

**Syllabus for M.Tech. in  
Smart Manufacturing**

Course Title	Course Code	Structure (I-P-C)		
Applied AI for Manufacturing	ME502	3	3	5

**Pre-requisite, if any:** Basic Concepts of Manufacturing Processes

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

<b>CO1</b>	Understand the capability of AI for production planning and decision making.
<b>CO2</b>	Understand the fundamental concepts of manufacturing scheduling and role of robot control system in manufacturing
<b>CO3</b>	Realize application of Machine Learning to Industrial Planning and Decision Making
<b>CO4</b>	Develop a practical understanding of effective scheduling.
<b>CO5</b>	Develop Integrated Software System for Intelligent Manufacturing and Planning for Robot Control Systems in Manufacturing.

**Syllabus:**

Application of Machine Learning to Industrial Planning and Decision Making, Special Purpose Resource Design in Planning to Make More Efficient Plans;

Geometric Reasoning Using a Feature Algebra, Backward Assembly Planning Symmetry Groups in Solid Model-Based Assembly Planning,

An Expert System Approach for Economic Evaluation of Machining Operation Planning, Interactive Problem Solving for Production Planning,

An Abstraction-Based Search and Learning Approach for Effective Scheduling, ADDYMS: Architecture for Distributed Dynamic Manufacturing Scheduling, An Architecture for Real-Time Distributed Scheduling, Exploiting Local Flexibility During Execution of Pre-computed Schedules

An Architecture for Integrating Enterprise Automation; An Intelligent Agent Framework for Enterprise Integration; Teamwork Among Intelligent Agents: Framework and Case Study in Robotic Service

Symbolic Representation and Planning for Robot Control Systems in Manufacturing; Integrated Software System for Intelligent Manufacturing; Enterprise Management Network Architecture: A Tool for Manufacturing Enterprise Integration; Design and Manufacturing: Integration through Quality

Introduction to Digital Twin and Cyber-Physical Manufacturing Systems.

**Practice:**

These Laboratory classes aims at:

1. Understanding the phenomena involved
2. Study of influencing parameters
3. Develop setup, instrumentation, equation, product, etc.
4. Modelling & Simulation of the process
5. Simple project
6. Creation of concept
7. Application to real problem

8. Assignments suggested by the instructor.

**Text Book(s) and References:**

1. A. Fazel Famili (Editor), Dana S. Nau (Editor), Steven H. Kim (Editor); Artificial Intelligence Applications in Manufacturing, AAAI Press.
2. Ellen Friedman, Ted Dunning, AI and Analytics in Production; O'Reilly Media, Inc., 2018 (ISBN: 9781492044116)
3. Çağlayan Arkan, The Future Computed: AI and Manufacturing; Global Lead, Manufacturing and Resources Industry, Microsoft, 2019.
4. A. Fazel Famili (Editor), Dana S. Nau (Editor), Steven H. Kim (Editor); Artificial Intelligence Applications in Manufacturing, AAAI Press.
5. Ellen Friedman, Ted Dunning, AI and Analytics in Production; O'Reilly Media, Inc., 2018 (ISBN: 9781492044116)
6. Çağlayan Arkan, The Future Computed: AI and Manufacturing; Global Lead, Manufacturing and Resources Industry, Microsoft, 2019.

Course Title	Course Code	Structure (I-P-C)		
Mechatronics Product Design	ME503	3	3	5

**Pre-requisite, if any:** Nil

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

<b>CO1</b>	Understand the basic concepts of the main sensors used in electromechanical systems
<b>CO2</b>	Understand the fundamental concepts of mechanical power transmission components, and pneumatic and hydraulic actuators
<b>CO3</b>	Use the common analogue and digital interfaces between sensors/actuators and the systems under control using open-source microcontrollers
<b>CO4</b>	Understand the integration of mechanisms, sensors, actuators, interfaces and software in the design of mechatronic systems.
<b>CO5</b>	Understand basics of open source hardware/software, Mechaphonics, and mobile/web apps
<b>CO6</b>	Hands-on laboratory experiments and team projects involving the above concepts.

**Syllabus:**

**Introduction:** Mechatronics, history, applications, and trends.

**Sensors and transducers:** Characterization, sensors for position, velocity, proximity, force, pressure, temperature and light.

**Signal conditioning:** Amplification, filtering, multiplexing, and telemetry. Data acquisition with A/D, D/A and digital I/O.

**Mechanical components:** Types of motion, kinematic chains, cams, gears and other power transmission mechanisms.

**Software development:** program structures for embedded systems, software design process, inter-processor communication, microcontrollers and peripherals.

**Pneumatic and hydraulic actuators:** Basics of fluid flow, control valves, cylinders and rotary actuators for pneumatics and hydraulics.

**Microcontrollers:** Introduction to use of open-source hardware (Arduino & Raspberry Pi); shields/modules for GPS, GPRS/GSM, Bluetooth, RFID, and Xbee, integration with wireless networks, databases and web pages.

**Basic closed-loop control:** open-loop, on-off, PID control, Mechatronic systems integration, rapid prototyping of mechanical and electrical systems. Demonstrations of mechatronic systems in class.

**Practice:**

These Laboratory classes aim at:

1. Arduino microcontroller I/O and interfacing
2. Basic sensors interfacing with Arduino
3. GPS and data logging with Arduino

4. Networking with Arduino: GSM and Bluetooth
5. Raspberry Pi microcomputer I/O and interfacing
6. Simple project
7. Creation of concept
8. Application to real problem
9. Assignments suggested by the instructor.

**Text Book(s) and References:**

1. J. Edward Carryer, et al., Introduction to Mechatronic Design, Prentice Hall, 1st edition, 2010, ISBN: 978-8131788257.
2. W. Bolton, Mechatronics, Pearson India, 4th edition, 2010, ISBN: 978-8131732533.
3. D. G. Alciatore and M. B. Hstand, Introduction to Mechatronics and Measurement Systems, McGraw-Hill, 4th edition, 2014, ISBN: 978-9339204365.

Course Title	Course Code	Structure (I-P-C)		
Advanced Manufacturing Processes	ME504	3	3	5

**Pre-requisite, if any:** Basic Concepts of Manufacturing Processes

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

<b>CO1</b>	Model the material removal in various advanced manufacturing processes.
<b>CO2</b>	Analyze the processes and evaluate the role of each process parameter during machining of various advanced materials.
<b>CO3</b>	Realize products using advanced manufacturing processes
<b>CO4</b>	Develop a practical understanding of advanced manufacturing processes and capabilities of each.
<b>CO5</b>	Identify and rectify defects in parts and manufacturing processes related problems.
<b>CO6</b>	Analyze data from experiments performed and reach conclusions.

**Syllabus:**

**INTRODUCTION TO ADVANCED MANUFACTURING PROCESSES:**

Introduction to manufacturing processes. Overview of non-conventional machining processes with (AJM, USM, ECM, EDM, EBM, LBM, AFM, MRF, MAF, MFP and MRAFF etc.). Introduction to use of non-conventional processes for micro-machining.

**MECHANICAL MATERIAL REMOVAL PROCESSES:**

**Abrasive Jet Machining (AJM)** – Introduction, process parameters, estimation of MRR and Modeling of MRR. Components of AJM and Numerical approach.

**Water Abrasive jet machining (WAJM):** Basic principle, estimation of MRR WAJM process video.

**Ultrasonic Machining (USM)** – Introduction, process parameters, estimation of MRR, modeling of MRR. Design of acoustic ultrasonic head and feed mechanism in USM. Numerical approach.

**ELECTROCHEMICAL MACHINING PROCESS:**

**Electrochemical Machining (ECM):** Basic Principle, Estimation of MRR, MRR in multiphase alloys, Modeling of Kinematics and Dynamics for ECM process, Tool design, Surface Finish and Numerical approach.

**Different Electrochemical Machining:** Grinding, drilling, Milling, Turning and boring (basic principle and process parameters)

**THERMAL MATERIAL REMOVAL PROCESSES:**

**Electro-discharge machining (EDM):** Basic Principle, Process parameters, Estimation of MRR, Modeling of depth of melting temperature, Role of cavitation and melting temperature of the work-piece material, Surface finishing and machining accuracy Electrode and dielectric fluid, EDM turning and Wire EDM.

**Electron Beam Machining (EBM):** Introduction, Comparison of E-beam machining with other thermal processes, Setup for EBM, Power requirement in E-Beam, Mechanics of EBM process, Derivation of functional characteristics in EBM by using Buckingham's Pie theorem.

**Laser Beam Machining (LBM):** Introduction, types of lasers and feedback mechanisms, MRR, Numerical modeling on semi-infinite surface and with circular beams, Estimation of machine time, Steady state hole penetration model in LBM.

**Practice:**

These Laboratory classes aim at:

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3. Develop setup, instrumentation, equation, product, etc.
4. Modelling & Simulation of the process
5. Simple project
6. Creation of concept
7. Application to real problem
8. Assignments suggested by the instructor.

**Text Book(s) and References:**

1. Advanced manufacturing processes, Hassan Abdel, Gabad El HOFFY, McGraw Hill.
2. V.K.Jain, Advance Machining Processes, Allied Publisher Bombay.
3. Ghosh and Mallik, Manufacturing Science, EWP Private Ltd.
4. Pandey P.C., Shan H.S., Modern machining processes, Tata McGraw-Hill Education
5. Weller E.J., Nontraditional machining processes, Society of Manufacturing Engineers, Publications.

Course Title	Course Code	Structure (I-P-C)		
Industrial IoT and Cloud Computing	ME511	3	3	5

**Pre-requisite, if any:** Nil

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

<b>CO1</b>	Understand the existing IoT architectures
<b>CO2</b>	Design an IoT system with cloud infrastructure
<b>CO3</b>	Implement a prototype of the IoT/cloud system design
<b>CO4</b>	Understand the existing cloud architectures

**Syllabus:**

Introduction, Physical design of IoT, Logical design of IoT, IoT enabling technologies, Domain specific IoTs  
IoT design methodology, logical design

IoT physical devices (such as Raspberry Pi, pcDuino, Beaglebone black, Cubieboard)

Introduction to cloud computing: cloud models, cloud service examples, cloud based services & applications

Virtualization, load balancing, scalability, deployment, replication, monitoring, SDN, network function virtualization, MapReduce, identity and access management, SLAs.

Cloud service and platforms: Commercial clouds (such as Amazon elastic compute cloud, Google Compute engine, Windows Azure), Storage services, database services, application services, content delivery services, analytics services, Open source private clouds.

Case studies: Industrial automation, Cloud for IoT

**Practice:**

These Laboratory classes aim at:

1. Understanding the phenomena involved
2. Study of influencing parameters
3. Develop setup, instrumentation, equation, product, etc.
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5. Simple project
6. Creation of concept
7. Application to real problem
8. Assignments suggested by the instructor.

**Practice:** (practice exercises can be mini projects)

Using IoT devices small systems like classroom automation, smart parking, environment monitoring can be designed and implemented. Also, hadoop cluster can be set up and studied. Cloud computing with IoT for healthcare and industrial automation can be studied

**Text Book(s) and References:**

1. A. Bahga and V. Madiseti, Internet of Things, A hands-on approach, CreateSpace Independent Publishing Platform, 1st edition, 2014, ISBN: 978-0996025515.



2. A. Bahga and V. Madiseti, Cloud Computing, A hands-on approach, CreateSpace Independent Publishing Platform, 1st edition, 2013, ISBN: 978-1494435141
3. S. Jeschke, C. Brecher, H. Song, and D. B. Rawat, Industrial Internet of Things: Cybermanufacturing Systems, Springer, 1st edition, 2017, ISBN: 978-3319425580.
4. T. Erl, Z. Mahmood, and R. Puttini, Cloud Computing: Concepts, Technology & Architecture, Prentice Hall, 1st edition, 2013, ISBN: 978-0133387520.

Course Title	Course Code	Structure (I-P-C)		
Modelling and Simulation of Manufacturing Systems	ME512	3	3	5

**Pre-requisite, if any:** Basics of simulation and modelling

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

<b>CO1</b>	Design and evaluate a given manufacturing system using simulation.
<b>CO2</b>	Generate random numbers and variants to execute a simulation model; and Modelling of statistical analysis and report generation
<b>CO3</b>	Evaluate queuing networks and markov chains in the context of manufacturing
<b>CO4</b>	Design a complete range of statistical distribution options to accurately model process variability.
<b>CO5</b>	Develop object paths and routes for simulation and
<b>CO6</b>	Realistic 2D and 3D animation capabilities to visualize results beyond numbers and Analyse Performance metrics and dashboards

**Syllabus:**

**Introduction to System and simulation:** Concept of system and elements of system, Discrete and continuous system, Models of system and Principles of modeling and simulation, Monte carlo simulation, Types of simulation, Steps in simulation model, Advantages, limitations and applications of simulation, Applications of simulation in manufacturing system.

**Review of statistics and probability:** Types of discrete and continuous probability distributions such as Geometric, Poisson, Uniform, Geometric distribution with examples, Normal, Exponential distribution with examples

**Random numbers:** Need for RNs, Technique for Random number generation such as Mid product method, Mid square method, and Linear congruential method with examples  
Test for Random numbers: Uniformity - Chi square test or Kolmogorov Smirnov test, Independency- Auto correlation test

**Random Variate generation:** Technique for Random variate generation such as Inverse transforms technique or Rejection method  
Analysis of simulation data: Input data analysis, Verification and validation of simulation models, Output data analysis

**Simulation languages:** History of simulation languages, Comparison and selection of simulation languages  
Design and evaluation of simulation experiments: Development and analysis of simulation models using simulation language with different manufacturing systems

**Practice:**

Predict the course and results of certain actions. Gain insight and stimulate creative thinking. Visualize your processes logically or in a virtual environment.

Identify problem areas before implementation. Explore the potential effects of modifications. Confirm that all variables are known.

Optimize your operations. Evaluate ideas and identify inefficiencies. Understand why observed events occur. Communicate the integrity and feasibility of your plans.

Improve visibility into the effect of a system or process change. Explore opportunities for new procedures or methods without disrupting the current system. Diagnose and fix problems. Reduce or eliminate bottlenecks

Reduce operating costs. Improve financial forecasting. Better assess hardware and software requirements. Reduce delivery times. Better manage inventory levels, personnel, communications systems, and equipment. Increase profitability through overall improved operations.

**Text Book(s) and References:**

1. Jerry Banks, John S. Carson, Barry L. Nelson, David M. Nicol, and P. Shahabudeen, Discrete Event System Simulation, PHI, New Delhi, 2008.
2. Averill M. Law and W. David Kelton, Simulation Modeling and Analysis, Tata McGraw Hill, New Delhi, 2006.
3. N. Viswanadham and Y. Narahari, "Performance Modeling of Automated Manufacturing Systems", PHI, New Delhi, 2007.

Course Title	Course Code	Structure (I-P-C)		
Micro and Nano Manufacturing Technology	ME513	3	3	5

**Pre-requisite, if any: Nil**

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

<b>CO1</b>	Model the material removal in various micro manufacturing processes.
<b>CO2</b>	Analyze the processes and evaluate the role of each process parameter during machining of various advanced materials.
<b>CO3</b>	Select the best process out of the available various advanced manufacturing processes for the given job assignment.
<b>CO4</b>	Understand requirements to achieve maximum material removal rate and best quality of machined surface while machining various industrial engineering materials.
<b>CO5</b>	Assess the difference between macro and micro machining process
<b>CO6</b>	Predict appropriate parameter for optimum machining and better product quality

**Syllabus:**

**Introduction:** Introduction to the Course & Classification of Micromanufacturing Processes. Challenges in Meso-, Micro-, and Nanomanufacturing.

**Introduction to Traditional and Advanced Micromachining Processes:** Microturning, Micromilling, Microgrinding, Biomachining, Micro- and Nano-manufacturing by Focused Ion Beam, Electric discharge micromachining, Electrochemical micromachining, Abrasive water jet micromachining.

**Microcasting and Micromolding:** Microcasting, Micromolding – A soft Lithography Technique.

**Microforming:** Introduction to Microforming, Micro- and Nanostructured Surface Development by Nano Plastic Forming and Roller imprinting, Microextrusion, Microbending with Laser.

**Microjoining:** Introduction to microjoining, Laser Microwelding, Electron Beams Microwelding and Applications. Fabrication of Microelectronic Devices.

**Nanofinishing:** Magnetorheological and Allied Finishing Processes and their theoretical analysis, Theoretical Analysis of Abrasive Flow Finishing, An Integrated Wafer Surface Evolution Model for Chemical Mechanical Planarization (CMP).

**List of suggested experiments:**

1. Experimental study on micro turning
2. Experimental study on micro milling
3. Experimental study on micro drilling
4. Investigation on micro machining under Minimum Quantity Lubrication (MQL) condition
5. Ultrasonic machining
6. Experiments on Electrochemical machining
7. Experiments on Electrodeposition

**Text Book(s) and References:**

1. Micromanufacturing, V. K. Jain (Ed.), CRC press, 2012.
2. Micromanufacturing & Nanotechnology, N. P. Mahalik, Springer.
3. Microfabrication & Nanomanufacturing, Mark J. Jackson, CRC press.
4. Introduction to Micromachining, V. K. Jain (Ed.), Narosa publisher, 2010.
5. HMT, Production Technology. Tata McGraw Hill, 2004.
6. ASTME, Tool Engineer's Handbook
7. E. P. DeGarmo, J. T. Black, and R. A. Kohser, "DeGarmo's materials and processes in manufacturing", John Wiley & Sons, 2011.
8. M. P. Groover, "Principles of Modern Manufacturing", 5th Edition, Wiley, 2014
9. S. Kalpakjain, and S. R. Schmid, "Manufacturing processes for engineering materials", 5th Edition, Pearson Education, 2010.
10. W. A. J. Chapman, Workshop Technology, Vol. 2 & 3. CBS Publishers & Distributors, 1980.
11. N. K. Mehta, Machine Tool Design and Numerical Control, 2<sup>nd</sup> ed. Tata McGraw Hill, 1996