VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI

SCHEME OF TEACHING AND EXAMINATION FOR

M.TECH. Computer Integrated Manufacturing

II SEMESTER **CREDIT BASED**

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work / Assignment / Tutorials		I.A	Exam		
16MAR21	Robotics for Industrial Automation	4	2	3	20	80	100	4
16MCM22	Flexible Manufacturing Systems	4	2	3	20	80	100	4
16MAR23	Computer Control of Manufacturing Systems	4	2	3	20	80	100	4
16MCM24	Non Traditional Machining	4	2	3	20	80	100	4
	Elective – II	4	2	3	20	80	100	4
16MCM26	Manufacturing Engineering Lab II		3	3	20	80	100	2
16MAR27	SEMINAR	--	3	--	100	--	100	1
	**PROJECT WORK PHASE-I COMMENCEMENT (6 WEEKS DURATION)	--	--	--	--	--	--	--
	Total	**20**	**13**	**15**	**220**	**480**	**700**	**23**

ELECTIVE-II

16MAR251	Intelligent Instrument and Management	16MCM253	Advanced Mechatronics
16MCM252	Concurrent Engineering and product life cycle management	16MAR254	Micro electro mechanical system

ROBOTICS FOR INDUSTRIAL AUTOMATION

(Common to MCM MAR, IAE)

Sub Code	: 16MAR21	***IA Marks***	: 20
Hrs/ Week	: 04	Exam Hours	: 03
Total Hrs.	: 50	Exam Marks	: 80

Course Objectives:

- This course is an attempt to provide a more updated view of the available tools and technique for kinematics, dynamics and control system on various kinds of robot manipulator.
- Study of various applications

Course Content:

Module 1. Introduction: Automation and Robotics, Historical Development, Definitions, Basic Structure of Robots, Robot Anatomy, Complete Classification of Robots, Fundamentals about Robot Technology, Factors related to use Robot Performance, Basic Robot Configurations and their Relative Merits and Demerits, Types of Drive Systems and their Relative Merits, the Wrist & Gripper Subassemblies. Concepts and Model about Basic Control System, Transformation and Block Diagram of Spring Mass System, Control Loops of Robotic Systems, PTP and CP Trajectory Planning, Different Types of Controllers, Control Approaches of Robots. **10 Hours**

Module 2. End Effectors And Robot Controls: Mechanical grippers-Slider crank mechanism, Screw type, Rotary actuators, cam type-Magnetic grippers-Vacuum grippers-Air operated grippers-Gripper force analysis-Gripper design-Simple problems-Robot controls-Point to point control, Continuous path control, Intelligent robot-Control system for robot joint-Control actions-Feedback devices-Encoder, Resolver, LVDT-Motion Interpolations-Adaptive control. **10 Hours**

Module 3. Time and Motion: Trajectories, Smooth One-Dimensional Trajectories, Multi Dimensional Case, Multi-Segment Trajectories, Interpolation of Orientation in 3D, Cartesian Motion, Time Varying Coordinate Frames, Rotating Coordinate Frame, Incremental Motion, Inertial Navigation Systems. Mobile Robot Vehicles, Mobility, Car-like Mobile Robots, Moving to a Point, Following a Line, Following a Path, Moving to a Pose. SLE: Flying Robots. **10Hours**

Module 4. Robot Arm Kinematics: Describing a Robot Arm, Forward Kinematics, A 2-Link Robot, A 6-Axis Robot, Inverse Kinematics, Closed-Form Solution, Numerical Solution, Under Actuated Manipulator, Redundant Manipulator, Trajectories, Joint-Space Motion, Cartesian Motion, Motion through a Singularity.
10Hours

Module 5. Robot Sensing & Vision: Various Sensors and their Classification, Use of Sensors and Sensor Based System in Robotics, Machine Vision System, Description, Sensing. Programming – powered, manual. Textual robo languages – first generation, second, future generation – VAL, VAL II, simple programming – exercises
10 Hours

Course outcomes:

1. Upon completion of the course, students will be able to understand importance of robotics in today and future goods production
2. Robot configuration and subsystems, principles of robot programming and handle with typical robot.

Text Books:

1. S.R. Deb, **Robotics Technology and flexible automation**, Tata McGraw-Hill Education., 2009
2.Mikell P Groover & Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta,
3.**Industrial Robotics, Technology programming and Applications**, McGraw Hill, 2012.

Reference Books

1."A Robot Engineering Textbook "– Mohsen Shahinpoor – Harper & Row publishers, New York, 1987.
2."Robotics, control vision and intelligence ," Fu, Lee and Gonzalez. McGraw Hill International, 1987.
3."Introduction to Robotics:Mechanics and Control", John J. Craig, Pearson, 3e, 2009

Scheme of Examination:
Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

FLEXIBLE MANUFACTURING SYSTEMS
(Common to MCM MAR,IAE)

Sub Code	: 16MCM22	***IA Marks***	: 20
Hrs/ Week	: 04	Exam Hours	: 03
Total Hrs.	: 50	Exam Marks	: 80

Course Learning Objectives:

To make student understand

1. the need for flexibility in manufacturing industries
2. to learn the development and implementation of an FMS
3. to learn the different types of automated material handling systems its design and calculations for different applications both AS/RS

Course Content:

Module 1.Introduction Flexible and rigid manufacturing, F.M. Cell and F.M. System concept, Types and components of FMS, Tests of flexibility, Group Technology and FMS, unmanned factories, Economic and Social aspects of FMS. **10 Hours**

Module 2.Control structure of FMS: Architecture of typical FMS, Automated work piece flow, Control system architecture – Factory level, Cell level; hierarchical control system for FMS, LANs - characteristics, transmission medium, signaling, network topology, access control methods; Factory networks, Structure and functions of manufacturing cell, Distributed Numerical Control (DNC) **10Hours**

Module 3. Scheduling & Loading Of FMS: Introduction, Scheduling of operations on a single machine, 2 machine flow shop scheduling, 2 machine job shop scheduling, 3 machine flow shop scheduling, scheduling 'n' operations on 'n' machines, Scheduling rules, loading problems , Tool management of FMS, material Handling system schedule. Problems. **10Hours**

Module 4.Tooling in FMS: Modern cutting tools and tool materials, tool holders, modular tooling, tool monitoring, presetting and offsets, wear and radius compensation, tool magazines, automatic tool changers, robotized tool assembly, tool management system **10 Hours**

Module 5.Fixturing in FMS: Part holding on Pallets, standard fixtures, pallet changers, pallet pool, flexible fixturing – principles and methodologies, modular fixturing system: T slot based, dowel pin based, fixturing components, computer aided fixture design – locating and clamping, use of GT in fixture design, fixture database **10Hours**

Course outcome:

1. The students will get a clear idea of importance of an FMS system in present manufacturing world
2. The student will learn the different types of FMS layouts, material handling and retrieval systems ,they will be able to solve the sequencing problems for different cases and tool management

Text Books

1. Groover, Mikell P. (2002), 2/e, **" Automation, Production Systems & Computer Integrated Manufacturing",** Pearson Education or PHI
2. Viswanadhan, N. & Narahari, Y. (1998), **"Performance Modelling of Automated Manufacturing Systems",** PHI
3. Pinedo, Michael & Chao, Xiuly (1999), **"Operations Scheduling with Applications in Manufacturing & Services",** McGraw Hill International Editions (with 2 Floppy Disks of LEKIN Scheduling Software)

Reference Books

1. Kelton, Sadowsky & Sadowsky, "Simulation with ARENA",2/e, McGraw Hill International Editions (with CD of ARENA Simulation Software)
2. Radhakrishnan, Subramanyan, "CAD / CAM / CIM", John Wiley
3. Rao, PN, Tewari NK, Kundra TK, "Computer Aided Manufacturing", TMH
4. Rong, Yeming; "Computer Aided Fixture Design", Marcel Dekker, ISBN 0-8247-9961-5
5. Hobbs, "Lean Manufacturing Implementation", J. Ross Publishing, ISBN 1-932150-14-2
6. Chowdiah, Gargesa & Kumar, "Agile Manufacturing", TMH

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

COMPUTER CONTROL OF MANUFACTURING SYSTEMS
(Common to MCM, MAR, IAE)

Sub Code	: 16MCM23	***IA Marks***	: 20
Hrs/ Week	: 04	Exam Hours	: 03
Total Hrs.	: 50	Exam Marks	: 80

Course Objectives:

1. To impart the basic concepts in manufacturing systems and fundamentals of NC & CNC system
2. Knowledge enhancement in design consideration and increasing productivity with NC machine tools, machining centers and tooling for CNC machines
3. To enhance students awareness in system devices that include feedback devices, counters, DAC converters and interpolators

Course Content:

Module 1.Introduction to Computer integrated Manufacturing Systems: Manufacturing Systems, Types of Manufacturing Systems, , Machine Tools and related equipment's, Material Handling Systems, Computer monitoring and control, Manufacturing support systems, The Product Cycle and CAD/ CAM, Functions of computers in CIMS: CIMS Data Files, System Reports, Benefits of Computer integrated Manufacturing Systems,

Fundamentals of Numerical Control: Basic concepts of NC, Classification of NC- Point to Point and contouring, Incremental and absolute system, Open loop and closed loop system, Advantages of NC. **10 Hours**

Module 2. NC/ CNC Machine Tools: General architecture of CNC Machine, Components of the CNC Systems: Machine Control Unit , CNC Driving system components: Hydraulic, Servo Motors, Stepper Motors, Feedback Devices: Encoder, Resolver, Inductosyn, Tachometers, Counting devices.

Constructional Features of CNC Machines: Design considerations of CNC machines for improving machining accuracy, Structural Members, Slide ways, bearings, Re-circulating ball Screws, Spindle drives, Work holding devices and tool holding devices, Automatic tool changers.

10 Hours

Module 3. N.C part programming: Introduction, NC/ CNC programming methods: Manual part programming for turning and milling centers, G codes, M codes, canned cycles, Programming with CAD/CAM integration, CAM packages for CNC part program generation, Practical Exercises on CNC part programming.

Computer Controls in NC: CNC Technology: Functions of CNC Control in Machine Tools, Advantages of CNC, Direct Numerical Control(DNC Systems): Configuration of DNC system, Functions of DNC, Communication between DNC computer & MCU, Advantages of DNC,

10 Hours

Module 4. **Adaptive control**: machining systems. Adaptive control optimization system,

adaptive control constraint system, applications to machining processes, Benefits of Adaptive control Machining.

Industrial Robotics: Robotics technology : Types of Robots, Robot Technology Levels, Robot geometric configurations and Technical Features, basic robot motions, Robot control systems, robot drive systems, Work-cell control and Interlocks, robot sensors, robot safety,
Robot-computer interface, industrial robot applications and benefits.

. **10 Hours**

Module 5: Computerized Manufacturing Planning and Control Systems: Computer aided process planning, Variant and Generative approaches, Computer integrated production planning and control systems, Typical production planning and control system, Material planning systems, Capacity planning, Shop Floor Control, Automatic identification, Automated data collection systems. **10 Hours**

Course Outcome:

1. Students will get clear understanding Of NC/CNC machines
2. Various elements of CNC machines and its uses, Constructional features of CNC machine Tools
3. Knowledge of CNC programming and its implementation.

TEXT BOOKS:

1. GROOVER M P, **Automation, Production Systems and Computer Integrated Manufacturing -**, Prentice Hall India (P) Ltd, 1989.
2. Mikell P. Groover and Emory W. Zimmer, Jr., **CAD/CAM Computer Aided Design and Manufacturing,** Prentice Hall India (P) Ltd, 1992. (unit 1)
3. M. Koren **—Computer Controls of Manufacturing Systems,** McGrawHill, 1983

REFERENCE BOOKS:

1. Martin J. **—Numerical control of machine tools".**
2. P.N. Rao – CAD/CAM **Principles and Applications**McGrawhill 2002
3. Y. Koren&J.Benuri **-"Numerical control of machine tools** -Khanna, 1992
4. Wilson F.M **—Numerical control in manufacturing**- McGraw Hill Newyork
5. Suk-Hwan Suh, Seong-Kyoon Kang, Dea-Hyuk Chung and Ian Stroud, **Theory and Design of CNC Systems**, , Springer, 2008

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

NON-TRADITIONAL MACHINING
(Common to MCM, MAR, IAE)

Sub Code	: 16MCM24	***IA Marks***	: 20
Hrs/ Week	: 04	Exam Hours	: 03
Total Hrs.	: 50	Exam Marks	: 80

Course objectives:

1. To demonstrate the need for development of newer/ non-traditional machining processes.
2. The student will be able to identify different energy sources like fluid motion, electric current, high speed electrons, high energy radiation, etc.
3. To analyze the concept, mechanism, parameters associated with the processes.
4. To demonstrate the operational principles, advantages applications, limitations of the various non-traditional machining processes.

Course Content:

Module 1. Introduction: Need for non-traditional machining processes, Process selection, classification, comparative study of different processes.
Ultra Sonic Machining: Definition, Mechanism of metal removal, elements of the process, Tool feed mechanisms, Theories of mechanics, effect of parameters, Different types of concentrators, horn design, applications, Limitations **.**
Abrasive Jet Machining: Principle, Process parameters, Influence of process parameters on MRR , applications, advantages and disadvantages. **10 Hours**

Module 2. Water Jet Machining: Principle, Equipment, Operation, Application, Advantages and limitations of water Jet machinery.
Thermal Metal Removal Processes: Electric discharge machining, Principle of operation, mechanism of metal removal, basic EDM circuitry, spark erosion generators, Analysis of relaxation type of circuit, material, removal rate in relaxation circuits, critical resistance parameters in Ro Circuit, Die electric fluids, Electrodes for spark erosion- surface finish, applications. **10 hours**

Module 3. Electro Chemical machining (ECM): Classification of ECM process, Principle of ECM, Chemistry of the ECM process, parameters of the process, Determination of the metal removal rate, dynamics of ECM process, Hydrodynamics of ECM process, polarization, Tool Design, advantages and disadvantages-applications. Electro Chemical grinding, Electro Chemical honing, Electrochemical deburring.

10 Hours

Module 4. Chemical Machining: Introduction, fundamental principle types of chemical machining, Maskants, Etchants, Advantages and disadvantages, applications
Plasma arc Machining: Introduction, Plasma, Generation of Plasma and equipment, Mechanism of metals removal, PAM parameters, process characteristics, types of torches, applications
Electron beam machining (EBM): Introduction, Equipment for production of Electron beam, Theory of electron beam machining, Thermal & Non thermal type, Process characteristics, applications. **10 Hours**

Module 5 . Laser Beam Machining: Introduction, principles of generation of lasers, Equipment and Machining Procedure, Types of Lasers, Process characteristics, advantages and limitations, applications of laser beam machining.
Ion Beam Machining: principle, equipment, working, sputtering rate, applications.
High Velocity forming processes: Introduction, development of specific process, selection, comparison of conventional and high velocity forming methods.
Types of high velocity forming methods: explosion forming process, electro-hydraulics forming, magnetic pulse forming. Applications, Advantages and limitations. **10Hours**

Course Outcomes:
1. Student will be in a position to appreciate the merits of nontraditional machining and its application in Industries.
2. Justify and demonstrate the benefits of non-traditional machining processes over traditional machining processes. Students will be able to decide a process suitable for a particular material based on the availability of the sources.

Text Books:
1. **Modern Machining Process -** P.C Pandy& H.S Shan Tata McGraw Hill.
2. **Modern Machining Processes -** P.K Mishra
3. **Thermal Metal Cutting Processes**-Dr.B.J.Ranganath,I K International,New Delhi.

Reference Books:

1. **New technology -** Bhattacharya, Institution of Engineers, India
2. **Production technology -** HMT Tata McGraw Hill.
3. **Metals hand book** - ASM Vol-3.
4. **High velocity forming of metals -** F.M Wilson ASTME PreticeHall.
5. **Modern Manufacturing Methods -** Adithan

Scheme of Examination:
Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Elective II

FLUID POWER AUTOMATION
(Common to MCM, MAR, IAE)

Sub Code	: 16MAR251	***IA Marks***	: 20
Hrs/ Week	: 04	Exam Hours	: 03
Total Hrs.	: 50	Exam Marks	: 80

Course Objectives

To make the students to learn the basic concepts of hydraulics and pneumatics and their controlling elements in the area of manufacturing process. To train the students in designing the hydraulic and pneumatic circuits using various design procedures.

Module 1. Introduction Need for Automation, Hydraulic & Pneumatic Comparison – ISO symbols for fluid power elements, Hydraulic, pneumatic ,application in different filed , advantage, disadvantage , Selection criteria. **10 Hour**

Module 2. Fluid Power Generating/Utilizing Elements Hydraulic pumps and motor gears, vane, piston pumps-motors-selection and specification-Drive characteristics – Linear actuator – Types, mounting details, cushioning – power packs – construction. Reservoir capacity, heat dissipation, accumulators – standard circuit symbols, circuit (flow) analysis. **10Hour**

Module 3. Control And Regulation Elements Direction flow and pressure control valves-Methods of actuation, types, sizing of ports-pressure and temperature compensation, overlapped and under lapped spool valves-operating characteristics electro hydraulic servo valves-Different types-characteristics and performance. **10Hour**

Module 4. Circuit Design Typical industrial hydraulic circuits-Design methodology – Ladder diagram-cascade, method-truth table-Karnaugh map method-sequencing circuits-combinational and logic circuit. **10Hour**

Module 5. Electro Pneumatics & Electronic Control Of Hydraulic And Pneumatic Circuits Electrical control of pneumatic and hydraulic circuits-use of relays, timers, counters, Ladder diagram. Programmable logic control of Hydraulics Pneumatics circuits, PLC ladder diagram for various circuits, motion controllers, use of field busses in circuits. Electronic drive circuits for various Motors**.** **10Hour**

Course outcome

Student has to gain the knowledge about hydraulics pneumatics, and their application in different filed ,different circuit, adoption of hydraulics pneumatics in automation.

Text book

1. W.Bolton, Mechatronics, Electronic control systems in Mechanical and Electrical Engineering Pearson Education, 2003.
2. Peter Rohner, Fluid Power Logic Circuit Design, Mcmelan Prem, 1994.

References Text Book

1. Antony Esposito, Fluid Power Systems and control Prentice-Hall, 1988

2. E.C.Fitch and J.B.Suryaatmadyn. Introduction to fluid logic, McGraw Hill, 1978

3. Peter Rohner, Fluid Power logic circuit design. The Macmillan Press Ltd.,London, 1979

4. Herbert R. Merritt, Hydraulic control systems, John Wiley & Sons, Newyork, 1967 7. Dudbey. A. Peace, Basic Fluid Power, Prentice Hall Inc, 1967

Scheme of Examination:
Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Elective II

CONCURRENT ENGINEERING AND PRODUCT LIFE CYCLE MANAGEMENT
(Common to MCM, MAR, IAE,)

Sub Code	: 16MCM252	***IA Marks***	: 20
Hrs/ Week	: 04	Exam Hours	: 03
Total Hrs.	: 50	Exam Marks	: 80

Course objectives

1. The graduates shall have the ability to understand the importance of product design in leveraging both manufacturing cost and product lifecycle cost.
2. The graduates shall have the ability to plan and implement a product development program.
3. The graduates shall have the ability to participate in multi-discipline Integrated Product Development teams.

Module 1. Introduction: Extensive definition of Concurrent Engineering(CE),CE design methodologies, Review of CE techniques like DFM (Design for manufacture), DFA(Design for assembly),QFD (Quality function deployment), RP (Rapid prototyping), TD (Total design), for integrating these technologies, organizing for CE, CE tool box, Collaborative product development. **10 Hour**

Module 2. Use of Information Technology: IT Support Solid modeling, product data management, Collaborative product commerce, Artificial Intelligence, expert systems, Software hardware component design**.** **10 Hour**

Module 3. Design Stage: Lifecycle design of products, opportunities for manufacturing enterprises, Modality of Concurrent engineering design, Automated analysis idealization control, CE in optimal structural design, Real time constraints**.** **10 Hour**

Module 4. Need for PLM: Importance of PLM, Implementing of PLM, Responsibility for PLM, Benefits to different managers, Components of PLM, Emergence of PLM, Life cycle problems to resolve, Opportunities to seize**.** **10 Hour**

Module 5. Components of PLM: components of PLM, Product lifecycle activities, Product organizational structure, Human resources in product lifecycle, Methods, techniques, practices, Methodologies, Processes, System components in lifecycle, slicing and dicing the systems, Interfaces, Information, Standards. **10 Hour**

Course outcome

1. The graduates shall have the ability to determine customer needs and define product specifications that meet professional ethical standards.
2. The graduates shall have the ability to define product architecture and design products for maximum economic impact.
3. The graduates shall have the ability to design and conduct experiments to ensure that the product design is robust and compatible with the capability of the manufacturing process.

Text Book

1. Integrated Product Development / M.M .Anderson and L.Hein/ IFS Publications
2. Design for Concurrent Engineering/ J Cleetus/ CE Research Centre, Morgantown,
3. Concurrent Engineering Fundamentals/ Prasad / Prentice hall India Integrated Product Development 4. Concurrent Engineering in product Design and Development/ I.Moustapha / New age International

REFERENCE BOOK

1.Product Life Cycle Management/ John Stark/ Springer –Verlag/ UK
2. Product Lifecycle Management/ Michael Grives/ Mc Graw Hill
3. Concurrent Engineering: Automation tools and Technology/Andrew Kusiak/ Wiley Eastern Technology

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Elective II

ADVANCED MECHATRONICS

(Common to MCM, MAR, IAE)

Sub Code	: 16MCM253	***IA Marks***	: 20
Hrs/ Week	: 04	Exam Hours	: 03
Total Hrs.	: 50	Exam Marks	: 80

Course objectives

1. Have a strong foundation in science and focus in mechanical, electronics, control, software, and computer engineering, and a solid command of the newest technologies.
2. Be able to design, analyze, and test "intelligent" products and processes that incorporate appropriate computing tools, sensors, and actuators.

Module 1. Mechatronics systems, elements, levels of mechatronics system, Mechatronics design process, system, measurement systems, control systems, microprocessor-based controllers, advantages and disadvantages of mechatronics systems. Sensors and transducers, types, displacement, position, proximity, velocity, motion , force, acceleration, torque, fluid pressure, liquid flow, liquid level, temperature and light sensors. **10 Hour**

Module 2. Solid state electronic devices, PN junction diode, BJT, FET, DIA and TRIAC. Analog signal conditioning, amplifiers, filtering. Introduction to MEMS & typical applications **10 Hour**

Module 3. Hydraulic and pneumatic actuating systems, Fluid systems, Hydraulic and pneumatic systems, components, control valves, electro-pneumatic, hydro-pneumatic, electro-hydraulic servo systems: Mechanical actuating systems and electrical actuating systems.**10 Hour**

Module 4.Digital electronics and systems, digital logic control, micro processors and micro controllers, programming, process controllers, programmable logic controllers, PLCs versus computers, application of PLCs for control**.** **10 Hour**

Module 5. System and interfacing and data acquisition, DAQS , SCADA, A to D and D to A conversions; Dynamic models and analogies, System response. Design of mechatronics systems & future trends. **10 Hour**

Course outcome

1. Select and apply the knowledge, techniques, skills and modern tools in mechatronics engineering technology.

2. Apply concepts of circuit analysis, analog and digital electronics, automation and controls, motors, electric drives, power systems, instrumentation, and computers to aid in the design, characterization, analysis, and troubleshooting of mechatronics systems.

Text Book

1. MECHATRONICS Integrated Mechanical Electronics Systems/KP Ramachandran & GK Vijaya Raghavan/WILEY India Edition/2008
2. Mechatronics Electronics Control Systems in Mechanical and Electrical Engineering by W Bolton, Pearson Education Press, 3rd edition, 2005.
3. Mechatronics Source Book by Newton C Braga, Thomson Publications, Chennai.

REFERENCE BOOK:

1. Mechatronics – N. Shanmugam / Anuradha Agencies Publishers.
2. Mechatronics System Design / Devdas shetty/Richard/Thomson.
3. Mechatronics/M.D.Singh/J.G.Joshi/PHI.
4. Mechatronics – Electronic Control Systems in Mechanical and Electrical Engg. 4th Edition, Pearson, 2012 W. Bolton 8. Mechatronics – Principles and Application Godfrey C. Onwubolu, Wlsevier, 2006 Indian print.

Scheme of Examination:
Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Elective II

MICRO ELECTRO MECHANICAL SYSTEMS
(Common to MCM MAR, IAE)

Sub Code	:	16MAR254	***IA Marks***	:	20
Hrs/ Week	:	04	Exam Hours	:	03
Total Hrs.	:	50	Exam Marks	:	80

Course Objective:
Students get exposure to various Micro Electronic Mechanical systems which find extensive usage in Industrial applications

Module 1. Introduction: Micro Electro-Mechanical Systems, Ultra Precision Engineering, Micro-sensors; Micro-actuators; Microelectronics Fabrication; Micromachining; Mechanical MEMS; Thermal MEMS : MOEMS; Magnetic MEMS; RF MEMS; Micro-fluidic Systems; Bio and Chemo – Devices; MEMS Packages and Design Considerations; Micro-Instrumentation.
10 Hours

Module 2. Microfabrication and Micromachining: Integrated Circuit Processes, Bulk Micromachining: Isotropic Etching and Anisotropic Etching, Wafer Bonding, High Aspect-Ratio Processes
Mechanical Sensors and Actuators: Principles of Sensing and Actuation; Beam and Cantilever; Microplates; Capacitive Effects; Piezoelectric material as Sensing and Actuating Elements; Strain Measurement; Pressure measurement; Flow Measurement using Integrated Paddle – Cantilever Structure; Pressure Measurement by Microphone; Shearmode Piezoactuator; Gripping Piezoactuator; Inchworm Technology. **10 Hours**

Module 3.Thermal and Fluidic Micro Sensors and Actuators : Thermal sensors, Electrical Sensors, Chemical and Biosensors Electromagnetic and Thermal microactuation, Mechanical design of microactuators, Microactuator examples, Micro Fluidic systems, Fluid actuation methods, microvalves, micropumps, micromotors-Microactuator systems : Ink-Jet printer heads, Micro-mirror TV Projector. **10 Hours**

Module 4. Surface Micromachining: One or two sacrificial layer processes, Surface micromachining requirements, Polysilicon surface micromachining, Other compatible materials, Silicon Dioxide, Silicon Nitride, Piezoelectric materials, Surface Micromachined Systems: Success Stories, Micromotors, Gear trains, Mechanisms.
10 Hours

Module 5. MEMS: Characterization: Technologies for MEMS characterization, Scanning Probe Microscopy (SPM): Atomic Force Microscopy (AFM), Scanning tunneling microscopy (STM), Magnetic Force Microscopy, Scanning Electron Microscope, Laser Doppler vibrometer, Electronic Speckle Interference Pattern technology (ESPI). **10 Hours**

Course Outcome:
Students will be in a position to demonstrate their knowledge in micro machining and micro electro mechanical systems

Text Books:

1.Rai-Choudhury P. MEMS and MOEMS Technology and Applications, PHI Learning Private Limited, 2009.

2.Stephen D. Senturia, "Microsystem Design" Springer, 2001.

3.MarcMadou, "Fundamentals of Microfabrication" Tay lor & Francis Group, 2002.

4.Gregory Kovacs, "Micromachined Transducers Source book" McGraw Hill 1998.

Reference Books

1.M.H. Bao, "Micromechanical Transducers: Pressure sensors, accelerometers, and gyroscopes" Handbook, Elsevier.

2.NadimMaluf, An Introduction to Microelectromechanical Systems Engineering, Artech House Publishers, 2000.

3.Stephen D. Senturia, "Microsystems Design" Kluwer Academic Publishers, New York.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Manufacturing Engineering Lab 2

Sub Code : 16MCM26 IA Marks :20

Hrs/ Week: 3 Exam Hours : 03

Total Hrs: 42 Exam Marks :80

Note:

- The focus is on experimental investigations on one or more topics identified below.
- Physical experiments as well as numerical experiments are welcome.
- Parametric studies and correlation studies are implied.
- Each student must prepare and submit a comprehensive report on the problems investigated and give a presentation on the same for internal evaluation.
- Any one of the exercises done from the following list has to be asked in the Examination for evaluation.

Exercises:

1. Study waviness produced by grinding process and characterize the resulting surface.
2. Develop and implement a program for pick and place of an object by a robot.
3. Modeling and simulation using MATLAB of a vibration control system and to draw time response/ frequency response curves.
4. Kinematic analysis of forward/reverse linkages of robots using MATLAB (Denavit-Hartenberg convention).
5. Trajectory planning of robots using MATLAB.
6. Design and analysis of PID controller for mechanical engineering applications using MATLAB.
7. Reduce MLT using Lean principles that are followed in major industries (using case studies and data from industries and make a proposal for redesigning existing machine shop).
8. To develop a CIM Layout consisting of 3 machining centers, one AGV and 3 material handling robots. Layout developed must indicate complete CIM environment consisting of tool crib, raw material storage and finished product storage area. (using solid edge, Autocad or any other available software).

9. Monitoring of vibrations/noise of a machine tool and to compare it with industry standards. List the causes of variation and suggest remedial measures.
10. Detection, location and characterization of defects in castings / welds/ adhesive bonds.