	Subject Name	L-T-P	Credits	Category
1	MRA -252	Dissertation – II / Project Work	-	20	**DCC**
		Total		20	

Note: Industrial training / Internships will be done in summer break of previous academic session. Assessment for the same will be done within first two weeks of opening of academic session by department.

List of Department Elective Courses

Category	Course Code	Subject	Credit
Department Elective Course – I	MRA -108	Modern Control Theory	3-0-2
	MRA -110	MEMS and Microsystems for Automation	3-0-2
	MRA -112	Applications of AI in Automation	3-0-2
	MRA -114	Instrumentation and Control Engineering	3-0-2
	MRA -116	Higher Numerical Techniques	3-0-2
Department Elective Course – II	MRA -118	Advanced digital signal processing	3-0-2
	MRA -120	Advanced Finite Element Analysis	3-0-2
	MRA -122	Neural Network and Fuzzy Logic	3-0-2
	MRA -124	Optimization for Engineering	3-1-0
	MRA -126	Modelling& Simulation for Automation	3-0-2
Department Elective Course – III	MRA -203	Machine Vision	3-0-2
	MRA -205	Wireless Sensor Networks	3-0-2
	MRA -207	Advanced Mechanism Design	3-0-2

	MRA -209	Applications of Machine learning in Automation	3-0-2
	MRA - 211	Design of Experiments	3-0-2
Department Elective Course – IV	MRA -213	Electrical machines and Power systems	3-0-2
	MRA -215	Industrial Engineering	3-0-2
	MRA -217	Embedded System Design for Automation	3-0-2
	MRA -219	Bio Sensors	3-0-2
	MRA -221	Multi-Body Dynamics	3-0-2
	MRA -223	VLSI Design for Automation	3-0-2

Advanced Robotics	
Course Code: MRA-201 Contact Hours: L-3 T-0 P-2 Course Category: DCC	Credits: 4 Semester: 3

Introduction: The robots are being used as manufacturing tools and as such there is requirement of higher accuracy and repeatability. This course has been designed for providing knowledge to cater to needs of these robots.

Course Objectives: The objectives of this course are to:

1. Provide an understanding of the role of automation technology in robot industry.
2. Develop high level mathematical skills for analysis and synthesis of an articulated arm robot.
3. Develop skills in the selection and application of different robots for various tasks.

Pre-Requisites: MRA-101 Robotics Engineering

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

1. Design multi-jointed serially linked manipulators.
2. Identify intermediate arm matrices describing individual links.
3. Determine the joint angle equations to attain a global position and angle of the end effector.
4. Determine how to identify velocity profiles of individual joints to achieve a desired global spatial trajectory.
5. Relate driving currents and torques needed to control this trajectory for electrically-driven robots.

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.

Class room teaching is consequently supported by practical sessions and assignments / projects given in labs during practical sessions.

Contents:

UNIT I	11 Hours
Review of serial, parallel robotic manipulators: Kinematic chain; Degrees of freedom; Forward and Inverse Kinematics; Dynamics **Different types of wheeled mobile robots and walking machines**: robots with wheels - Omni directional, torus, etc., legged robots - Biped, Quadruped, etc.	
UNIT II	11 Hours
Algorithmic issues for inverse and forward kinematics of robotic systems: Efficiency (Computational Count); Accuracy in numerical calculations; Numerical stability (tolerances in numerical solutions of algebraic and differential equations). **Kinematic design of serial and parallel robots based on singularity and workspace:** Workspace and calculation, Singularity and calculation.	
UNIT III	10 Hours
Manipulability and dexterity techniques. **Dynamic algorithms -Inverse, forward:** Formulation of dynamic model (equations of motion); Newton-Euler algorithm; Use of computer-orientated approaches, e.g., Decoupled Natural Orthogonal Complement (DeNOC) based; Inverse dynamics; Forward dynamics; Mechanical design (choice of material, cross-section, etc.)	
UNIT IV	10 Hours
Control of robotic systems: Basics of control; PD, PI and PID control; Force control; Adaptive control **Mechanical design of robot links and joints**: Design from mechanical failure and stiffness criteria; Consideration of natural frequency in design.	

Text Books	
1.	Ghosal, A., “Robotics”, Oxford, New Delhi, 2006
2.	Siegwart, Illah R Nourbakhsh, Davide Scaramuzza, “Autonomous Mobile Robots”, PHI, 2011
Reference Books	
1.	Craig, J.J., “Introduction to Robotics: Mechanics and Control”, Pearson, Delhi, 3rd Edition, 2009
2.	Tsai, L, “Robot Analysis”, John Wiley & Sons, Singapore, 1999
3.	Saha, S.K., “Introduction to Robotics”, Tata McGraw Hill, 4th reprint, 2010

Machine Vision	
Course Code: MRA-203 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 3

Introduction: The automated manufacturing environment has started using vision sensors. This course aims to enlighten students about this technology.

Course Objectives: The objective of this course is to gain theoretical and practical knowledge about machine and computer vision and get students acquainted with possibilities and limitations of application of image processing and machine vision.

Pre-Requisites: Mechatronics systems and Applications (MRA 103)

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

1. Have an in-depth understanding of digital images and their formation;
2. Acquire knowledge and practical exposure to digital image processing and Interfacing of cameras to computer for application in Industry Automation.

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.
Class room teaching is consequently supported by practical sessions and assignments / projects given in labs during practical sessions.

Contents:

UNIT I	11 Hours
Introduction to machine vision, Fundamental concept: Digital image, Elements of a machine vision system, Parts of machine vision system, Forming an image, Illumination Techniques, **Camera Image model:** perspective geometry, image function, **Camera Calibration:** Intrinsic and extrinsic parameters, Current and future applications	
UNIT II	11 Hours
Images and basic image processing: Different types of images (spectral, colour, gray-level, binary), Operating on gray level images, Image gray-level histogram, Efficiency considerations in image processing, **Thresholding:** (a) Problem definition and trivial solution (b) Adaptive thresholding, Edge detection, Image segmentation	
UNIT III	10 Hours
High level Segmentation, Tessellation and connectivity, Connected component labelling,	

Crack and border following, **Image Enhancement:** Gray Scale Modification, Histogram Modification, **Image restoration:** Laplacian operator, Image filtering operations: sharpening, smoothing, averaging, median-filtering		
UNIT IV		10 Hours
From segmentation to object analysis: Shape as a simple description of objects, Representing shapes (binary and boundary pattern shape descriptors), from shapes to features (different features and invariance), **Morphological Image Processing:** Binary erosion/dilation, opening/closing, hit-or-miss transforms, Gray-scale morphology, **Recognition:** Hough transform techniques, Geometric constraints, Matching		
Text Books		
1.	González, Rafael C. and Woods, Richard Eugene, "Digital Image Processing", Prentice Hall, 3rdEdition, 2008.	
2.	Ballard, D.H. and Brown, C.M., "Computer Vision", Prentice-Hall Inc., Englewood Cliffs, New Jersey, 1992.	
Reference Books		
1.	Davies, E.R., "Machine Vision: Theory, Algorithms, Practicalities", Academic Press, London, 2012.	
2.	Dougherty, E.R., "An Introduction to Morphological Image Processing, SPIE Optical Engineering Press", Bellingham, Washington, 1992.	
3.	Grimson, W.E.L., "Object Recognition by Computer: The Role of Geometric Constraints", The MIT Press, Cambridge, Massachusetts, 1990.	
4.	Haralick, R.M. and Shapiro, L.G., "Computer and Robot Vision (Volumes I and II)", Addison-Wesley, Reading Massachusetts, 1990.	
5.	Rosenfeld, A. and Kak, A.C., "Digital Picture Processing (Volumes I and II)", 2ndEdition, Academic Press, Orlando, Florida, 1992.	

Wireless Sensor Networks	
Course Code: MRA-205 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 3

Introduction: Wireless sensor network aims to understand the network of devices that can communicate the information gathered from a monitored field through wireless links. This course will discuss fundamental concepts of wireless sensors networks and learning of how these concepts can be utilized to solve problems pertaining to wireless sensor networks for applications in Industry Automation.

Course Objectives: The objective of this course is to learn theoretical and practical knowledge about wireless sensor networks, architectures and networking and get students acquainted with infrastructure establishment and **Sensor Network Platforms and Tools.**

Pre-Requisites: Mechatronics systems and Applications (MRA 103).

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

1. Have an in depth understanding of technologies for wireless sensors networks.
2. Develop high level skill of network architectures, MAC protocols, mediation device protocol and geographic routing and major routing protocol etc.
3. Acquire knowledge of infrastructure establishment, Sensor Node Hardware, Programming Challenges, Embedded Operating System, Node level Simulators and State-centric programming.

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.

Class room teaching is consequently supported by practical sessions and assignments / projects given in labs during practical sessions.

Contents:

UNIT I	11 Hours
Overview: Introduction, Challenges for Wireless Sensor Networks, Enabling Technologies for Wireless Sensor Networks. **Architectures:** Single-Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes, Operating Systems and Execution Environments, Network Architecture, Sensor Network Scenarios, Optimization Goals and Figures of Merit, Gateway Concepts	
UNIT II	11 Hours

Networking: Physical Layer and Transceiver Design Considerations, MAC Protocols for Wireless Sensor Networks, Low Duty Cycle Protocols And Wakeup Concepts, S-MAC, The Mediation Device Protocol, Wakeup Radio Concepts, Address and Name Management, Assignment of MAC Addresses, Routing Protocols- Energy-Efficient Routing, Geographic Routing and Major Routing Protocols.	
UNIT III	10 Hours
Infrastructure Establishment: Topology Control, Clustering, Time Synchronization, Localization and Positioning, Sensor Tasking and Control.	
UNIT IV	10 Hours
Sensor Network Platforms And Tools: Sensor Node Hardware – Berkeley Motes, Deployment, Programming Challenges, Node-level software platforms, Embedded Operating System, Node level Simulators, State-centric programming.	

Text Books	
1.	Holger Karl & Andreas Willig, "Protocols And Architectures for Wireless Sensor Networks", John Wiley2005.
2.	Feng Zhao & Leonidas J. Guibas, "Wireless Sensor Networks- An Information Processing Approach", TMH, 2004.
Reference Books	
1.	Elsevier B.W. Anderson, "The Analysis and Design of Pneumatic Systems", Wiley, 1995.
2.	Kazem Sohraby, Daniel Minoli, &Taieb Znati, "Wireless Sensor Networks-Technology, Protocols, And Applications", John Wiley, 2007.
3.	Anna Hac, "Wireless Sensor Network Designs", John Wiley, 2003.
4.	Feng Zhao and Leonidas Guibas, "Wireless Sensor Networks", Morgan Kaufman Publishers,2007.
5.	Robert Faludi, "Building Wireless Sensor Networks", O'reily Publications. John Pippenger & Tyler Hicks, "Industrial Hydraulics", 3rd edition McGraw Hill, 2010.

Advanced Mechanism Design	
Course Code: MRA-207 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 3

Introduction:

In this course advanced topics in kinematics are discussed with a focus of mechanism synthesis techniques. The course primarily focuses on planar mechanisms and also treats spherical and spatial mechanisms. The subject will give knowledge required for complex mechanism design.

Course Objectives: The objective of this course is to study kinematics of various mechanisms and Kinematics synthesis of linkages so as to design complex mechanisms.

Pre-Requisites: Basic Knowledge of Kinematics of Machines is essential.

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

1) Visualize and design different types of advanced mechanisms,
2) Analyze and synthesize mechanisms;
3) Perform graphical constructions of acceleration analysis.
4) Perform static and dynamic force analysis of linkages.
5) Kinematics analysis and kinematics synthesis of spatial mechanisms

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.

Class room teaching is consequently supported by practical sessions and assignments / projects given in labs during practical sessions.

Contents:

UNIT I	12 Hours
Introduction: Review of fundamentals of kinematics, mobility analysis, formation of one D.O.F. multi loop kinematic chains, network formula, Gross motion concepts. **Kinematic Analysis:** Position Analysis, vector loop equations for four bar, slider crank, inverted slider crank, geared five bar, and six bar linkages. Analytical solutions for velocity and acceleration analysis, human tolerance for acceleration, four bar linkage jerk analysis. Plane complex mechanisms, auxiliary point method. Analytical synthesis techniques including dyad form, ground pivot specification, M&K circles, Burmester curves, Chebychev spacing Precision positions Over lay Method, Analytical Methods, Blotch's Synthesis, Freudestien's Method, Coupler curve Synthesis, Cognate linkages, The Roberts, Chebycher theorem	

UNIT II	11 Hours
Path Curvature Theory: Fixed and moving centroids, inflection points and inflection circle, Euler savary equation, graphical constructions, cubic stationary curvature. **Synthesis of Mechanisms**: Type synthesis, case study of casement window mechanisms Number synthesis, Associated linkage concept Dimensional synthesis, function generation, path generation, motion generation, Graphical methods for two, three positions, circle point and centre point circles, order synthesis of four bar function generation, four positions, special cases of four position synthesis, Finite Ball's point, five positions, cognate linkages.	
UNIT III	10 Hours
Five Bar & Six bar Mechanisms: Geared five bar and parallelogram six bar cognates, six bar parallel motion generator, coupler curve synthesis, design of six bar mechanisms for different applications including dwell. **Algebraic methods:** Using vector loop equations and complex algebra, synthesis of multi loop linkage mechanisms, geared linkages, application of instant centre in linkage design. Practical considerations in mechanism design, mechanism defects.	
UNIT IV	9 Hours
Dynamics of Mechanisms: Static force analysis with friction, inertia force analysis, slider crank mechanism, four bar mechanism, crank– shaper mechanism, combined static and inertia force analysis, shaking force, kinetostatic analysis of a card bunch, time response of a four bar linkage, modification of the time response of a mechanism, virtual work. Introduction to force and moment balancing of linkages **Spatial Mechanisms and Robotics:** Kinematic analysis of spatial RSSR mechanism – Denavit - Hartenberg parameters, Forward and inverse kinematics of robotic manipulators	

Text Books	
1.	Sandor, G.N. and Erdman, A.G. (1984) Advanced Mechanism Design Analysis and Synthesis. Prentice Hall
2.	Shigley, J.E. and Uicker, J.J. (1995) Theory of Machines and Mechanisms. McGraw Hill
3.	Amitabha Ghosh and Ashok Kumar Mallik, (1999) Theory of Mechanism and Machines. EWLP
Reference Books	
1.	Nortron R.L. (1999) Design of Machinery. McGraw Hill
2.	Kenneth Waldron, J. and Gary Kinzel, L. (1999) Kinematics, Dynamics and Design of Machinery. John Wiley & sons

Applications of Machine learning in Automation	
Course Code: MRA-209 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 3

Introduction: Machine learning techniques enables automatic extraction of features from data so as to solve predictive tasks, such as speech recognition, object recognition, machine translation, question-answering, anomaly detection, medical diagnosis and prognosis, automatic algorithm configuration, personalization, robot control, time series forecasting, and much more. Learning systems adapt so that they can solve new tasks, related to previously encountered tasks, more efficiently. The technology is need of hour for intelligent Machines and robots.

Course Objectives: This course will serve as a comprehensive introduction to various topics in machine learning so that the student is able to design and implement machine learning solutions for classification, regression, and clustering problems and be able to evaluate and interpret the results of the algorithms.

Pre-Requisites: Machine Learning is a mathematical discipline, and students will benefit from a good background in probability, linear algebra and calculus. Programming experience is essential.

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

1) Have a good understanding of the fundamental issues and challenges of machine learning: data, model selection, model complexity, etc.
2) Have an understanding of the strengths and weaknesses of many popular machine learning approaches.
3) Appreciate the underlying mathematical relationships within and across Machine Learning algorithms and the paradigms of supervised and un-supervised learning.
4) Be able to design and implement various machine learning algorithms in a range of real-world applications

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.

Class room teaching is consequently supported by practical sessions and assignments / projects given in labs during practical sessions.

Contents:

UNIT I		11 Hours
Introduction: Well posed learning problem, designing a learning system: training experience, target function, final design. Issues in machine learning Concept, Learning and **General to specific ordering:** concept learning task, concept learning as search, version spaces and candidate elimination, inductive bias.		
UNIT II		11 Hours
Decision Tree learning (DTL): Introduction, decision tree representation, problems for DTL, DTL algorithm, hypothesis space search, inductive bias in DTL, issues in DTL. **Bayesian Learning:** Introduction, Bayes Theorem, concept learning, least square hypothesis, predicting probabilities, Bayes optimal classifiers, EM algorithm.		
UNIT III		10 Hours
Instance Based Learning: Introduction, K-nearest neighbour learning, locally weighted regression, case based reasoning. **Learning set of rule:** Introduction, sequential covering algorithm, learning rule sets, first order rules.		
UNIT IV		10 Hours
Analytical learning: introduction, perfect domain theory, explanation based learning. Inductive analytical approaches to learning.		
Text Books		
1.	Tom M. Mitchell , "Machine learning", McGraw Hill 1997.	
2.	Ethem Alpaydin, "Introduction to machine learning", PHI learning, 2008.	
Reference Books		
1.	Rajjan Shinghal, "Pattern Recognition", Oxford Press, 2006.	
2.	Duda, Hart and Stork, "Pattern Classification", 2000.	
3.	Hastie, Tibshirani, Friedman, "The Elements of Statistical Learning", Springer 2001.	

Design of Experiments and Statistical techniques	
Course Code: MRA-211 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 3

Introduction: Whether a person work in engineering, R&D, or a science lab, understanding the basics of experimental design can help one achieve more statistically optimal results from experiments and improve output quality. The subject teaches the technique to design experiments for reliability and replicability. It is also valuable for robustness testing in production environment to ensure quality before releasing a product or system to the market.

Course Objectives: This course will serve as a comprehensive introduction to various topics required to apply concept of design of experiments and statistics for problem solving.

Pre-Requisites: Nil

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

1) Understand significance of design of experiments and apply it in problems;
2) Understand significance of Hypothesis and Annova;
3) Design and Solve random and uncertain block problems;
4) Solve complete factorial design problems;
5) Solve 3^nFactorial Experiment problems.

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.

Class room teaching is consequently supported by practical sessions and assignments / projects given in labs during practical sessions.

Contents:

UNIT I	11 Hours
Introduction: Need for Research, Need for Design of Experiments, Experimental Design Techniques, Applications in area of Design, Marketing, Production, Finance, Personnel planning.	
UNIT II	11 Hours
Analysis of Variance: Test of Hypothesis, Tests of Hypotheses Concerning Mean(s), Two Tailed Test Concerning Difference between Two Means when the Variances of the Populations are Known, Two Tailed Test Concerning Difference between Two Means When the Variances of the Populations are Unknown and the Sample Sizes are Small.	
UNIT III	10 Hours

Design of Annova : Limitations of Testing of Hypothesis for Difference between the Means, Using F-Test, F-Distribution, Two Tailed F-Test, Introduction and Need for Analysis of Variance (ANOVA), Completely Randomized Design, Randomized Complete Block Design, Latin Square Design, Duncan’s Multiple Range Test, Case Study.	
UNIT IV	10 Hours
Adaptive Filtering Algorithms: Introduction, Two-factor complete factorial experiment, Complete factorial experiment with three factors, 2^n factorial experiment, Concept of 2^2 factorial experiment, Concept of 2^3 design, Yates’ algorithm for 2^nfactorial experiment, 3^nfactorial experiment, Concept of 3^2 factorial experiment.	

Text Books	
1	Mead, R. (1990). The design of experiments: statistical principles for practical applications. Cambridge university press.
2	Anderson, V. L., & McLean, R. A. (2018). Design of experiments: a realistic approach. Routledge.
Reference Books	
1.	Barton, R. R. (2012). Graphical methods for the design of experiments (Vol. 143). Springer Science & Business Media.
2.	Mathews, P. G. (2005). *Design of Experiments with MINITAB*. ASQ Quality Press.

Electrical Machines and Power Systems	
Course Code: MRA-213 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 3

Introduction: This course gives an introduction to the design, operation and use of electrical machines. Emphasis is put on understanding of basic physical relationships. The machines are analyzed in steady state operation for relevant applications. The course covers transformers, DC machines, asynchronous, synchronous and fractional kW machines (1-phase and special purpose motors), including permanent magnet machines. It is also an introductory subject in the field of electric power systems and electrical to mechanical energy conversion. Electric power has become increasingly important as a way of transmitting and transforming energy in industrial, military and transportation uses. Electric power systems are also at the heart of alternative energy systems, including wind and solar electric, geothermal and small scale hydroelectric generation.

Course Objectives: The objective of this course is to give the required knowledge in the area of electrical prime movers which is backbone of every automated factory. The course gives an opportunity to strengthen concepts of electrical machines.

Pre-Requisites: The pre-requisites for Electrical Machines are Network Analysis (specially Phasor Analysis) and the basics of Electromagnetic Theory.

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

1) Understanding the principles of operations and characteristics of DC machines;
2) Knowledge of electrical transformers and induction motors;
3) Visualize the operation of synchronous motors stepper and servo motors;
4) Comprehend the power transmission and distribution 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.

Classroom teaching is consequently supported by practical sessions and assignments/projects given in labs during practical sessions.

Contents:

UNIT I	11 Hours
DC Machines: D.C. Machines: – Principle of operation and construction of motor and generator – torque equation – Various excitation schemes – Characteristics of Motor and Generator – Starting, Sped control of D.C. Motor.	
UNIT II	11 Hours
Transformers : Constructional Details, Principle of Operation, EMF Equation, Transformation Ratio, Transformer on No Load, Parameters Referred To HV/LV Windings, Equivalent Circuit, Transformer on Load, Regulation, Testing, Load Test, 3- PHASE Transformers connections.	
UNIT III	10 Hours
Induction Motors: Construction, types, principle of operation of three-phase induction motors, equivalent circuit starting and speed control, single-phase induction motors (only qualitative analysis). **Single Phase Induction Motors and Special Machines:** Types of single phase induction motors, Double field revolving theory, Capacitor start capacitor run motors, Shaded pole motor, Repulsion type motor, Universal motor, Hysteresis motor, Switched reluctance motor, Brushles D.C motor, stepper motor.	
UNIT IV	10 Hours
Introduction To Power System: Structure of electric power systems, generation, transmission, sub-transmission and distribution systems, EHVAC and EHVDC transmission systems, substation layout. (Concepts only).	

Text Book	
	Murugesh Kumar K. , Electric Machines Vo I and Vol II. Vikas Publishing House Pvt Ltd, 2010
2.	Mehta V.K. and Rohit Mehta, Principles of Power System", S.Chand and Company Ltd, 2003
Reference Books	
1	Fitzgerald A.E., Charles Kingsley, Stephen.D.Umans, Electric Machinery", Tata McGraw Hill publishing Company Ltd, 2003
2	Gupta J.B., Theory and Performance of Electrical Machines", S.K.Kataria and Sons, 2002.
3	Kothari D.P. and Nagrath I.J., Electric Machines", Tata McGraw Hill Publishing Company Ltd, 2002.
4	Bhimbhra P.S. , Electrical Machinery", Khanna Publishers, 2003.

Industrial Engineering	
Course Code: MRA-215 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 3 Semester: 3

Introduction: An Engineer has to also manage operations in an Industry. This course develops the skills required in a manager for effective management of industry operations.

Course Objectives: World class performance in operations i.e. in product design, manufacturing, engineering and distribution, is essential for competitive success and long term survival. This course considers the operations from a managerial perspective. Key performance measures of operations (productivity, quality and response time) and further improvement in these is required on continual basis. At the end of the course students will have a fair understanding of the role of industry operations Manager and quantitative analysis for solving problems arising in the management of operations.

Pre-Requisites: None

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

1) Gain an understanding of principles of management, responsibilities of Operations manager;
2) Gain knowledge about Forms of Business Enterprises;
3) Gain knowledge about Product Development process;
4) Production Planning and Control;
5) Inventory Control;
6) Production Cost Concepts;
7) Supply chain management;
8) Entrepreneurship.

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.

Class room teaching is consequently supported by assignments / group discussions and student presentations in practical classes.

Contents:

UNIT I	12 Hours
Introduction: Definition and objectives of Industrial Engineering, Principles of management, Responsibilities of Operations manager, Productivity, types of productivity and enhancement; Industry location and Layout decision; Organization Structure; Product life cycle. **Forms of Business Enterprises:**, Introduction, Types of ownership, Sole proprietor enterprise, partnership firm, Joint Hindu family business, Joint stock company, classification of company, Comparison of public private and joint sector companies, Cooperative organisations, Types of cooperative societies, Comparison of different forms of business ownership.	
UNIT II	10 Hours
Product Design, Planning and Development: Introduction, Requirements of a good product design, product development approaches, Product development process. **Production Planning and Control:** Types and characteristics of production systems, Objectives and functions of Production, Planning & Control, capacity planning, Routing, sequencing problems, Scheduling, job shop scheduling problems, Loading, Gantt charts, Master Production Schedule Material requirement planning, MRP-II.	
UNIT III	12 Hours
Work System Design: Method study - Gilbreth's contributions; micro-motion study, SIMO charts, principles of motion economy; work measurement - stop watch time study, work sampling, standard data. **Inventory Control** - Introduction, Reasons for Holding Inventories, Relevant Costs of Inventories, EOQ models, Quantity Discount Models, Safety Stock, Inventory control system, Selective Control of Inventory ABC analysis. **Production Cost Concepts** – Introduction, Cost of Production, Classification and analysis of Cost, Break even analysis, Make and Buy.	
UNIT IV	8 Hours
Supply Chain Management: Introduction, Benefits of supply chain integration, Performance of supply chain, Aims of supply chain management, ERP versus SCM; Third party logistics and fourth party Logistics, vehicle routing concept, make or buy decision. **Entrepreneurship:** Introduction, Role of entrepreneurship in economy, Qualities of good entrepreneur, Role of motivation in entrepreneurship, Entrepreneurial failure and remedial measures.	

Text Books	
1.	Industrial Engineering and Management by Dr Ravi Shankar Galgotia Publications,2009
2.	Production and operations management - An Applied modern approach, Joseph S. Martinich, Wiley India edition- 2008.

Reference Books	
1.	Industrial Engineering and Management, Pravin Kumar, Pearson Education, 1stedition, ISBN- 9789332543560, 2015.
2.	Industrial Engineering and Management; B. Kumar, Khanna Publication, ISBN-8174091963, 2011.

Embedded System Design for Automation	
Course Code: MRA-217 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 3

Introduction: An embedded system is a combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. Industrial machines, agricultural and process industry devices, automobiles, medical equipment, cameras, household appliances, airplanes, vending machines and toys as well as mobile devices are all possible locations for an embedded system.

Course Objectives: The objective of this course is to give students knowledge about the basic functions, structure, concepts, programming and applications of embedded systems.

Pre-Requisites: Mechatronics systems and Applications (MRA 103)

Course Outcomes: Upon successful completion, the students will be able to:

- Understand the architecture of embedded systems;
- Make programs for different applications;
- Practically apply gained theoretical knowledge to design, analyze and implement embedded systems for application in industry automation.

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.
Class room teaching is consequently supported by practical sessions and assignments / projects given in labs during practical sessions.

Contents:

UNIT I	11 Hours
Fundamental design aspects: Embedded design life cycle. Product Specification of Hardware & Software, Partitioning, Design and Integration, Selection Process, Performance Selections and Evaluation of development Tools, Benchmarking, RTOS, Hardware Software co-design, Pre-Design and Memory organization, interfacing.	
UNIT II	11 Hours

Embedded controllers: Processor Selection for embedded systems and its issues. Overview of 8051 architecture, Atmel AVR controllers, Atom architecture in terms of architecture, programming, interfacing and applications.	
UNIT III	10 Hours
Introduction to ARM Architectures and Its Programming: Interrupt Service Routines Watchdog timers, Flash memory, Basic toolset, Host based debugging, Remote debugging, ROM emulators, Logic Analyzer, Caches, Computer Optimization, Statistical profiling, In circuit emulators, Buffer control, Real-Time trace, Hardware break points, Overlay memory, Timing Constraints, Usage Issues, Triggers. Comparison between ARM and Atom processors.	
UNIT IV	10 Hours
Interfacing and Application Development: Cortex M4/A0/Atom (E6xx) Architecture and Programming by using Atmel SAM4 L Starter Kit/ NXP LPC11U24 (mbed)/, Tools, remote compilation, debugging and testing. Interfacing of displays, keyboard, and sensors.	

Text Books	
1.	Andrew Sloss, Dominic Symes, Chris Wright, “ARM System Developer's Guide: Designing and Optimizing System Software”, The Morgan Kaufmann Series an imprint of Elsevier, 2009.
2.	William Hohl, “ARM Assembly Language: Fundamentals and Techniques”, CRC Press, 2012
Reference Books	
1.	Arnold S. Berger “Embedded System Design” CMP Books USA 2002
2.	David.E.Simon “An Embedded Software Primer”Pearson Education 2001
3.	Frank Vahid and Tony Gwargie “Embedded System Design “John Wiley & Sons 2002
4.	Steve Heath “Embedded System Design” Elserian Second Edition 2004 Petter Barry
5.	Peter Barry, Patrick Crowley “Modern Embedded Computing”2012.

Bio Sensors	
Course Code: MRA-219 Contact Hours: L-3 T-0 P-2 Course Category: DCC	Credits: 4 Semester: 3

Introduction: This course provides a concise overview of biosensor technology and its application in healthcare, food safety, environmental monitoring, and security. With fast growth in the field of biomedical engineering, there is demand of bio sensors and as such importance of this course. The theoretical and practical knowledge is required for construction, design, and manufacture of biosensors by using emerging materials and components.

Course Objectives: The overall target of the course is to give the student a thorough understanding of the fundamentals and applications of biosensor technology, together with an appreciation of its current and future impact on society. Following the course, the student should be able to design and construct a simple biosensor, know how to operate a biosensor in the laboratory and have an understanding of the manufacture, commercialization and use of biosensors for a variety of applications in the real world.

Pre-Requisites: Basic physics and basic chemistry along with basic Electronics and design and manufacturing subjects of mechanical engineering.

Course Outcomes: Upon successful completion, the students will be able to:

1. Describe the most commonly used biosensors today and their detection principles;
2. Explain how biosensors are used for different applications;
3. Describe and critically examine selected applications within the field of biosensors;
4. Propose a new type of biosensor for a given problem.

Pedagogy: Classroom teaching is supported by Whiteboard, blackboard, 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.
Class room teaching is consequently supported by practical sessions and assignments / projects given in labs during practical sessions.

Contents:

UNIT I **Introduction to biosensors**: The concept of Biosensor and their classification and biosensor Application. Selectivity, sensitivity, stability and response time. Detection by bio-catalytic or by binding event. Different transduction mechanisms in sensors. Surface characterization and modification. Coatings with membrane sensors.	11 Hours
UNIT II **Transducers:** Performance factors. Types of recognition layers. Examples and functioning of different kinds of biosensors. Optical, mechanical (e.g., micro-cantilever, piezo, SAW, etc.), electrochemical, FET, thermal, etc types of biosensors .Physiological and environmental Transducers/Sensors. Principles and general concepts. Static and dynamic parameters.	11 Hours
UNIT III **Analytical modelling of biosensors**: Biosensors stability. The evolution of the glucose biosensor. Last generation biosensors. Future prospects. Class project based on biosensor.	10 Hours
UNIT IV Case studies of essential devices /Study and application of some sensors.	10 Hours

Text Books	
1.	Handbook of biosensors and biochips: Marks, Robert S....et al.: John Wiley, 2007
2.	Biosensors: fundamentals and applications / edited by Anthony P.F. Turner, Isao Karube and George S. Wilson
Reference Books	
1	Engineering biosensors, kinetics and design applications by AjitSadana..San Diego, Academic Press, 2002
2	Biosensors by Tran Minh Canh. London. Chapman and Hall, 1993
3	Biosensors: theory and applications by Donald G. Buerk. Lancaster: Technomic Pub., 1993.
4	Biosensors By E hall
5	Applied biosensors / edited by Donald L. Wise. Boston: Butterworths, 1989
6	Biosensors and their applications by Victor C. Yang and That T. Ngo
7	Biosensors by Jon Cooper and Tony Cass
8	Journal papers from Biosensors and Bioelectronics, IEEE sensors journal and other journals in this domain

Multi-Body Dynamics	
Course Code: MRA-221 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 3

Introduction: Cars and robots are complex systems. They exhibit a complicated three-dimensional motion, which is difficult to treat by the fundamental mechanic's problem approach. Multiple degrees-of-freedom, complex constraints, three-dimensional rotations, coupled oscillations, and stability problems are among the complications that may occur. This course is designed to provided more dedicated and focused tools needed for analyzing these complex mechanisms.

Course Objectives: The overall target of the course is to give the student a thorough understanding of the tools needed to analyze complex mechanism problems, make use of Analytical as well as software for simulating the complex real-world dynamical systems.

Pre-Requisites: Basic courses in Mechanics, Linear Algebra and Calculus, and introductory kinematics and dynamics of mechanisms.

Course Outcomes: Upon successful completion, the students will be able to:

- Give an account of the most important results in the theory of multi-body dynamics;
- Formulate theoretical models for systems of connected rigid bodies and simple elastic bodies;
- Work on computer programmes used for analysis and further simulate the complex MBD problems.

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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.

Class room teaching is consequently supported by practical sessions and assignments / projects given in labs during practical sessions.

Contents:

UNIT I	11 Hours
Overview of kinematic loops, constraints, degrees of freedom: Links and joints; Open and Closed-kinematic chains; Kinematic constraints (Holonomic and non-holonomic); Independent coordinates; Degrees of freedom. **Review of dynamics for open and closed-loop chains:** Generalized coordinates; Euler Lagrange equations of motion; Newton's 2nd law; Euler's equations for rotational motion	
UNIT II	11 Hours
Computer-based approaches: Kane's equations of motion; Partial velocities; Orthogonal complement based approached like using Decoupled Natural Orthogonal Complement matrices. **Dynamic algorithms:** Inverse dynamics; Forward dynamics; Recursive algorithms; Use of software like ADAMS, Recur-Dyn, MATLAB- Sim Mechanics, ReDySim.	
UNIT III	10 Hours
Dynamics of closed-loop systems: Free-body diagrams; Tree-type systems; Cut-loop systems; Lagrange multipliers to represent cut-open joints; Dynamic algorithms for closed-loop systems. **ODE and DAE formulations:** Ordinary Differential Equations (ODE); Differential Algebraic Equations; Numerical instability; Stiff and non-stiff systems; Numerical algorithms to solve ODE and DAE equations.	
UNIT IV	10 Hours
Kinematic constraints of rigid and flexible systems: Discretization of deformation; Lagrange equations of motion; Inclusion of kinematic constraints due to joints. **Dynamics of flexible multi body systems, dynamic analysis using classical approximation, FEM:** Forward dynamics simulation of flexible body systems; Use of Finite Elements to represent deformations; Equations of motion; Use of software, e.g., ADAMS, RecurDyn.	

Text Books	
1.	Shabana, A., "Dynamics of Multi body Systems", Cambridge University Press, 2005
2.	Saha, S.K., "Introduction to Robotics", TMH, 2008
Reference Books	
1.	Chaudhary, H., Saha , S. K., "Dynamics and Balancing of Multi body Systems", Springer, 2009 Farid Amirouche Fundamental of Multibody Dynamics Theory and Applications Journal Papers on multibody dynamics from different journals

VLSI Design for Automation	
Course Code: MRA-223 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 3

Introduction: Automation industry is fast moving toward miniaturization. The knowledge in area of VLSI design is need of the hour for an automation engineer to stay with time.

Course Objectives: The objective of this course is to provide students with a sound knowledge of VLSI systems to understand processor architectures, memory organization, performance analysis, concepts and techniques for parallel processing, pipeline processing, high-speed synchronization design and system noise elimination.

Pre-Requisites: Basic understanding of circuits and Digital Electronics and Mechatronics systems and Applications (MRA 103)

Course Outcomes: Upon successful completion, the students will be able to:

1) Have an understanding of the characteristics of CMOS circuit construction and the comparison between different state-of-the-art CMOS technologies and processes
2) Mathematical methods and circuit analysis models in analysis of CMOS digital electronics circuits, including logic components and their interconnect;
3) Apply CMOS technology-specific layout rules in the placement and routing of transistors and interconnect, and to verify the functionality, timing, power, and parasitic effects.
4) Complete a significant VLSI design project having a set of objective criteria and design constraints.

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.

Class room teaching is consequently supported by practical sessions and assignments / projects given in labs during practical sessions.

Contents:

UNIT I	11 Hours
Introduction to VLSI: Manufacturing process of CMOS integrated circuits, CMOS n-well process design rules, packaging integrated circuits, trends in process technology.MOS transistor, Energy band diagram of MOS system, MOS under external bias, derivation of threshold voltage equation, secondary effects in **MOSFETS:** MOSFET scaling and small geometry effects, MOS capacitances, **Modeling of The Wire:** MOS transistors using SPICE, level I, II and equations, capacitance models. Interconnect parameters: capacitance, resistance and inductance. **Electrical wire models:** The ideal wire, the lumped model, the lumped RC model, the distributed RC model, the transmission line model, SPICE wire models	
UNIT II	11 Hours
MOS inverters: Resistive load inverter, inverter with n-type MOSFET load, CMOS inverter: Switching Threshold, Noise Margin, Dynamic behavior of CMOS inverter, computing capacitances, propagation delay, Dynamic power consumption, static power consumption, energy, and energy delay product calculations, stick diagram, IC layout design and tools.	
UNIT III	10 Hours
Designing Combinational Logic Gates in MOS and CMOS:MOS logic circuits with depletion MOS load. **Static CMOS Design:** Complementary CMOS, Rationed logic, Pass transistor logic, BiCMOS logic, pseudo nMOS logic, Dynamic CMOS logic, clocked CMOS logic CMOS domino logic, NP domino logic, speed and power dissipation of Dynamic logic, cascading dynamic gates. **Designing sequential logic circuits**: Timing matrices for sequential circuits, classification of memory elements, static latches and registers, the bistability principle, multiplexer based latches , Master slave Edge triggered register , static SR flip flops, dynamic latches and registers, dynamic transmission gate edge triggered register, the C2MOS register.	
UNIT IV	10 Hours
Registers: Pulse registers, sense amplifier based registers, Pipelining, Latch verses Register based pipelines, NORA-CMOS. Two-phase logic structure; **VLSI designing methodology:** Introduction, VLSI designs flow, Computer aided design technology: Design capture and verification tools, Design Hierarchy Concept of regularity, Modularity & Locality, VLSI design style, Design quality.	

Text Books	
1	Digital integrated circuits a design perspective by Jan M Rabaey, Anantha Chadrakasan Borivoje Nikolic, Pearson education, 2011.
2	CMOS digital integrated circuits by Sung MO Kang Yusuf Leblebici, Tata McGraw Hill Publication, 2002.
Reference Books	
1	Principle of CMOS VLSI Design by Neil E Weste and Kamran Eshraghian, Pearson education, 2000