<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Name of the Subject</th>
<th>Teaching hours/week</th>
<th>CREDIT BASED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lecture</td>
<td>Practical / Field Work / Assignment / Tutorials</td>
</tr>
<tr>
<td>16MAR21</td>
<td>Robotics for Industrial Automation</td>
<td>4 2</td>
<td>3</td>
</tr>
<tr>
<td>16MCM22</td>
<td>Flexible Manufacturing Systems</td>
<td>4 2</td>
<td>3</td>
</tr>
<tr>
<td>16MAR23</td>
<td>Computer Control of Manufacturing Systems</td>
<td>4 2</td>
<td>3</td>
</tr>
<tr>
<td>16MCM24</td>
<td>Non Traditional Machining</td>
<td>4 2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Elective – II</td>
<td>4 2</td>
<td>3</td>
</tr>
<tr>
<td>16MCM26</td>
<td>Manufacturing Engineering Lab II</td>
<td>3 3</td>
<td>20 80</td>
</tr>
<tr>
<td>16MAR27</td>
<td>SEMINAR</td>
<td>-- 3</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>**PROJECT **</td>
<td>-- --</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>WORK PHASE-I COMMENCEME</td>
<td>-- --</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>NT (6 WEEKS DURATION)</td>
<td>-- --</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>**PROJECT **</td>
<td>-- --</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>**PROJECT **</td>
<td>-- --</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>**PROJECT **</td>
<td>-- --</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>**PROJECT **</td>
<td>-- --</td>
<td>--</td>
</tr>
<tr>
<td>Total</td>
<td>20 13 15 220 480 700</td>
<td>23</td>
<td></td>
</tr>
</tbody>
</table>
**ELECTIVE-II**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>16MAR251</td>
<td>Intelligent Instrument and Management</td>
<td>16MCM253</td>
<td>Advanced Mechatronics</td>
</tr>
<tr>
<td>16MCM252</td>
<td>Concurrent Engineering and product life cycle management</td>
<td>16MAR254</td>
<td>Micro electro mechanical system</td>
</tr>
</tbody>
</table>

**ROBOTICS FOR INDUSTRIAL AUTOMATION**

(Common to MCM MAR, IAE)

<table>
<thead>
<tr>
<th>Sub Code</th>
<th>IA Marks</th>
<th>Hrs/ Week</th>
<th>Exam Hours</th>
<th>Total Hrs.</th>
<th>Exam Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>16MAR21</td>
<td>20</td>
<td>04</td>
<td>03</td>
<td>50</td>
<td>80</td>
</tr>
</tbody>
</table>

**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, LVD-T-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. 10 Hours

10 Hours


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:

Reference Books

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 ) 10 Hours

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. 10 Hours

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 10 Hours

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


Reference Books

2. Radhakrishnan, Subramanyan, "CAD / CAM / CIM", John Wiley
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:


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


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 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.

**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.

**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

**TEXT BOOKS:**

**REFERENCE BOOKS:**
1. Martin J. — *Numerical control of machine tools*.

**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.
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:


**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.  


**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.


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.
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:
2. Modern Machining Processes - P.K Mishra

Reference Books:
1. New technology - Bhattacharya, Institution of Engineers, India
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 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 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 hydraulic pneumatics in automation.

Text book

References Text Book

7. Dudbey.

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,)

<table>
<thead>
<tr>
<th>Sub Code</th>
<th>IA Marks</th>
<th>Hrs/ Week</th>
<th>Exam Hours</th>
<th>Total Hrs.</th>
<th>Exam Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>16MCM252</td>
<td>20</td>
<td>04</td>
<td>03</td>
<td>50</td>
<td>80</td>
</tr>
</tbody>
</table>

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.  

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

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.

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.

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.

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
2. Design for Concurrent Engineering/ J Cleetus/ CE Research Centre, Morgantown,
New age International

REFERENCE BOOK
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)

<table>
<thead>
<tr>
<th>Sub Code</th>
<th>IA Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>16MCM253</td>
<td>20</td>
</tr>
</tbody>
</table>

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


REFERENCE BOOK:

3. Mechatronics/M.D.Singh/J.G.Joshi/PHI.

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)

<table>
<thead>
<tr>
<th>Sub Code</th>
<th>IA Marks</th>
<th>Hrs/ Week</th>
<th>Exam Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>16MAR254</td>
<td>20</td>
<td>04</td>
<td>03</td>
</tr>
<tr>
<td>Total Hrs.</td>
<td></td>
<td>50</td>
<td>Exam Marks</td>
</tr>
</tbody>
</table>

**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.


**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.

**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.

**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.


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

**Reference Books**

**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.


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.