Sanjeev Agrawal Global Educational (Sage) University, Bhopal

Master of Technology (Robotics &Mechatronics)
2 Years Degree Program

Program Educational Objectives (PEOs)

The Program MTech. **(Robotics & Mechatronics)** will develop and ability to identify and solve the real world problems related to various areas of Sciences. The course will:

- Expertise in analyzing real life problems in various Robotics & Mechatronics systems, giving appropriate solutions that are technically sound, economically feasible and socially acceptable.
- To provide a quality education for students entering the Robotics & mechatronics engineering profession or seeking careers in related fields
- Post Graduates will be engaged in ongoing learning and professional development through self study, continuing education in mechanical engineering and also in other allied fields.
- To disseminate technical information through scholarly publication, conferences and continuing education.
- Students will adopt ethical attitude and exhibit effective skills in communication, management, teamwork and leadership qualities.

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Program Outcomes (POs):

At the end of the Program a graduate will be able to

- Apply the knowledge of basic sciences and fundamental engineering concepts in solving engineering problems.
- Identify and define engineering problems, conduct experiments and investigate to analyze and interpret data to arrive at substantial conclusions.
- Propose an appropriate solution for engineering problems complying with functional constraints such as economic, environmental, societal, ethical, safety and sustainability.
- Perform investigations, design and conduct experiments, analyze and interpret the results to provide valid conclusions.
- Select/develop and apply appropriate techniques and IT tools for the design & analysis of the systems.
- Give reasoning and assess societal, health, legal and cultural issues with competency in professional engineering practice.
- Demonstrate professional skills and contextual reasoning to assess environmental/societal issues for

sustainable development.

- Demonstrate Knowledge of professional and ethical practices.
- Function effectively as an individual, and as a member or leader in diverse teams, and in multi-disciplinary situations.
- Communicate effectively among engineering community, being able to comprehend and write effectively reports, presentation and give / receive clears instructions.
- Demonstrate and apply engineering & management principles in their own / team projects in multidisciplinary environment.
- Recognize the need for, and have the ability to engage in independent and lifelong learning.

Master of Technology (Robotics & Mechatronics)
2 Years Degree Program
Curriculum Components

Components	Credits
Program Core (09Courses)	**30**
Program Electives (Discipline Specific Electives) (04Courses)	**12**
Generic Electives (01 Courses)	**02**
Project Based Learning (PBL)/MOOCs (04 courses)	**12**
Project (02 Courses)	**28**
Total	**84**

Sanjeev Agrawal Global Educational University (SAGE), Bhopal

School Of Engineering & Technology

M Tech (Robotics & Mechatronics)

First Year – Semester First																
Course Code	**Course Title**	**Contact Hours per Week**			**Credits**	**ETE Duration**	**Theory**						**Practical**			
		L	**T**	**P**			**MSE**	**ASG**	**TA**	**ATTD**	**ESE**	**Total**	**CE**	**ESE**	**Total**	**Grand Total**
MA20M101	Advanced Mathematics	3	1	-	4	3	30	05	05	10	50	100	-	-	-	100
RM20M101	Manufacturing Automation	3	1		4	3	30	05	05	10	50	100	-	-	-	100
RM20M102	Microprocessors & Micro Controllers	3	1	-	4	3	30	05	05	10	50	100	-	-	-	100
	DSE – I	3	-	-	3	3	30	05	05	10	50	100	-	-	-	100
	DSE – II	3	-	-	3	3	30	05	05	10	50	100	-	-	-	100
RM20M103	Mechatronics System Design Lab	-	-	4	2	2	-	-	-	-	-	-	20	30	50	50
RM20M104	Advance Machining Process Lab	-	-	4	2	2	-	-	-	-	-	-	20	30	50	50
PB20M101	Project Based Learning	-	-	4	2	2	-				-	-	50	50	100	100
-	-	Total			24	-	-					500			200	700

MSE- Mid Semester Exam, ASG- Assignment, TA- Teacher's Assessment, ATTD-Attendance, ESE- End Sem Exam ,CE-continuous Evolution

Scheme for MTech (Robotics & Mechatronics)

First Year – Semester Second																
Course Code	**Course Title**	**Contact Hours per Week**			**Credits**	**ETE Duration (Hrs.)**	**Theory**						**Practical**			
		L	**T**	**P**			**MSE**	**ASG**	**TA**	**ATTD**	**ESE**	**Total**	**CE**	**ESE**	**Total**	**Grand Total**
RM20M201	Drives &Control Systems for Automation	3	1	-	4	3	30	05	05	10	50	100	-	-	-	100
RM20M202	Embedded System Design	3	1		4	3	30	05	05	10	50	100	-	-	-	100
RM20M203	Design of Mechanism &Manipulators	3	1		4	3	30	05	05	10	50	100	-	-	-	100
	DSE – III	3	-	-	3	3	30	05	05	10	50	100	-	-	-	100
	DSE – IV	3	-	-	3	3	30	05	05	10	50	100	-	-	-	100
GE20M201	Generic Electives I	2	-	-	2	2	30	05	05	10	50	100	-	-	-	100
RM20M204	CAD/CAM & Robotics Lab	-	-	4	2	3	-	-	-	-	-	-	20	30	50	50
PB20M201	Project Based Learning	-	-	4	2	2	-				-	-	50	50	100	100
-	-	Total			24	-	-					600			150	750

MSE- Mid Semester Exam, ASG- Assignment, TA- Teacher's Assessment, ATTD-Attendance, ESE- End Sem Exam ,CE-continuous Evolutio

Scheme for MTech (Robotics & Mechatronics)

Second Year – Semester Third																
Course Code	**Course Title**	**Contact Hours per Week**			**Credits**	**ETE Duration**	**Theory**						**Practical**			
		L	**T**	**P**			**MSE**	**ASG**	**TA**	**ATTD**	**ESE**	**Total**	**CE**	**ESE**	**Total**	**Grand Total**
PB20M301	MOOC –1	-	-	8	4	-	-	-	-	-	-	-	50	50	100	100
PB20M302	MOOC - 2	-	-	8	4	-	-	-	-	-	-	-	50	50	100	100
RM20M301	Dissertation Phase-I	-	-	24	12	2	-				-	-	200	200	400	400
-	-	Total			20		-					-	-		-	600

MSE- Mid Semester Exam, ASG- Assignment, TA- Teacher's Assessment, ATTD-Attendance, ESE- End Sem Exam ,CE-continuous Evolution

Scheme for M.Tech (Robotics & Mechatronics)

Second Year – Semester Fourth																	
Course Code	**Course Title**	**Contact Hours per Week**			**Credits**	**ETE Duration**	**Theory**						**Practical**			
		L	**T**	**P**			**MSE**	**ASG**	**TA**	**ATTD**	**ESE**	**Total**	**CE**	**ESE**	**Total**	**Grand Total**
RM20M401	Dissertation Phase-II	-	-	32	16	2	-				-	-	250	250	500	500
-	-	Total			16		-					-	-		-	500

MSE- Mid Semester Exam, ASG- Assignment, TA- Teacher's Assessment, ATTD-Attendance, ESE- End Sem Exam ,CE-continuous Evolution

Master of Technology (Robotics & Mechatronics)
2 Years Degree Program

Distribution of credits across all components

SEM No.	Prog. Core	Discipline Specific Electives (DSE)	Generic Electives (GE)	Project Based Learning (PBL)/ MOOCs	Project	Total Credit
I.	16	6	-	2	-	**24**
II.	14	6	2	2	-	**24**
III.	-	-	-	8	12	**20**
IV.	-	-	-	-	16	**16**
Total	**30**	**12**	**02**	**12**	**28**	**84**

Master of Technology (Robotics & Mechatronics)

List of Program (Discipline Specific) Electives (DSE)

First Year – Semester One		
SN	Course Code	Course Title **(DSE-I)**
1.	RM20M105	Product Design & Development
2.	RM20M106	Wireless Sensor Networks
3	RM20M107	Fluid Power System Design
First Year – Semester One		
SN	Course Code	Course Title **(DSE-II)**
1.	RM20M108	Simulation, Modelling & Analysis
2.	RM20M109	Robot Dynamics & Analysis
3	RM20M110	Operations Management
First Year – Semester Second		
SN	Course Code	Course Title **(DSE-III)**
1.	RM20M205	Numerical methods & computer programming
2.	RM20M206	Micro-electro-mechanical systems
3.	RM20M207	Ultra-precision machining
First Year – Semester Second		
SN	Course Code	Course Title **(DSE-IV)**
1	RM20M208	Artificial Intelligence
2	RM20M209	Virtual Instrumentation
3	RM20M210	Metrology & Computer Aided Inspection

Generic Electives
List of Generic Electives

S.NO	Code	Nomenclature of the course	Offering School
1.	GE20M01	Java Programming	School of Engineering & Technology
2.	GE20M02	Python Programming	School of Advance Computing
3.	GE20M03	Matlab Programming	School of Engineering & Technology
4.	GE20M04	C++ Programming	School of Engineering & Technology
5.	GE20M05	R Programming	School of Advance Computing
6.	GE20M06	CAD/CAM Software	School of Engineering & Technology

Sanjeev Agrawal Global Educational (SAGE) University, Bhopal

Syllabus

For

M Tech

ROBOTICS & MECHATRONICS

I Semester

School of Engineering & Technology

M Tech (Robotics &Mechatronics Engineering)
Syllabus I Semester

Code	Advanced Mathematics	Total Lecture:45 Tutorial: 15
MA20M101		3-1-0=4

Course Objectives

This course is design to develop coherent understanding of various areas of Advanced Mathematics. Principle course objectives are:

- To introduce students to the theoretical distributions, sampling distributions and their applications
- To introduce the students to the solution of partial differential equation
- Demonstrate an understanding to the theory and applications of linear algebra
- To extend the concept of the computer algorithms related to dimensionality reduction and feature extraction.
- To introduce the concepts of Stochastic process and Markov process transition.

UNIT	Contents	Hours
1	Probability, compound probability and discrete random variable. Binomial, Normal and Poisson's distributions, Sampling distribution, elementary concept of estimation and theory of hypothesis, recurred relations.	10
2	Solution of Partial Differential Equation (PDE) by separation of variable method, numerical solution of PDE (Laplace, Poisson's, Parabola) using finite difference methods, Elementary properties of FT, DFT, WFT, Wavelet transform, Haas transform.	9
3	Finite differences: forward, backward and central difference operators, polynomial interpolation: equally spaced and unequally spaced data; Numerical Differentiation, Numerical integration- Trapezoidal and Simpson1/3rd and 3/8th rules; Initial value problems - Taylor series method, Euler and modified Euler methods, Runge- Kutta methods.	9
4	Solution of Linear systems– Gaussian elimination method, LU factorization method, Cholesky's factorization method. Linear least-squares problems - Normal equations, QR method (or Gram Schmidt Ortho- normalization), Singular value decomposition (SVD) for linear least-squares problems, numerical rank determination via SVD, Principal Component Analysis.	9
5	Stochastic process, Markov process transition probability transition probability matrix, just and higher order Markov process, Application	8

	of Eigen value problems in Markov Process, Markov chain. Queuing system, transient and steady state, traffic intensity, distribution queuing system, concepts of queuing models (M/M/1: Infinity/ Infinity/ FC FS), (M/M/1: N/ Infinity/ FC FS), (M/M/S: Infinity/ Infinity/ FC FS).	

Course Outcomes	
At the end of the course the students should be able to:	
CO1	Be able to understand probability, sampling distribution and discrete random variable.
CO2	Understand the terms and their applications of Solution of Partial Differential Equations
CO3	Understand the numerical methods and their use in obtaining approximate solutions to otherwise intractable linear/non-linear system of equations and differential equations.
CO4	Analyse the fundamental use of matrices in the computer algorithms related to dimensionality reduction and feature extraction.
CO5	Implement Stochastic process, Markov process transition probability transition probability matrix and Markov process.
Text Book	• S C *Gupta* & V K *Kapoor*, 2014, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, Delhi. • Gilbert Jimmie, 2010, Gilbert, Linear Algebra And Matrix Theory, Elsevier India. • Dr B S Grewal, 2014, Numerical Methods in Engineering & Science: With Programs in C, C++ & MATLAB, 10th Edition, Khanna Publishers.
Reference Books	• Rohatgi, V.K., and Saleh, A.K.Md. Ehsanes, 2009, An introduction to probability and statistics. Second Edition, Wiley India. • L. N. Trefethen and David Bau, 1997, Numerical Linear Algebra, SIAM, Philadelphia.

Code	Manufacturing Automation	Total Lecture:45 Tutorial: 15
RM20M101		3-1-0=4

Course Objectives:

To learn the concepts of automation systems in manufacturing sector.

- To be aware of intelligent machining operations.
- Acquire the fundamental concepts of automated flow lines and their analysis
- Illustrate adaptive control systems and automated inspection methods.

Unit	Contents	Hours
1	Automation :Introduction, automation principles and strategies, basic elements of advanced functions, levels modeling of manufacturing systems Computer Aided Process Planning Computer Aided process planning, Generative, variant, hybrid CAPP, Material requirement planning (MRP), Manufacturing resource planning (MRP II), production planning and control system, master production schedule, Capacity planning, Shop floor control.	10
2	Computer Aided Manufacturing Group Technology, Part family, Sensor technologies, Automated inspection and testing, Coordinate measuring machines, Machine vision, Rapid prototyping..	10
3	Automated handling and storage system Automated material handling systems – AGV, Transfer mechanism - Buffer storage – Analysis of transfer lines, Robots in material handling, Automated storage and Retrieval Systems (AS/RS) – carousel storage – Automatic data capture – bar code technology, Automated assembly systems.	9
4	Automated Control structures in Manufacturing systems Automated inspection and testing, Sensor technologies, Coordinate measuring machines, Machine vision, Group Technology, Part family, Programmable controllers.	8
5	Manufacturing support Systems Flexible manufacturing, Building blocks of FMS, FMS layout, FMS planning and implementation issues, Just-in-Time Manufacturing, lean manufacturing, agile manufacturing, Cellular manufacturing, Intelligent Manufacturing Systems Artificial Intelligence based systems, Knowledge - Based Systems, Expert Systems Technology, Agent Based Technology, Virtual Business, e-Commerce Technologies, Global Manufacturing Networks, Digital enterprise technologies. Introduction to PLM.	8

Course Outcomes

At the end of the course the students will be able to:

CO 1	Identify the basic components required for manufacturing systems automation

CO 2	Intend an automated material handling and inspection systems with robotics
CO 3	To know the fundamentals about smart manufacturing and Intelligent manufacturing• systems
CO 4	Realize the importance and potential of Sensor technologies in the context of manufacturing engineering.
CO 5	Interface sensor and actuator for a mechatronic system.
Text Books	• Mikell P. Grover, Automation, Production Systems and Computer Integrated Manufacturing , Fourth Edition, Pearson Education. • P. Radhakrishnan, S. Subramanyan, V. Raju, CAD/CAM/CIM , New age International
Reference Books	• Mikell P. Grover, Enory W. Jr Zimmers, CAD/CAM (2006), Pearson Education. • P. N. Rao, CAD/CAM: Principles and Applications (2010), Tata Mc Graw Hill. • Tien-Chein Chang, Richard A. Wysk, Hsu-Pin (Ben) Wang, Computer Aided Manufacturing (2009), Pearson Education.

Code	Microprocessors & Microcontrollers	Total Lecture:45 Tutorial: 15
RM20M102		3-1-0=4

Course Objectives:

- The Purpose of the course is to provide students with the Knowledge of Microprocessors and Microcontroller.
- To solve real world problems in an efficient manner, this course also emphasis on architecture, Programming and system design used in various day to day gadgets.
- Know the internal organization, addressing modes and instruction sets of 8085 processor.

UNIT	Contents	Hours
1	Introduction to Microprocessor 8085 Microprocessor Architecture and Its Operations, Memory, Input/Output (I/O), Microcomputer System, Interfacing Devices, Basic Instructions, Programming Techniques with Additional Instructions, Counter and Timing Delays, Stack and Subroutines, Code Conversion, BCD Arithmetic and 16-Bit, Data Operations, Software Development Systems and Assemblers.	10
2	8086 Microprocessor Architecture 8086 CPU Pins and Signals, Operating Modes, Minimum Mode, Maximum Mode, System Interrupt Configurations, Bus Timing Diagrams, Minimum Mode, and Maximum Mode.	9
3	8086 Assembly Language Instruction and Programming Instruction Set, Registers and Flags, General Purpose Registers, Pointer Registers, Index Registers, Segment Registers, Flags Register, How Instructions Affect the Flags Register, Addressing Modes, Program Memory Addressing Modes, Data Memory Addressing Modes, Addressing Mode Byte, Segment Override, Memory Addressing Tables, Instruction Set Mnemonics, Assemblers. Dependent Mnemonics, 8086	9
4	8051 Microcontroller 8051 Architecture Interfacing, 8051 Instruction Set, 8051 Application,	9
5	8085 / 8086 / 8051 Interfacing Interfacing Peripherals (I/O'S) & Applications, Parallel Input/Output and Interfacing Applications, Keyboard & display Interface, Interrupts Interfacing Data Converters, Programmable Interface Devices, General Purpose Programmable Peripheral Devices, Serial I/O & Data Communication Microprocessor Applications.	8

Course Outcomes

At the end of the course the students should be able to:

CO1	acquire knowledge about microprocessors and its need
CO2	write the programs using 8085 and 8086 microprocessor
CO3	know the internal architecture and interfacing of different peripheral devices with 8085 and 8086 microprocessor
CO4	design the system using 8051 processors
CO5	Understand 8085 / 8086 / 8051 Interfacing Interfacing Peripherals (I/O'S) & Applications.
Text Books	• Gaonkar, Ramesh, Microprocessor Architecture, Programming and Applications with the 8085, Penram International Publishing India Pvt, Ltd., 2005. • Hall, D.V, Microprocessor and Interfacing, Tata McGraw Hill Publishing Company, 2006 • Ayala, Kenneth J, The 8051 Microcontroller: Architecture, Programming, and Application, 2008. • Mckenzie, Scott, The 8051 Microcontroller, PHIs, 1995.
Reference Books	• Rafiquzzaman, M., Microprocessors and Microcomputer-Based System Design, CRC Press, 1995 • . Gibson, Glenn A, Liu, Yu-Cheng, Microcomputer Systems: The 8086/8088 Family Architecture Programming And Design, Pearson, 2001. • . Simon, David E, An Embedded System Primer, Pearson Education, 2005.

	Discipline Specific Elective-I	
Code	**Product Design & Development**	**Total Lecture:45**
RM20M105		**3-0-0=3**

Course Objectives:

- The focus of Product Design and Development
- It will help in integration of the marketing
- To design, and manufacturing functions of the firm in creating a new product
- Awareness of the role of multiple functions in creating a new product (e.g. marketing, finance, industrial design, engineering, production).

Unit	Contents	Hours
1	Introduction: Introduction to Product Design, Design by Evolution and Innovation, Essential factors of product design, Production consumption cycle, Flow and value addition in Production consumption cycle. Functional & Aesthetics Consideration: Basic design considerations, Role of Aesthetics in product design, Basic concept and elements of Visual design, Functional design practice.	10
2	Manufacturing Consideration: Producibility Requirements in the design of machine components, Forging design, Pressed component design, Design for machining, Ease of location and Clamping, Some additional aspects of production design, Design of powder metallurgical parts, Redesigning on basis of production consideration.	10
3	Legal & Economic Considerations: Product value, Design for safety, reliability and Environmental considerations, Economic analysis, profit and competitiveness, break even analysis, Economics of a new product design, Concurrent Design, Quality function deployment, Reverse engineering.	9
4	Value Engineering: Value, Nature and measurement of value, Maximum value, Normal degree of value, Importance of value, The value Analysis Job Plan, Creativity, Steps to problem solving and value analysis, Value Engg., Idea generation check list, Cost reduction, materials and process selection in value engineering.	8
5	Product Development: Definition and Objective, Role of designer in product development, Manufacturing & economic aspects of product development, Product promotion & development	8

Course Outcomes

At the end of the course the students will be able to:

CO 1	Competence with a set of tools and methods for product design and development.
CO 2	Confidence in your own abilities to create a new product.
CO 3	Awareness of the role of multiple functions in creating a new product (e.g. marketing, finance, industrial design, engineering, production).
CO 4	Ability to coordinate multiple, interdisciplinary tasks in order to achieve a common objective
CO 5	Reinforcement of specific knowledge from other courses through practice and reflection in an action-oriented setting. Enhanced team working skills
Text Boks:	• Kail T Ulrich and Steven D Eppinger, "Product Design and Development." • AK Chitale and Gupta, "Product Design and Engineering"
Reference Books:	• Niebel & Draper, "Product Design and Process Engineering" • Middendorf Marcel Dekker, "Design of Systems and Devices"

	Discipline Specific Elective-I	
Code	**Wireless Sensor Networks**	**Total Lecture:45**
RM20M106		**3-0-0=3**

Course Objectives:

- To introduce the characteristics, basic concepts and systems issues in Wireless sensor
- networks
- To illustrate architecture and protocols in wireless sensor networks
- To identify the trends and latest development of the technologies in the area
- To provide a broad coverage of challenges and latest research results related to the design and management of wireless sensor networks

Unit	Contents	Hours
1	Introduction, Applications of Wireless Sensor Networks, WSN Standards, IEEE 802.15.4, Zigbee. Network Architectures and Protocol Stack – Network architectures for WSN, classification of WSN, protocol stack for WSN. Wireless Transmission Technology and Systems Radio Technology, Available Wireless Technologies Wireless Sensor Technology Sensor Node Technology, Hardware and Software, Sensor Taxonomy, WN Operating Environment	10
2	Medium Access Control Protocols for Wireless Sensor Networks Fundamentals of MAC Protocols, MAC Protocols for WSNs, Contention-Based protocols: Power Aware Multi-Access with Signaling - Data-Gathering MAC, Contention-Free Protocols: Low Energy Adaptive Clustering Hierarchy, B-MAC, S-MAC. Dissemination Protocol for Large Sensor Network.	10
3	Deployment and Configuration Target tracking, Localization and Positioning, Coverage and Connectivity, Single-hop and Multi hop Localization, Self-Configuring Localization Systems. Routing Challenges and Design Issues in Wireless Sensor Networks, Routing Strategies in Wireless Sensor Networks, Routing protocols: data centric, hierarchical, location based energy efficient routing etc. Querying, Data Dissemination and Gathering.	9
4	Energy Efficiency and Power control Need for energy efficiency and power control in WSN, passive power conservation mechanisms, active power conservation mechanisms Operating Systems For Wireless Sensor Networks Operating System Design Issues, TinyOS, Contiki – Task management, Protothreads, Memory and IO management.	8
5	Sensor Network Platforms And Tools Sensor Node Hardware – Tmote, Micaz, Programming Challenges, Node-level Software Platforms, Node-level Simulators, State-centric Programming	8

Course Outcomes	
At the end of the course the students will be able to:	
CO 1	Architect sensor networks for various application setups.
CO 2	Explore the design space and conduct trade-off analysis between performance and resources.
CO 3	Determine suitable medium access protocols and radio hardware.
CO 4	Design of Power control mechanisim and apply.
CO 5	To have a basic knowledge of Sensor Network Platforms and to carry out various inspection in accordance with the established procedures.
Text Books	• Kazem Sohraby, Daniel Minoli, Taieb Znati, "Wireless Sensor Networks, Technology, Protocols and Applications", Wiley, 2007 • Holger Karl, Andreas Willig, "Protocols And Architectures for Wireless Sensor Networks", John Wiley, 2005
Reference Books	• Jun Zheng, Abbas Jamalipour, "Wireless Sensor Networks: A Networking Perspective", Wiley, 2009. • Ian F. Akyildiz, Mehmet Can Vuran, "Wireless Sensor Networks", Wiley, 2010 • Ibrahiem M. M. El Emary, S. Ramakrishnan, "Wireless Sensor Networks: From Theory to Applications", CRC Press Taylor & Francis Group, 2013

	Discipline Specific Elective-I	
Code	**Fluid Power System Design**	**Total Lecture:45**
RM20M107		**3-0-0=3**

Course Objectives:

- Course provides comprehensive introduction to fluid power system design including both hydraulics and pneumatics.
- To understand concepts and relationships surrounding force, pressure, energy and power in fluid power systems.
- To examine concepts centering on sources of hydraulic power, rotary and linear actuators, distribution systems, hydraulic flow in pipes, and control components in fluid power systems

Unit	Contents	Hours
1	Introduction to Fluid Power Definition- Hydraulics vs Pneumatics – ISO symbols - Application –Pascal's Law- Transmission and multiplication of force - Basic properties of hydraulic fluids - static head pressure-pressure loss – Power - absolute pressure and Temperature - gas laws- vacuum	10
2	Hydraulic and Pneumatic Power Supply Source Hydraulic Pump - graphic symbol- pump types -pump flow and pressure- pump drive torque and Power- pump efficiency –air compressor- graphic symbol-compressor types -compressor sizingvacuum pumps	10
3	Control Elements Directional control valves - Pressure control valves - Flow control Valves -electronic control components - Valve configurations, General valve analysis, valve lap, flow forces and lateral forces on spool valves. Series and parallel pressure compensation flow control valves. Flapper valve Analysis and Design, Time delay valve, Proportional and Servo valves.	9
4	Circuits DCV controlling single acting, double acting cylinder - Regenerative circuits, high low circuits, Synchronization circuits, and accumulator sizing. Intensifier circuits, Meter-in, Meter-out and Bleed-off circuits; Fail Safe and Counter balancing circuits- pressure intensifier circuitaccumulator circuits - AND and OR valve circuit Design of Circuits Design and analysis of typical hydraulic and pneumatic circuits - Design method consideration for sequential circuits-intuitive circuit design method-cascade method- sequential logic circuit design using KV method-compound circuit design-step counter design	8

5	Electro-Hydraulic and Electro-Pneumatic systems Electrical control of pneumatic and hydraulic circuits-use of relays, timers, counters, Programmable logic control of hydraulic and pneumatic circuits, PLC ladder diagram for various circuits, motion controllers, Servo systems – fundamentals. Applications in Assembly, Feeding, Metalworking, materials handling and plastic working. Fluid Power System Maintenance Introduction, Sealing Devices - Reservoir System - Filters and Strainers - Beta Ratio of Filters - Wear of Moving Parts - Gases in Hydraulic Fluids - Temperature Control - Troubleshooting	8

Course Outcomes	
At the end of the course the students will be able to:	
CO 1	Know the fundamental principles and analytical modeling of fluid power components and its symbols, circuits, and systems
CO 2	Acquire knowledge of the applications of fluid power in various engineering fields.
CO 3	To know the benefits and limitations of fluid power compared with other power transmission technologies
CO 4	Interface PLC with hydraulic and pneumatic systems.
CO 5	Ability to learn effective practices in uses fluid field and understand Electro-Hydraulic and Electro-Pneumatic systems .
Text Books	• James L.Johnson, Introduction to Fluid power(2003), Delmar Thomson Learning Inc. • James R. Daines, Fluid Power: Hydraulics and Pneumatics (2012), Goodheart-willcox Publishers
Reference Books	• . Ahmed Abu Hanieh, Fluid Power Control (2012), Cambridge International Science Publishing Ltd. • Anthony Esposito, Fluid Power with Applications (2010), Pearson Higher Ed. • M GalalRabie, Fluid power engineering (2009), Mc-Graw Hill.

	Discipline Specific Elective-II	
Code	**Simulation, Modeling & Analysis**	**Total Lecture:45**
RM20M108		**3-0-0=3**

Course Objectives:

- to provide an understanding of methods, techniques and tools for modeling,
- To Provide simulation and performance analysis of complex systems such as communication and computer networks.

Unit	Contents	Hours
1	Introduction: A review of basic probability and statistics, random variables and their properties, Estimation of means variances and correlation.	10
2	Physical Modelling: Concept of System and environment, Continuous and discrete systems, Linear and non-linear systems, Stochastic activities, Static and Dynamic models, Principles of modeling, Basic Simulation modeling, Role of simulation in model evaluation and studies, advantages of simulation	10
3	System Simulation: Techniques of simulation, Monte Carlo method, Experimental nature of simulation, Numerical computation techniques, Continuous system models, Analog and Hybrid simulation, Feedback systems, Computers in simulation studies, Simulation software packages.	9
4	System Dynamics: Growth and Decay models, Logistic curves, System dynamics diagrams. Probability Concepts in Simulation: Stochastic variables, discrete and continuous probability functions, Random numbers, Generation of Random numbers, Variance reduction techniques, Determination of length of simulation runs. Simulation of Mechanical Systems: Building of Simulation models, Simulation of translational and rotational mechanical systems, Simulation of hydraulic systems.	8
5	Simulation of Manufacturing Systems: Simulation of waiting line systems, Job shop with material handling and Flexible manufacturing systems, Simulation software for manufacturing, Case studies.	8

Course Outcomes

At the end of the course the students will be able to:

CO 1	Students will understand the techniques of modeling in the context of hierarchy of

	knowledge about a system and develop the capability to apply the same to study systems through available software.
CO 2	Students will learn different types of simulation techniques
CO 3	Students will learn to simulate the models for the purpose of optimum control by using software.
CO 4	Develop simulation term projects that address critical research issues and/or industrial applications in systems architecting and engineering.
CO 5	Overview current and future research in the disciplines, and the future directions of modeling and simulation in general.
Text Books	• System Simulation Geoffrey Gordon Prentice Hall • System Simulation: The Art and Science Robert E. Shannon Prentice Hall • System Modelling and Control J. Schwarzenbach and K.F. Gill Edward Arnold
Reference Books	• Modelling and Analysis of Dynamic Systems Charles M Close and Dean K. Frederick Houghton Mifflin • Simulation of manufacturing Allan Carrie John Wiley & Sons

	Discipline Specific Elective-II	
Code	**Robot Dynamics & Analysis**	**Total Lecture:45**
RM20M109		**3-0-0=3**

Course Objectives:

- To develop the student's knowledge in various robot structures and their workspace.
- To develop student's skills in performing spatial transformations associated with rigid body motions.
- To develop student's skills in perform kinematics analysis of robot systems.
- To provide the student with knowledge of the singularity issues associated with the operation of robotic systems.

Unit	Contents	Hours
1	Basic concepts, Robot anatomy, Robot configurations, Basic robot motions, Types of drives, Applications-Material handling, processing,-Assembly and Inspection, safety considerations. End effectors, Classification, Mechanical, Magnetic, Vacuum, Adhesive. Force analysis and Gripper design.	10
2	Sensors in robot systems, non optical and optical position sensors, Velocity and Acceleration, Range, Proximity, touch, Slip, Force, Torque sensors, Machine vision system, Image components, Representation, Hardware , Picture coding , Object recognition and categorization - Software consideration,	10
3	operations - Translational transformations and Rotational transformations, Properties of transformation matrices-Homogeneous transformations and Manipulator, Robot kinematics, Forward solution, Inverse solution , Control system concepts, Analysis , control of joints ,Adaptive and optimal control ,Trajectory Planning,	9
4	Robot Dynamics, Langragian formulation, D Alemberts principle Robot programming Methods - Robot programming languages - VAL Language,	8
5	Computer controller and Robot communication, Economics of Robots, Telechiric robots.	8

Course Outcomes

At the end of the course the students will be able to:

CO 1	Comprehensive fundamental and technical knowledge of Robotics
CO 2	Ability to apply computing of design criteria's of robot elements
CO 3	Ability to apply the knowledge of specifying the robot elements and selection of robots
CO 4	Ability to analyze robots through Kinematic and Dynamic study & its programming ea.
CO 5	Ability to learn effective practices in uses of robots, robot economics and novel advancements in this ar
Text Books	• M. P. Grover, M. Weiss, R. N. Nagel, N. G. Odrey, : Industrial Robotics Technology, Mc Graw Hill book Co. 1995 • Robert J. Schilling, Fundamentals of Robotics-Analysis and Control, Prentice Hall India, 1990. • Fu K.S., Gonzalez R.C.., and Lee C.S.G., "Robotics control, sensing, vision, and intelligence ", McGraw-Hill Book Co., 1987.
Reference Books	• Klafter R.D., Chmielewski T.A. and Negin M., " Robot Engineering An Intergrated approach ", Prentice Hall of India, New Delhi, 1994. • Deb S.R., "Robotics Technology and Flexible Automation ", Tata McGraw-Hill Publishing Co., Ltd., 1994.6. Craig J.J., • "Introduction to Robotics Mechanics and Control", Addison-Wesley, 1999

	Discipline Specific Elective-II	
Code	**Operations Management**	**Total Lecture:45**
RM20M110		**3-0-0=3**

Course Objectives:

- To develop an understanding of how the operations, have strategic importance and can provide a competitive advantage in the workplace.
- To understand the relationship between operations and other business functions.
- To impart concepts of operation management and product life cycle. operation management engineering through the use of analytical techniques, experiments, computer simulation methods, and other modern engineering tools.

Unit	Contents	Hours
1	Operations Management (OM): Definition, history, industrial and IT revolution (ERP); tangible and service products continuum, employment shift from agriculture, manufacturing to service; customer orientation; basic process formats on product volume-variety graph; concept of raw process time, critical WIP, bottle neck thruput and cycle-time with example of Penny-Fab-1,2; Little's law, best and worst case performance, thruput and cycle time formula in practical-worstcase; criteria of performance, decision area, business strategy, environment scan, SWOT, Porters' five forces, core competency, competitive priorities of cost, quality, time and flexibility, order winners; production strategy of Make To Order-MTO, MTS and ATO (assemble to order); productivity, standard of living and happiness.	10
2	Product:-Life Cycle and PLC management; design steps, evolution and innovation, traditional v/s concurrent design, form and functional design, simplification and standardization, differentiation/ mass customization, modular design, design for mfg and environment (DFM, DFE), technologies used in design. Service characteristics and classification based on peoplethings v/s direct-indirect service actions, service triangle of customer, provider and system; technical and functional (delivery) service quality and other service performance factors, Valerie's service quality model; globalization of services	10
3	Processes: transformation and value addition, selection based on cost, quality and flexibility considerations; reliability, failure density and hazard rate graphs for constant hazard bath-tub curve, series and parallel components, MTBF; availability and maintainability, preventive maintenance, TPM; value analysis; replacement models; Quality-definition, Taguchi loss function, cost of quality, chain action of improving quality to productivity to motivation and low cost; product and process specs; the funnel-marble experiment and variance reduction, process capability, six sigma and its implementation by	9

	DMAIC, QFD, TQM and ISO-9000.	
4	Plant-facilities: Impact of organization strategies on choice of region and site, existing or new organization, decision-affecting factors for location, load distance, dimensional and factor analysis methods, Brown-Gibson model, foreign locations, non-profit govt. services (health, school) locations. facility layout objectives and factors, basic layouts, merits and optimization; subjective relationship ranking method, computer programs CRAFT and 3-d modeling; problems of inventories flow and operators in process layout and inflexibility in product layout, flexible cellular layout, group technology; capacity and equipment selection, importance of spare capacity to reduce Q-length and cycle time.	8
5	Programs/ procedures of production control (PPC): corporate and production planning process, aggregate plan, master production schedule and material planning; matching supply to demand fluctuations over time horizon, Forecasting elements, time series, regression, causal and Delphi methods; use of LP in aggregate plan and HMMS model, assembly line balancing, elemental task, station time and cycle time, balance delays; sequencing, Johnson method for njob 2/3 m/c, NP hard job-shop sequencing, heuristic dispatch rules; synchronous mfg, TOC, drum-buffer-rope and focus on bottleneck as control point; JIT lean mfg, Kanban and CONWIP shop floor controls, Kaizen.	8

Course Outcomes	
At the end of the course the students will be able to:	
CO 1	Identify the elements of operations management and various transformation processes to enhance productivity and competitiveness.
CO 2	Analyze and evaluate various facility alternatives and their capacity decisions, develop a balanced line of production & scheduling and sequencing techniques in operation environments
CO 3	Develop aggregate capacity plans and MPS in operation environments.
CO 4	Plan and implement suitable materials handling principles and practices in the operations.
CO 5	Plan and implement suitable quality control measures in Quality Circles to TQM.
Text Books	• Chary SN; Production and Operations Management; TMH • Hopp W and Spearman M; Factory Physics; TMH • . Gitlow Howard et al; Quality Management; TMH • Stevenson W J; Operations Management; TMH
Reference Books	• Khanna RB; Production and Operations Management; PHI • Vollman, Berry et al; Manufacturing planning and control for SCM; TMH. • Chase Richard B et al; Operations management; SIE-TMH • . Adam EE and Ebert RJ; Production and Operations Management Concepts…; PHI Learning

Code	Mechatronics System Design Lab	Practical:30
RM20M103		0-0-4=2
	Contents	Hours
1	Calibration of flow meters.	
2	Calibration of Thermocouples/ RTD.	
3	Study of Load Cells.	
4	Vibration measurement using accelerometers.	
5	Displacement measurement/ level measurement.	
6	Verification of P, P+I, P+D, P+I+D control actions.	
7	Study of XY position control systems.	
8	Study of linear conveyor control system.	
9	Study of rotary table positioning systems.	
10	Study of different switches and relays.	
11	Study of Microcontrollers	
12	Analysis of control system using software like MATLAB/SIMULINK or equivalent.	
13	Development of ladder diagram/programming PLC for level control, position control	

Code	Advance Machining Process Lab	Practical:30
RM20M104		**0-0-4=2**
Contents		
1	Machining and material removal using EDM machine	
2	To study various applications of Electrochemical Machining process	
3	To study generation and control of electron beam for machining application	
4	Machining of Turbine blades using EBM and ECM	
5	To study Hybrid Unconventional Machining Process	
6	To study Magnetic Abrasive finishing Process	
7	To study Economic Considerations of different Unconventional Machining Process	
8	To study Abrasive water jet machining process	
9	Experiment on sliding wear test rig	

Code	Project Based Learning I	Practical:30
PB20M101	0-0-4=2	
	Contents	**Hours**
	In this course we have only practical part and student are allowed to devlop small project on the basis of the knowledge .They have required however ,if a student show interest in the basis technology of the Computer Science/Electronics/Mechanical/Civil Engineering. Then appropriate guidance will be given by relative faculty member	30

Sanjeev Agrawal Global Educational (SAGE) University, Bhopal

Syllabus

For

M.Tech

ROBOTICS & MECHATRONICS

II Semester

School of Engineering & Technology

MTech(Production Engineering)

Syllabus-II Semester

Code	Drives & Control Systems For Automation	Total Lecture:45 Tutorial: 15
RM20M201		**3-1-0=4**

Course Objectives:

- To understand the basic concepts of different types of electrical machines and their performance.
- To know the different methods of starting D.C motors and induction motors.
- To introduce the controllers for automation.

Unit	Contents	Hours
1	Introduction: Working principle of synchronous, Asynchronous & stepper motors, Difference betwe Induction and servo motors, Torque v/s speed characteristics, Power v/s. Speed characteristics, Vecto induction motors, Concepts of linear and frameless motors, Selection of feedback system, Duty cycle control, Flux Vector control.	10
2	Industrials Drives: DC and AC motors operation and selection, method of control and application of brushless DC motor, PMSM, stepper motor, A.C servomotor, selection criteria for servo motor and servo amplifier, universal motor, electric drive, types of industrial drives, the characteristics of drive, advantages of drives over other prime movers, motor rating, heating effects, electric braking, rheostatic and regenerative braking principles in power converters	10
3	Motion laws for rotary and linear systems: converting rotary to linear system, conceptsand principles of ball screws, rack and pinion, belt and pulley, chain drives, gear drives, Selection of converting systems, Dynamic response gearing, and control approaches ofRobots, Control loops using Current amplifier	9
4	Introduction to Programmable Logic Controllers: Definitions of PLC, basic structure ofPLC, working principles, data storage methods, inputs / outputs flag processing's, types of variables, definition of firmware, software, programming software tool and interfacing with PC (RS232 & TCP-IP), methods of PLC programming (LD, ST, FBD & SFC), function blocks logical / mathematical operators & data types, array & data structure, PID, types of tasks and configuration, difference between relay logic and PLC, selection of PLC controller	8
5	Logic, instructions & Application of PLC: What is logic, Conventional Ladder v/s PLCladder, series and parallel function of OR, AND, NOT logic,	8

	Ex Or logic, Analysis of rung. Timer and Counter Instructions; on delay and Off delay and retentive timer instructions, PLC counter up and down instructions, combining counters and timers, Comparison and data handling instructions, Sequencer instruction, Visualization Systems, Types of visualization system, PC based Controller, Applications of HMI's, and Interfacing of HMI with	

Course Outcomes

At the end of the course the students will be able to:

CO 1	Explain the basic concepts of different types of dc generators and their performance
CO 2	Evaluate the performance of different dc motors and their starting methods
CO 3	Analyze the performance of transformer and induction motor
CO 4	Explain about Constant voltage and Instrument transformers
CO 5	Compare types of stepper motors and their control, introduce and choose the controllers for automation
Text Books	• Process Control Instrumentation Technology, Johnson Curties, Prentice hall of India, 8th edition • Andrew Parr, Industrial drives, Butterworth – Heineamann • G.K.Dubey.Fundamentals of electrical drives • Programmable Logic Controllers by W.Bolton
Reference Books	• Introduction to Programmable Logic Controllers by Garry Dunning, 2nd edition, Thomson, ISBN:981-240-625-5 • Instrumentation Engineers Hand Book - Process Control, Bela G Liptak, Chilton book company, Pennsylvania • A.E. Fitzerald ,C.Kingsley and S.D Umans, Electric Machinery - McGraw Hill Int. Student edition • S.K.Pillai. A First course on electric drives –Wiley Eastern 1990 • Programmable Logic Controllers by Hugh Jack.

Code	Embedded System Design	Total Lecture:45 Tutorial: 15
RM20M202		3-1-0=4

Course Objectives:

- To introduce the Building Blocks of Embedded System
- To Introduce Bus Communication in processors, Input/output interfacing.
- To impart knowledge in various processor scheduling algorithms.
- To introduce Basics of Real time operating system and example tutorials to discuss on
- To introduce one real time operating system tool.

UNIT	Contents	Hours
1	Introduction to embedded system : Background and History of Embedded System, Defination and Classification, Programming language for embedded system: desirable characterstic of programming language for embedded system, low-level versus high-level language, main language implementation issue : control, typing. Major programming languages for embedded systems.Embedded System on a Chip (SOC) and the use of VLSI designed circuits	10
2	Processor and Memory Organization : Structural units in processor, Processor selection for an embedded system, Memory devices, Memory selection, Allocation for memory to program segments and blocks and memory map of a system, DMA, Interfacing Processor. I/O Devices-Device I/O types and examples V Synchronous – Iso-synchronous and Asynchronous Communication from serial devices – Examples of internal serial-communication devices –UART and HDLC –Parallel Port Devices –Sophisticated interfacing features in Device/ports –Timer and Counting Device	10
3	Microcontroller : Introduction to microcontrollers, Evolution, Microprocessors vs Microcontrollers, MCS-51 Family Overview, Important Feature, Architecture. 8051 Pin functions,Architecture, Addressing Modes, Instruction set, Instruction Types	9
4	Programming : Assembly Programming . Timer Registers, Timer modes, Overflow flags, clocking sources, timer counter interrupts, baud rate generation. Serial port register, mode of operation, initialization,accessing, multiprocessor communications, serial	8

	port baud rate	
5	Interrupts: Interrupt Organisation, Processing interrupts, Serial port interrupts, External interrupts, interrupt service routines. Microcontroller specification, Microcontroller design, testing, timing subroutines, look up tables, serial data transmission	8
Course Outcomes		
At the end of the course the students should be able to:		
CO1	Acquire a basic knowledge about fundamentals of microcontrollers.	
CO2	Acquire a basic knowledge about programming and system control to perform a specific task.	
CO3	Acquire knowledge about devices and buses used in embedded networking.	
CO4	Develop programming skills in embedded systems for various applications.	
CO5	Acquire knowledge about basic concepts of circuit emulators.	
Text Books	• JohnB.Peatman, "Design with PIC Microcontroller",Pearson Pub 2. Predko, "programming and customizing the 8051 microcontroller " , TMH.	
Reference Books	• Mazidi, "The 8051 microcontroller and embedded system" ,Pearson Pub. • Deshukh, "Microcontroller" ,TMH.	

Code	Design Of Mechanism & Manipulators	Total Lecture:45 Tutorial: 15
RM20M203		3-1-0=4

- To develop skills for designing and analyzing linkages, cams, gears and other mechanisms.
- To develop skills for use of mathematics software and for writing computer programs to solve kinematics problems.
- To provide a foundation for the study of machine design.

Unit	Contents	Hours
1	Mobility analysis, Degree of Freedom (DOF), Mixed Mobility, Total, Partial and Fractional DOF, Closed and Open Chain Systems, Application of D-H representation for 1) Kinematic parameter tables for standard robot structures like.	10
2	Link coordinate diagram and arm matrix of SCARA, Alpha-II, PUMA articulated robot, standard robot, polar frame, structure robot, Enter transform solution, Arm matrix of standard Robots, Polar frame, structure robots	10
3	Structural Analysis and Synthesis of mechanisms, Alternative design solutions; Coding, evaluation and selection of optimum mechanism. Type synthesis, number synthesis and design of mechanisms. Indexes of merit; Graphical, Algebraic and Optimization techniques, Matrix methods of design and analysis; Design of function, Path and Motion Generators; Structural and Mechanical error; Design and Analysis using software like ADAMS.	9
4	Manipulators- Classifications, actuation and transmission systems; Coordinate Transformation – DH notations, Inverse and Forward kinematics, Manipulator dynamics from Lagrangian and Newtonian point of view.	8
5	Forces in Manipulator, manipulate Dynamics, selecting of robots for Robot Application Reliability of Robotic & Automation systems and their evaluation.	8

Course Outcomes

At the end of the course the students will be able to:

CO 1	Ability to apply the principles of balancing of masses to various links, mechanisms and engines
CO 2	Ability to conduct static and dynamic force analysis and equilibrium of forces for mechanical systems
CO 3	Ability to study the various principles of vibrations of different systems
CO 4	Select appropriate actuation and transmission systems
CO 5	Analyse forces in Manipulator, Automation systems and their evaluation.
Text Books	• Andeen, G.B., "Robort Design Hand Book", SRI International, McGraw Hill, • Craig, J.J., "Introduction to Robotics", Mechanics and Control, Addison Wesley • Spong, M., and Vidyasagar, M. "Robot Dynamics and Control", John Wiley, NY, 1989.
Reference Books	• Venkataraman. S.T., and liberall. T., "Dextrous Robot Hands", S • AppuKuttan, "Robotics", I.K. International Publishing house

	Discipline Specific Elective-III	
Code	**Numerical Methods & Computer Programming**	**Total Lecture:45**
RM20M205		**3-0-0=3**

Course Objectives:

- To provide suitable and effective methods called Numerical Methods, for obtaining approximate representative numerical results of the problems.
- To solve problems in the field of Applied Mathematics, Theoretical Physics and Engineering which requires computing of numerical results using certain raw data.
- To solve complex mathematical problems using only simple arithmetic operations. The approach involves formulation of mathematical models of physical situations that can be solved with arithmetic operations.
- To deal with various topics like finding roots of equations, solving systems of linear algebraic equations, interpolation and regression analysis, numerical integration & differentiation, solution of differential equation, boundary value problems, solution of matrix problems.

Unit	Contents	Hours
1	Introduction: Working principle of synchronous, Asynchronous & stepper motors,Difference between I and servo motors, Torque v/s speed characteristics, Power v/s. Speed characteristics, Vector duty inductio Concepts of linear and frameless motors, Selection of feedback system, Duty cycle, , V/F control, Flux control.	10
2	Industrials Drives: DC and AC motors operation and selection, method of control and application of brushless DC motor, PMSM, stepper motor, A.C servomotor, selection criteria for servo motor and servo amplifier, universal motor, electric drive, types of industrial drives, the characteristics of drive, advantages of drives over other prime movers, motor rating, heating effects, electric braking, rheostatic and regenerative braking principles in power converters.	10
3	Motion laws for rotary and linear systems: converting rotary to linear system, conceptsand principles of ball screws, rack and pinion, belt and pulley, chain drives, gear drives, Selection of converting systems, Dynamic response gearing, and control approaches of Robots, Control loops using Current amplifier	9
4	Introduction to Programmable Logic Controllers: Definitions of PLC, basic structure ofPLC, working principles, data storage methods, inputs / outputs flag processing's, types of variables, definition of firmware, software, programming software tool and interfacing with PC (RS232 & TCP-IP), methods of PLC programming (LD, ST, FBD & SFC), function	8

	blocks logical / mathematical operators & data types, array & data structure, PID, types of tasks and configuration, difference between relay logic and PLC, selection of PLC controller	
5	Logic, instructions & Application of PLC: What is logic, Conventional Ladder v/s PLCladder, series and parallel function of OR, AND, NOT logic, Ex Or logic, Analysis of rung. Timer and Counter Instructions; on delay and Off delay and retentive timer instructions, PLC counter up and down instructions, combining counters and timers, Comparison and data handling instructions, Sequencer instruction, Visualization Systems, Types of visualization system, PC based Controller, Applications of HMI's, and Interfacing of HMI	8

Course Outcomes

At the end of the course the students will be able to:

CO 1	Familiar with finite precision computation.
CO 2	Familiar with calculation and interpretation of errors in numerical method. 6. Familiar with programming with numerical packages like MATLAB
CO 3	Familiar with numerical integration and differentiation, numerical solution of ordinary differential equations
CO 4	Apply Numerical analysis which has enormous application in the field of Science and some fields of Engineering.
CO 5	Familiar with numerical solutions of nonlinear equations in a single variable
Text Books:	• .Process Control Instrumentation Technology, Johnson Curties, Prentice hall of India, 8th edition • Andrew Parr, Industrial drives, Butterworth – Heineamann • .G.K.Dubey.Fundamentals of electrical drives • Programmable Logic Controllers by W.Bolton
Reference Books:	• Introduction to Programmable Logic Controllers by Garry Dunning, 2nd edition, Thomson, ISBN:981-240-625-5 • Instrumentation Engineers Hand Book - Process Control, Bela G Liptak, Chilton book company, Pennsylvania .A.E. Fitzerald ,C.Kingsley and S.D Umans, Electric Machinery - McGraw Hill Int. Student edition • S.K.Pillai. A First course on electric drives –Wiley Eastern 1990 • Programmable Logic Controllers by Hugh Jack.

	Discipline Specific Elective-III	
Code	**Micro-Electro-Mechanical Systems**	**Total Lecture:45**
RM20M206		**3-0-0=3**

Course Objectives:

- Students will be introduced to technology for development of micro electromechanical systems
- Student are exposed to microsystem fabrication process and manufacturing.
- Students are taught principal of microsystem and Micro manufacturing

Unit	Contents	Hours
1	Overview of MEMS and Microsystems: MEMS and Microsystems, Microsystems and Microelectronics, Microsystems and miniaturization, Application of Microsystem. Working Principles of Microsystem: Microsensors- Acoustic wave sensors, biomedical sensors and bio sensors, chemical sensors, optical sensors, pressure sensors, thermal sensors. Microactuation- actuation using thermal forces, actuation using shape-memory alloys, actuation using piezoelectric crystals, actuation using electrostatic forces. MEMS and Micro actuators- Micro grippers, micromotors, microvalves, micropumps, microaccelerometers, Microfluidics.	10
2	Materials for MEMS and Microsystems: substrates and wafers, active substrate materials, silicon as a substrate material- the ideal substrate for MEMS, single crystal silicon and wafers, crystal structure, the miller indices, mechanical properties of silicon. Silicon compounds- silicon dioxide, silicon carbide, silicon nitride, polycrystalline silicon Silicon piezoresistors, Gallium arsenide, polymers for MEMS and Microsystems, conductive polymer, the Langmuir-Blodgett film, packaging materials.	10
3	Microsystems Fabrication Processes: Photolithography-photo resists and application, light sources, photo resist development, photo resist removal and post baking. Ion implantation, diffusion, oxidationthermal oxidation, silicon dioxide, thermal oxidation rates, oxide thickness by color ; Chemical vapor deposition- working principle of CVD, chemical reaction s in CVD, rate of deposition, enhanced deposition ; physical vapor deposition- sputtering ;Deposition by epitaxy ; Etching- Chemical etching, plasma etching	9
4	Micro manufacturing: Bulk Manufacturing- overview of etching, isotropic and anisotropic etching, wet etchants; etch stop, dry etching, and comparison of wet versus dry etching. Surface micromachining- general description, process in general, mechanical problems associated with	8

	surface micromachining. The LIGA Process- general description of the LIGA process, materials for substrates and photo resists, electroplating. The SLIGA process.	
5	Microsystems Design: Design Considerations- Design constraints, selection of materials, selection of manufacturing processes, selection of signal transduction, electromechanical system and packaging Process design- photolithography, thin film fabrications, geometry shaping, Mechanical design- thermo mechanical loading, thermo mechanical stress analysis, dynamic analysis, interfacial fracture analysis. Design of micro fluidic network systems- fluid resistance in microchannels, capillary electrophoresis network systems, mathematical modeling of capillary electrophoresis network systems	8

Course Outcomes

At the end of the course the students will be able to:

CO 1	Students will explain MEMS Technology, Present, Future and Challenges.
CO 2	Students will be able to explain micro sensors, micro-actuators, their types and applications
CO 3	Students will be able to explain micro sensors, micro-actuators, their types and applications
CO 4	Students will be able to explain about fabrication processes for producing micro-sensors and actuators.
CO 5	They will also be able to apply Reliability, and Failure Analysis Testing
Text Books	• Tai Ran Hsu,MEMS& Micro systems Design and Manufacture Tata McGraw Hill, NewDelhi • An Introduction to Microelectromechanical Systems Engineering By Nadim Maluf, Kirt Williams Artech House
Reference Books	• Franssila Sami, Introduction to Micro Fabrication, WILEY, 2nd Edition, 2010 • NadimMaluf, An Introduction to Microelectromechanical Systems Engineering, Artech House, 3 rd edition, 2000. • Mahalik Nitaigour Premchand, MEMS, McGraw-Hill, 2007.

	Discipline Specific Elective-III	
Code	**Ultra-Precision Machining**	**Total Lecture:45**
RM20M207		**3-0-0=3**

Course Objectives:

- This course will give you the basic precision engineering principles
- This course will give you state-of-the-art concepts for designing higher accuracy into your machines,
- This course will give you Nano-processing systems whether they are ultra-precision or otherwise

Unit	Contents	Hours
1	Introduction: Definition of ultra-precision machining; Taniguchi curves of evolution of accuracy in the twentieth century; definition of Nanotechnology; Positional accuracy of today's manufacturing processes and equipment; Deviational and scattering errors in achieving nanometric resolution. Atomic-bit and atomic cluster processing methods: Nano-mechanical, nano-physical and nano-chemical and –electrochemical processes, their capabilities and advantages.	10
2	Mechanism of nano-mechanical processing of atomic clusters: Processing stress, breaking stress and processing energy density; Concept of size effect in mechanical processing; thresholds of specific energy; Nano-machining, abrasive and adhesive processing, theories of nanometric processing of ductile and brittle materials, and polymers; Failure and fracture under uniform and localized loading; Atomic-bit processing and lattice defect density, theories of nano-indentation and scratching.	10
3	Mechanism of nano-physical and -chemical processing of atomic-bits: Scanning tunneling effect, directional photon, electron and ion beam processing, plasma surface processing, molecular beam processing; Principles of chemical and electro-chemical processing, equilibrium of chemical and electro-chemical reactions.	9

4	Nano-processing systems (Nano-mechanical processing) - Diamond turning: Soft metal single-point diamond turning technology, the ultra-precision CNC machine, plane and spherical mirrors machining; Nano-grinding: technology and requirements, concept of critical depth of cut, size-effect in form and fine grinding, Elid grinding, Elastic emission grinding; mechano-chemical polishing of Si wafers, principles and models; Ultra-precision polishing: Principles of ultra-precision polishing of block gauges, balls and aspherical lenses.	8
5	Nano-processing systems (Nano-physical and –electrochemical processing): Photo beam processing: Thermal and chemical processes in photon beam ablation; Electron and ion beam processing: removal mechanism in electron and ion beam processing, abilities and limitations; scanning tunneling microscope (STM) processing; Chemically reactive milling and etching processes, Chemically reactive deposition and consolidation, electrochemical machining and deposition processes. Nano-measuring systems: In-situ processes, mechanical and optical measuring systems, Scanning probe and image processing systems.	8

Course Outcomes	
At the end of the course the students will be able to:	
CO 1	Define ultra-precision machining, Nano-mechanical, Nano-chemical, Nano-physical and electro-chemical machining.
CO 2	Understand mechanism of Nano machining in atomic bit and cluster, Nano indentation and scratching.
CO 3	Study and understand mechanism of directional photon, electron, plasma, molecular beam processing.
CO 4	Explain mechanism of diamond turning and ultra-precision polishing and grinding
CO 5	Understand Nano physical and electrochemical processes. Study mechanical and optical measuring system for Nano machining
Text Books	• N. Taniguchi, Nanotechnology: Integrated Processing Systems for Ultra-precision and Ultra-fine Products, Oxford University Press Inc., NY, • J. McGeough, Micromachining of Engineering Materials, Marcel Dekker, Inc., NY,
Reference Books	• M. C. Shaw, Principles of Abrasive Processing, Oxford: Clarendon Press,

	Discipline Specific Elective-IV	
Code	**Artificial Intelligence**	**Total Lecture:45**
RM20M208		**3-0-0=3**

Course Objectives:

- To be familiar with the applicability, strengths, and weaknesses of the basic knowledge representation,
- To problem solving, machine learning, knowledge acquisition and learning methods in solving particular engineering problems.

Unit	Contents	Hours
1	Overview: foundations, scope, problems, and approaches of AI. Intelligent agents: reactive, deliberative, goal-driven, utility-driven, and learning agents Problem-solving through Search: forward and backward, state-space, blind, heuristic, problemreduction, A, A*, AO*, minimax, constraint propagation, neural, stochastic, and evolutionary search algorithms, sample applications.	10
2	Knowledge Representation and Reasoning: ontologies, foundations of knowledge representation and reasoning, representing and reasoning about objects, relations, events, actions, time, and space; predicate logic, situation calculus, description logics, reasoning with defaults, reasoning about knowledge, sample applications..	10
3	Planning: planning as search, partial order planning, construction and use of planning graphs Representing and Reasoning with Uncertain Knowledge: probability, connection to logic, independence, Bayes rule, Bayesian networks, probabilistic inference, sample applications. Decision-Making: basics of utility theory, decision theory, sequential decision problems, elementary game theory, sample applications.	9
4	Machine Learning and Knowledge Acquisition: learning from memorization, examples, explanation, and exploration. Learning nearest neighbour, naive Bayes, and decision tree classifiers, Q-learning for learning action policies, applications.	8
5	Languages for AI problem solving: Introduction to PROLOG syntax and data structures, representing objects and relationships, built-in predicates. Introduction to LISP- Basic and intermediate LISP programming Expert Systems: Architecture of an expert system, existing expert systems like MYCIN, RI, Expert system shells.	8

Course Outcomes

At the end of the course the students will be able to:	
CO 1	Learn the basics and applications of artificial intelligence and categorize various problem domains, basic knowledge representation and reasoning methods.
CO 2	Analyze basic and advanced search techniques including game playing, evolutionary search algorithms, constraint satisfaction.
CO 3	Learn and design intelligent agents for concrete computational problems.
CO 4	Design of programs in AI language(s).
CO 5	Acquire knowledge about the architecture of an expert system and design new expert systems for real life applications
Text Books	• Rich E., Artificial Intelligence, Tata McGraw Hills (2009). • George F. Luger, Artificial Intelligence: Structures and Strategies for Complex Problem Solving, Pearson Education Asia (2009).
Reference Books	• Patterson D.W, Introduction to AI and Expert Systems, Mc GrawHill (1998). • Shivani Goel, Express Learning- Artificial Intelligence, Pearson Education India(2013).

	Discipline Specific Elective-IV	
Code	**Virtual Instrumentation**	**Total Lecture:45**
ME20M209		**3-0-0=3**

Course Objectives:

- The objective of this course is to introduce the concept of virtual instrumentation
- To develop basic programs using loops, case structures etc.
- To including its applications in image, signal processing and motion control.

Unit	Contents	Hours
1	Review of Virtual Instrumentation: Historical perspective, Block diagram and Architecture of Virtual Instruments Data-flow Techniques: Graphical programming in data flow, Comparison with conventional programming.	10
2	VI Programming Techniques: VIs and sub-VIs, Loops and Charts, Arrays, Clusters and graphs, Case and sequence structures, Formula nodes, Local and global variables, Strings and file I/O.	10
3	Data Acquisition Basics: ADC, DAC, DIO, Counters and timers. Common Instrumentation Interfaces: RS232C/ RS485, GPIB, PC Hardware structure, DMA software and hardware installation.	9
4	Use of Analysis Tools: Advanced analysis tools such as Fourier transforms, Power spectrum, Correlation methods, Windowing and filtering and their applications in signal and image processing, Motion Control. Additional Topics: System buses, Interface buses: PCMCIA, VXI, SCXl, PXI, etc.	8
5	Laboratory Work : Components of Lab VIEW, Celsius to Fahrenheit conversion, Debugging, Sub-VI, Multiplot charts, Case structures, ASCII files, Function Generator, Property Node, Formula node, Shift registers, Array, Strings, Clusters, DC voltage measurement using DAQ	8

Course Outcomes

At the end of the course the students will be able to:

CO 1	To demonstrate the working of LabVIEW
CO 2	To explain the various types of structures used in LabVIEW.
CO 3	To analyze and design different type of programs based on data acquisition.
CO 4	. To demonstrate the use of LabVIEW for signal processing, image processing etc
CO 5	To learn and use different analysis tools

Text Books	• Johnson, G., LabVIEW Graphical Programming, McGraw−Hill (2006). • Sokoloft, L., Basic Concepts of LabVIEW 4, Prentice Hall Inc. (2004). • Wells, L.K. and Travis, J., LabVIEW for Everyone, Prentice Hall Inc. (1996).
Reference Books	• Gupta, S. and Gupta, J.P., PC Interfacing for Data Acquisition and Process Control, Instrument Society of America (1988).

	Discipline Specific Elective-IV	
Code	**Metrology & Computer Aided Inspection**	**Total Lecture:45**
RM20M210		**3-0-0=3**

Course Objectives:

- To impart concepts of computer aided design
- To study computer aided manufacturing engineering through the use of analytical techniques,
- To introduce experiments, computer simulation methods, and other modern engineering tools
- To extend the concept of Reflex detection, & Proximity detection, Applications of Inductive and Capacitive proximity sensors,

Unit	Contents	Hours
1	Metrology and Techniques: Standards in metrology, definitions, Traceability, Characteristics Length & Angular measurements-Review of standard instruments, GD and tolerance procedure-Review of dimension & form tolerance and methods of measurement, Tolerance analysis, Surface metrologyInstruments, Methods and new approaches.	10
2	Laser Applications in Metrology: LASER light source, LASER interferometer, LASER alignment telescope, LASER micrometer, On-line and in-process measurements of diameter, Roundness and surface roughness using LASER, Micro holes and topography measurements.	10
3	Special Measuring Instruments and Techniques: Optoelectronic devices, contact and non-contact types, Applications in on-line and in-process monitoring systems, Tool wear measurement, Surface measurement, Machine vision, shape identification, Edge detection techniques, Normalisation, gray scale correlation, Template Techniques, Surface roughness using vision system, Interfacing robot and image processing system.	9
4	Co-ordinate Measuring Machine: Types of CMM, Probes used, Applications, Non-contact CMM using electro optical sensors for dimensional metrology, Non-contact sensors for surface finish measurements, statistical evaluation of data using computer, Data integration of CMM and data logging in computers.	8

5	Sensors in Inspection: Manufacturing applications of photo detectors, deflection methods-beam detection, Reflex detection, & Proximity detection, Applications of Inductive and Capacitive proximity sensors, Understanding microwave sensing applications laser sensors and limit switches. Advanced sensor technology-Bar code systems, Principles and applications of Colour sensors, electro-magnetic identifier, Tactile sensors, Ultrasonic sensors, Odour sensors.	8

Course Outcomes	
At the end of the course the students will be able to:	
CO 1	Generalise the importance of measuring system
CO 2	Demonstrate the concepts of linear and angular measurements to practical applications
CO 3	Illustrate the methods for form measurements
CO 4	Describe the principles and applications of laser in metrology.
CO 5	Select the equipment and suitable technique to measure power, force and temperature.
Text Books	• Fundamentals of dimensional Metrology T. Busch and R. Harlow Delmar, 3e • Engineering Metrology G. Thomas and G. Butter Worth PUB • Sensors and Control systems in Manufacturing Sabne Soloman McGraw Hill Book • Measurement systems: Applications & Design Doebelin International Student Edition
Reference Books	• Optoelectronics for Technology and Engineering Robert G. Seippel Prentice Hall India • Interface Technology for Computer Controlled Manufacturing processes Ulrich-Rembold, Armbruster and Ulzmann Marcel Dekker Publications, NY • Optoelectronics J. Watson Van Nostrand Rein Hold (UK) Company

Code	CAM & Robotics	Practical:30
RM20M204		0-0-4=2
	Contents	Hours
1	Line drawing or Circle drawing algorithm experiment: writing the program and running it on computer.	
2	Transformations algorithm experiment for translation/rotation/scaling: writing program and running it on computer.	
3	Design problem experiment: writing the program for design of machine element or other system and running it on computer.	
4	Optimization problem experiment: writing a program for optimizing a function and running it on computer.	
5	Auto CAD experiment: understanding and use of Auto CAD commands.	
6	Writing a small program for FEM for 2 spring system and running it. Or using a FEM package.	
7	Use of Graphic software standards packages e.g. GKs/PHICS/GL etc.	
8	Use of pro Engineer/Ideas etc.	
9	Writing a part-programming (in word address format or in APT) for a job for drilling operation (point-to-point) and running on NC machine.	
10	Writing a part programming (in word address format or in APT) for a job for milling operation (contouring) and running on NC machine	
11	Experiment on Robots and it programs	
12	Experiment on Transfer line/Material handling.	
13	Experiment on difference between ordinary machine and NC machine, study or retrofitting.	
14	Experiment on study of system devices such as motors and feedback devices.	
15	Experiment on Mechatronics & controls	

Code	Project Based Learning II	Practical:30
PB20M201		**0-0-4=2**
	Contents	**Hours**
	In this course we have only practical part and student are allowed to devlop small project on the basis of the knowledge .They have required however ,if a student show interest in the basis technology of the Computer Science/Electronics/Mechanical/Civil Engineering. Then appropriate guidance will be given by relative faculty member	30