M. Tech. Mech. Manufacturing Engineering

Structure & Syllabus

2021-2023

Department of Mechanical Engineering

K. E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute Affiliated to Shivaji University)

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Rajarambapu Institute of Technology, Rajaramnagar

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Department of Mechanical Engineering

Curriculum Structure and Evaluation Scheme of

M. Tech. Mechanical- (Manufacturing Engineering)

With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: F. Y. M. Tech. **Semester:** I

Course Code	Course	Teaching Scheme				Evaluation Scheme				
							Theory Marks		Practical Mark	
		L	T	P	Credits	Scheme	Max	Min. % for passing	Max.	Min.% for passing
SHP5131	Advanced Mathematical Methods in Engineering	3	-	-	3	ISE	20	40	----	----
						UT1	15		----	----
						UT2	15		----	---
						ESE	50	40	----	----
MMF101	Additive Manufacturing for Industry 4.0	3	-	-	3	ISE	20	40	----	----
						UT1	15		----	----
						UT2	15		----	----
						ESE	50	40	----	----
MMF102	Industrial Process Automation Systems	3	-	-	3	ISE	20	40	----	----
						UT1	15		----	----
						UT2	15			
						ESE	50	40	----	----
PE-I	Program Elective-I	3	-	-	3	ISE	20	40	----	----
						UT1	15		----	----
						UT2	15		---	----
						ESE	50	40	----	----
PE-II	Program Elective-II	3	-	-	3	ISE	20	40	----	----
						UT1	15		----	----
						UT2	15			
						ESE	50	40	----	----
MMF1161	Software Proficiency-I	-	-	4	2	ISE	----	----	50	50
						ESE	---	----	50	50
MMF1171	Manufacturing Simulation Lab	-	-	4	2	ISE	----	----	50	50
						ESE	----	----	50	50
SHP5511	Technical Communication	2	-	-	Audit Course	ISE	-	-	50	50
	TOTAL	**17**	**-**	**08**	**19**					

Total Contact Hours/week 25
Total Credits 19

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Program Elective-I

Sr. No.	Course Code	Course
1.	MMF1031	Advanced System Components & Integration
2.	MMF1041	Mechatronics System Design for Manufacturing
3.	MMF1051	Industrial Networks & Controllers
4.	MMF106	Metal Cutting & Tool Design
5.	MMF107	Applied Data Analytics
6.	MMF108	Advanced Manufacturing Technology
7.	MMF109	Finite Elements Methods in Manufacturing

Program Elective-II

Sr. No.	Course Code	Course
1.	MMF1101	Solidification Processes
2.	MMF1111	Digital Process Control
3.	MMF1121	Machine Vision & Application
4.	MMF1131	Advanced MEMS fabrication & Microfluidics
5.	MMF114	Industrial Surface Engineering
6.	MMF115	Composite Materials & Processing

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Class: F. Y. M. Tech. **Semester:** II

Course Code	Course	Teaching Scheme				Evaluation Scheme					
							Theory Marks			Practical Marks	
		L	T	P	Credits	Scheme	Max	Min. % for passing		Max.	Min.% for passing
MMF201	Robotics & Automation	3	-	-	3	ISE	20	40	40	----	----
						UT1	15			----	----
						UT2	15			----	----
						ESE	50	40		----	----
MMF202	Lean Six Sigma	3	-	-	3	ISE	20	40	40	----	----
						UT1	15			----	----
						UT2	15			----	----
						ESE	50	40		----	----
PE-III	Program Elective-III	3	-	-	3	ISE	20	40	40	----	----
						UT1	15			----	----
						UT2	15				
						ESE	50	40		----	----
PE-IV	Program Elective-IV	3	-	-	3	ISE	20	40	40	----	----
						UT1	15			----	----
						UT2	15			---	----
						ESE	50	40		----	----
MMF2131	Research Methodology & IPR	2	-	-	2	ISE	20	40	40	----	----
						UT1	15			----	----
						UT2	15				
						ESE	50	40		----	----
MMF2141	CAM Lab	-	-	4	2	ISE	----	----		50	50
						ESE	---	----		50	50
MMF2151	Software Proficiency-II	-	-	4	2	ISE	----	----		50	50
						ESE	----	----		50	50
MMF2161	Mini Project	-	-	4	2	ISE	---	---		50	50
	TOTAL	**14**	**-**	**10**	**20**						

Total Contact Hours/week **24**
Total Credits **20**

ISE = In Semester Exam, MSE (UT1+UT2) UT-I = Unit Test-I, UT-II = Unit Test-II ESE = End Semester Exam

*Note- Student has to complete internship of 02 weeks after 2nd semester however its evaluation will be carried out in 3rd semester.

Program Elective-III

Sr. No.	Course Code	Course
1.	MMF2031	Material Characterization & Failure Analysis
2.	MMF2041	System Modelling & Simulation
3.	MMF205	Polymer Processing & Die Design
4.	MMF206	Product Life Cycle Management
5.	MMF207	Metrology 4.0

Program Elective-IV

Sr. No.	Course Code	Course
1.	MMF2081	Sustainable Manufacturing Processes
2.	MMF2091	Logistics & Supply Chain Management
3.	MMF210	Project Management for Industry 4.0
4.	MMF211	Quality and Reliability Engineering
5.	MMF212	Optimization Techniques & Industrial Applications

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Class: S. Y. M. Tech. **Semester:** V

Course Code	Course	Teaching Scheme				Evaluation Scheme				
							Theory Marks		Practical Mark	
		L	T	P	Credits	Scheme	Max	Min.% for passing	Max.	Min. % for passing
MMF3011	Industry Internship	-	-	2	Audit Course	ISE	-	-	P/NP	
MMF302	Open Elective	3	-	-	3	ISE	50	40	--	--
MMF3031	Dissertation Stage I	-	-	8	4	ISE	---	---	100	50
MMF3041	Dissertation Stage II	-	-	12	6	ISE	----	----	100	50
						ESE	----	----	100	50
	TOTAL	**3**	-	**22**	**13**					

Total Contact Hours/week 25
Total Credits 13

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Open Elective-I

Sr. No.	Course Code	Course
1.	MOE2010	Artificial Intelligence - Machine Learning
2.	MOE2020	Creative Thinking: Techniques and Tools
3.	MOE2030	MOOC Course
4.	MOE2040	Condition Monitoring and Signal Processing
5.	MOE2050	Aircraft Conceptual Design

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Class: S. Y. M. Tech. **Semester:** IV

Course Code	Course	Teaching Scheme				Evaluation Scheme				
							Theory Marks		Practical Mark	
		L	T	P	Credits	Scheme	Max	Min.% for passing	Max.	Min. % for passing
MMF4011	Dissertation Stage III	-	-	12	6	ISE	---	---	100	50
MMF4021	Dissertation Stage IV	-	-	20	10	ISE	----	----	100	50
						ESE	----	----	100	50
	TOTAL	-	-	**32**	**16**					

Total Contact Hours/week **32**
Total Credits **16**

ISE = In Semester Exam, MSE (UT1+UT2) UT-I = Unit Test-I, UT-II = Unit Test-II ESE = End Semester Exam

TOTAL CREDITS:19+20+13+16=68
TOTAL CONTACT HOURS:25+23+25+32=105

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Class: -**F. Y. M.Tech.**	Semester-**I**
Course Code: **SHP5131**	Course Name: **Advanced Mathematical Methods in Engineering**

L	T	P	Credits
03	-	--	03

Course Description:

Advanced Mathematical Methods in Engineering is a core subject introduced at Semester I of first year M.Tech. Mechanical Engineering. This course intends to build the competency in the students to apply the knowledge of mathematics to the solution of engineering problems and to analyze it.

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Evaluate Fourier series and Fourier Transforms for given function and apply it to solve the partialdifferential equations in Engineering problems.
2. Apply the specific method of solution of partial differential equations for solving the givenproblems.
3. Formulate and solve a boundary value problem (Partial differential equation, boundary.
4. Use the relevant method for solving the simultaneous linear equations and compute the Eigenvalues.
5. Estimate numerically the solution of given algebraic equation.
6. Analyze the variance and explain the different research designs.

Prerequisite: Undergraduate engineering mathematics

Course Content

Unit No	Description	Hrs
1.	**FOURIER SERIES AND FOURIER TRANSFORMS** Fourier series: The Fourier series of a function, Convergence of a Fourier series, Fourier Cosine and Sine series, Integration and differentiation of Fourier series. The Fourier Integral, The Fourier Cosine and Sine Integrals, The Complex Fourier Integral and the Fourier Transforms, Inverse Fourier Transforms.	06

2.	First order partial differential equations; Second order linear partial differential equation: Canonical forms: Second order equation (Parabolic, Elliptic and Hyperbolic) in rectangular, cylindrical, polar and spherical coordinate systems; Solution techniques: Separation of variables, Eigen function expansions.	06
3.	**APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS** The wave Equation and Initial and Boundary Conditions, Fourier Series solution of the wave equation, Fourier Transform Solution of Problems on Unbounded Domains, Characteristics and D'Alembert's Solution: D'Alembert's solution for the wave equation, A nonhomogeneous wave equation, Forward and backward waves, Normal modes of vibration of a circular elastic membrane, Vibration of rectangular membrane.	06
4.	**SIMULTANEOUS LINEAR EQUATIONS** Gaussian Elimination method, Gauss Jordan method, LU- decomposition from Gaussian Elimination method, Solution of Tridiagonal Systems, Eigen Value problems.	06
5.	**NUMERICAL METHODS** Muller's Method, Horner's Method, Multiple roots, Lin Bairtow's Method,Graeffe's Squaring Method.	06
6.	**ANOVA** One-way, Two-way with/without interactions., ANOVA technique, Principles of Design of Experiment: Some standard designs such as Latin-Square Design (LSD), Completely Randomized Design (CRD), Randomized Block Design (RBD).	06

References –

1. Larry C. Andrews, Ronald L. Phillips, Mathematical Techniques for Engineers and Scientists, Prentice Hall of India Private Ltd. New Delhi, ISBN-81-203-2826-14, 2005.
2. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley Eastern, NEWDELHI, Tenth Edition, 2010.
3. J. B. Doshi, Differential Equations for Scientients and Engineers, Narosa 2010.
4. Peter O'Neil, Advanced Engineering Mathematics, Seventh Edition,Cengage Learning2012 (Indian Edition)
5. Michel Greenberg, Advanced Engineering Mathematics, Second Edition, Pearson's Education, 2002 (Indian Edition).
6. Ramamurthy. V., Computer Aided Design in Mechanical Engineering., Tata McGraw HillPublishing Co., 1987.
7. Fundamental Concepts in the Design of Experiments, 5th Ed., by Hicks and Turner.

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Class: - **F.Y. M. Tech**	Semester-I
Course Code: **MMF101**	Course Name: **Additive Manufacturing for Industry 4.0**

L	T	P	Credits
3	-	--	3

Course Description:

The course, Additive Manufacturing Systems, deals with various aspects of additive, subtractive, and joining processes to form three-dimensional parts with applications ranging from prototyping to production. Additive manufacturing (AM) technologies fabricate three- dimensional (3D) parts using layer-based manufacturing processes directly from computer-aided-design (CAD) models. Direct digital manufacturing (DDM) or rapid manufacturing (RM) is the use of AM technologies in direct manufacturing of end-use parts. In this course, students will learn about a variety of AM and other manufacturing technologies, their advantages and disadvantages for producing both prototypes and functional production quality parts, and some ofthe important research challenges associated with using these technologies.

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Describe the Importance of AM technologies in Manufacturing
2. Classify and select additive manufacturing processes for a given application.
3. Design for manufacture for AM and carry out Process Analysis
4. Point out the software issues addressed in the additive manufacturing process.
5. Identify the Different methods for Post-processing of AM parts
6. Suggest the Applications of AM in Automobile, Aerospace, and Bio-medical etc.

Prerequisite:

Fundamentals of basic engineering principles.

Course Content		
Unit No	**Description**	**Hrs**
1.	**Basic principles of Additive Manufacturing:** Introduction to AM, AM evolution, Distinction between AM & CNC machining, Advantages of AM **AM process chain**: Conceptualization, CAD, conversion to STL, Transferto AM, STL file manipulation, Machine setup, build, removal and clean up,post processing.	**06**

2.	**Classification of AM processes:** Liquid polymer system, discrete particle system, molten material systems, and solid sheet system.	**06**
3.	**Design for AM:** Design tools for AM, Part Orientation, Removal of Supports, hollowing out parts, Inclusion of Undercuts and Other Manufacturing Constraining Features, Interlocking Features, Reduction of Part Count in an Assembly, Identification of markings/ numbers etc. Motivation, DFMA concepts and objectives, AM unique capabilities, Exploring design freedoms	**06**
4.	**Guidelines for process selection:** Introduction, selection methods for a part, challenges of selection, example system for preliminary selection, production planning and control. Software issues in Additive Manufacturing, problems with STL file, STL file manipulation.	**06**
5.	**Post Processing** Support Material removal, Surface texture improvement, accuracy improvements, Aesthetic improvements, preparation for use as a pattern, Property enhancement.	**06**
6.	**AM Applications:** Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts, Re-manufacturing. Application examples for Aerospace, defense, automobile, Bio-medical and general engineering industries.	**06**

References -

Text Books:

1. Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles & Applications", World Scientific, 2003.
2. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010
3. Ali K. Kamrani, Emand Abouel Nasr, "Rapid Prototyping: Theory & Practice",Springer, 2006.
4. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001

Reference Books:

1. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011.

2. J.D. Majumdar and I. Manna, Laser-assisted fabrication of materials, Springer Series in Material Science, 2013.
3. L. Lu, J. Fuh and Y. S. Wong, Laser-induced materials and processes for rapid prototyping, Kluwer Academic Press, 2001.
4. Zhiqiang Fan and Frank Liou, Numerical modeling of the additive manufacturing (AM) processes of titanium alloy, InTech, 2012

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Class: **F.Y. M. Tech.**	Semester-**I**
Course Code: **MMF102**	Course Name: **Industrial Process Automation Systems**

L	T	P	Credits
3	--	--	3

Course Description: The course gives an overview of automation history and followed by units on PLC, DCS and SCADA - describing how such technologies have become synonymous in process instrumentation and control. The introduction of the niche of Fieldbuses in process industries is vital to technologies. It then goes on to discuss wireless communication in the automation sector and its applications in the industrial arena. The course covers all aspects related to Batch Automation System Design & functional safety & safety instrumented system design

Course Learning Outcomes:

At the end of course students must be able to:

1. Select appropriate automation technologies for process control system.
2. Design industrial process automation as per specifications of the customers
3. Anaysze system performance.

Course Content

Unit No.	Description	Hrs.
1.	**Industrial Process Automation:** Role of automation in process industry-Transmission media & technology-Device Connectivity-Automation System Controllers-Objectives of the plant information & control systems-The generic duties of an Automation system in hierarchical form-functional requirements of an integrated information and automation systems: a generic list-conceptual/functional topology of an automation system-physical architecture	06
2.	**Programmable Logic Controllers (PLC)-** Role of PLC in process automation-Advanced PLC functions-PLC communication-Selection and commissioning of PLC-Future of PLC-PLC based automation-PLC & Programmable Automation Controller-Unified Human-Machine Interface-Plug & Play Solutions-Wireless link of PLC-Enterprise resource planning with PLC-Industrial internet Things & PLC.	06

3.	**Distributed Control System (DCS)-** Computers in process automation-Role of computers in Process Automation-Architecture of computer based industrial automated system-hardware & software configurations-Process Simulation-functional components of DCS-functional features of DCS, Process Automation Network-Components of Industrial Network & Topologies-Communication Modes-Protocols in Process Automation, **Supervisory Control & Data Acquisition (SCADA)-** SCADA architecture-First Generation-Second Generation-Third Generation - Fourth Generation-Functions of SCADA-Elements of SCADA-SCADA communication Protocol-SCADA software & their key features-SCADA & IIoT	06
4.	**Batch Automation System-** Batch Process-batch control-importance & characteristic of batch-Batch Industry Classification-Special Operations in batch-Architecture of Batch Control System-Standards Related to Batch Industries-S88.01 & S88 .02 Standard-Sequential & Procedural Control-Structure of SCM/RCM	06
5.	**Functional Safety and Safety Instrumented Systems-** Introduction-what if functional safety-safety functions & safety related systems-examples of functional safety-Legislations & Standards-IEC 61508/IEC 61511: An Introduction-Scope of The Standard-The Overall Safety Life Cycle (Sls)- Risk and Its Analysis and Reduction-Safety Requirements And Safety Functions-Safety Integrity Levels (Sil)- Functional Safety Management-Layers Of Protection-Risk Analysis Techniques-Safety Requirement Specifications-Reliability And Diagnostics.	06
6.	**Fire And Gas Detection System-** Introduction-the Fire and Gas (F&G) Detection System-Need for An F&G System-Challenges In Process Plants-Causes Of Fire-Understanding Industry Safety Performance Standards-Critical Components-F&G Detectors-F&G Network Architecture-Addressable Devices-Nonaddressable Devices-F&G Network-Fire Alarm Panel-Public Announcement System-Integrated Approach For F&G-Typical Industry Application.	06

References: Text Books:

1. Industrial Process Automation System, by B. R. Mehta, Elsevier Publishing.
2. Industrial Automation Technologies, Chanchal Dey, Sunit Kumar Sen CRC Press, Taylor & Francis Group.

Reference Books:

1. Anderson, N.A., 1998. Instrumentation for Process Measurement and Control Third ed. CRC Press.
2. Olivier Hersent, David Boswarthick, Omar Elloum, The Internet of Things: Key Applications and Protocols, ISBN: 978-1-119-99435-0, 2nd Edition, Willy Publications
3. Integrated Fire and Gas Solutions – Improves Plant Safety and Business Performance, ISA
4. Internet of Things- From Research and Innovation to Market

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Semester I: Program Elective I

Class: - **F. Y. M.Tech.**	Semester-**I**
Course Code: **MMF1031**	Course Name: **Advanced System components & Integration**

L	T	P	Credits
03	-	--	03

Course Description: The main objective of this course is to teach new paradigm i.e. Industry 4.0, Digital Industry or Industrial Internet of Things (IIoT). This paradigm seeks to leverage the potential optimization in production and logistics caused by increased and integrated industrial automation, intelligent system monitoring, and autonomous decision making that is supported by real-time or almost real-time communication at all levels. This course covers the network technologies that support system integration of process/manufacturing automation, building automation, environment management, as well as energy management and electricity systems automation (smart grid systems). In other words, the course covers the network (hardware and software, including Net DDE, OPC, and SCADA Systems) infrastructure of IIoT. Moreover, the course covers other IIoT infrastructure components such as Artificial Intelligence based control systems. Apart from this, the use of wireless technology in automation systems, safety systems, and organizational approach to automation are also covered.

Prerequisite: Basic knowledge about manufacturing systems & process automation, VB, CC, both hardware & software

Course Learning Outcomes:

At the end of course students must be able to:

1. Identify hardware and software issues for system integration in process and manufacturing automation and be able to offer solutions.
2. Use engineering software tools such as VB & C++, .NET, NetDDE, OPC (including COM & DCOM), web services, HMI, DLLs and APIs.
3. Specify hardware and software components and functions of advanced systems such as robotics and vision, automated work cells, flexible manufacturing systems, and computer integrated manufacturing as related to plant wide automated system integration and IIoT.
4. Implementation of Fuzzy Logic and Neural Network Control Systems, and identify advantages, and disadvantages of such controllers.
5. Select state-of-the art advanced sensors and actuators for process and manufacturing automation systems.
6. Describe and apply wireless standards and applications used in industrial automation projects.
7. Apply process and machine safety standards in the design, integration and maintenance of process automation systems.

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Course Content		
Unit No	**Description**	**Hrs**
1.	**Introduction & Web Technologies** Topics: Introduction, Application Protocols, Standards and Web Services, Communication Protocols, ISO Communication Reference Model, TCP/IP Protocol, Using Ethernet to Integrate Industrial Systems. **Automation Using IEC 61850** Topics: Introduction to Power system operation and Control, Legacy Electricity Data System, IEC61850 Standard	06
2.	**OPC Foundations & Technology** Topics: Introduction, legacy systems, OPC support technologies, OPC Data Access, OPC Alarms and Events, Using OPC to Support IIoT (Data Hub). OPC Batch, OPC Unified Architecture, OPC and Substation automation,HMI, SCADA **Profinet** Topics: Introduction Profinet controllers and I/O, Diagnostics, RT, IRT, Redundancy. PROFINET for PA, PROFINET CBA	06
3.	**Building Automation Systems** Topics: BACnet, LONworks, gateways, Routers, Network, Architecture, services, Using OPC to Integrate BACnet with other Industrial Automation Protocols to form IIoT. **Flexible Manufacturing** Topics: Material movement and positioning. Manufacturing Flexibility, FMS Features, FMS Priority, Planning and Control Hierarchy, Generic Control Model, System Design, Scheduling and Control	06
4.	**Artificial Intelligence & Fuzzy Logic** Topics: Components of AI systems, Diagnostic AI systems, Knowledge Based Systems, Expert System, Use of AI in IIoT **Neural Network Control Systems** Topics: What are Neural Networks, Biological Neural Networks, Artificial Neural Networks-ANN - Feed forward net, Training	08
5.	**Wireless Systems** Topics: Overview of wireless technologies, factors for industrial application, design consideration, Implementation, security considerations	04
6.	**Advanced Sensors and Actuators** Topics: Pneumatic and Hydraulic Systems, Piezoelectric Motors, RFIDsensors **PC in Automation** Topics: PCI Cards, Devicenet Scanner, Profibus Scanner, ApplicomIO, EtherCAT, HMI, SCADA Systems, IIoT. **Safety Standards & System Integration** Topics: IEC61508, IEC 61511, Integrated safety, OPC & SI	06

References -

1. A Practical Approach to Industrial System Integration, Tom Wanyama publisher: IAA

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Department of Mechanical Engineering
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M. Tech. Mechanical- (Manufacturing Engineering)
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Class: -**F. Y. M.Tech.**	Semester-**I**
Course Code: **MMF1041**	Course Name: **Mechatronics System Design for Manufacturing**

L	T	P	Credits
03	-	--	03

Course Description:

Mechatronics emphasizes the necessity of integration and interaction among different branches of engineering. Mechatronics philosophy challenge traditional engineering thinkingand practices. Mechatronics implementation involves a team activity and crossing boundaries between conventional engineering disciplines.

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Demonstrate the method and importance of integration of Mechanical, Electronicsand Control in the design of Mechatronics system.
2. Select key elements of sensors and transducers and interfacing the same with problem under consideration through PLC.

Prerequisite:
Basic knowledge in electrical and digital electronics.

Course Content

Unit No	Description	Hrs
1.	**Mechatronic System:** Evolution, scope and components of mechatronic systems, mechatronics in product and measurement system, control system and modes of control, traditional design and mechatronic design. **Actuators, Sensors and Transducers:** Hydraulic, pneumatic and electrical actuators and their system modeling, performance terminology,system modeling of sensors; displacement, position and proximity sensors, velocity and acceleration sensors, flow sensors, force sensors, temperature sensors, ultrasonic and fiber-optic sensors, selection of sensor, piezo-electric sensors.	06

2.	**Hardware Components** Number system in Mechatronics, binary logic, Karnaugh Map minimization, transducer signal conditioning process, principles of analogue and digital signal conditioning, protection, filtering operational & instrumentational operational amplifiers and their gains, analogue to digital and digital to analogue conversions, multiplexers and pulse modulations.	06
3.	**Programmable Logic Controller** Review of logic gates, basic structure, features, input/output processing, programming, functional block diagram (FBD), ladder diagram, logic functions, latching, sequencing, jumps, internal relays, counters, shift registers, master and jump control, data handling, data movement, data comparison, arithmetic operations, code conversion, analog input and output, applications for automation, diagnostics and conditionmonitoring.	06
4.	**Microcontroller:** Comparison between microprocessor and microcontroller, organization of microcontroller system, architecture of MCS 51 controller, pin diagram of 8051, addressing modes, programming of 8051, interfacing input and output devices, interfacing D/A converters and A/D converters, Various applications for automation and control purpose.	06
5.	**Real-Time Interfacing:** Introduction, Elements of Data Acquisition and Control System, Overview of I/O Process, Installation of the I/O Card and Software, Installation of the application Software, Examples, Over framing.	06
6.	**Advanced Applications in Mechatronics:** Mechatronic control in automated manufacturing, Artificial Intelligencein mechatronics, Fuzzy Logic application in Mechatronics, Microsensors in Mec hatronics, Case studies of Mechatronic systems.	06

References -

1. Mechatronics, 3/e --- W. Bolton (Pearson Education)
2. The 8051 Microcontroller: Architecture, Programming and Applications, 2/e Kenneth J. Ayala (Penram International).
3. Mechatronics: Principles, Concepts and Applications - N. P. Mahalik (TMH).
4. Introduction to Mechatronics & Measurement Systems - David G. Alciatore & Michael B. Histand (TMH).
5. Mechatronics System Design - Devdas Shetty, Richard A. Kolk (Thomson).
6. Computer Control of Manufacturing Systems – Yoram Koren (McGraw Hill).
7. Automated Manufacturing Systems: Sensors, Actuators - S. Brain Morriss (McGrawHill)
8. Sensors in Production Engg. - FESTO Controls Pvt. Ltd., Bangalore.
9. Programmable Logic Controllers" Programming Methods and -Jack R. Hackworth& Fredrick D. Hackworth, Jr.(Pearson Education).

K.E. Society's
Rajarambapu Institute of Technology, Rajaramnagar
(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)
Department of Mechanical Engineering
Curriculum Structure and Evaluation Scheme of
M. Tech. Mechanical- (Manufacturing Engineering)
With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: **F.Y. M. Tech**	Semester-I
Course Code: **MMF1051**	Course Name: **Industrial Network & Controllers**

L	T	P	Credits
3	--	--	3

Course Description:

Courses contents fundamental knowledge about Corporate and industrial networks, OSI model, Ethernet and TCP/IP, Modbus, Foundation Field bus, DeviceNet, PROFIBUS, AS-I,proprietary buses and protocols and interfaces, distributed I/O, drivers and devices and theirimplementation in PC and PLC based systems.

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Design Industrial Networking architecture.
2. Select networking technologies for industrial automation applications.
3. Follow I/O bus installation and wiring connections guidelines for setting up industrial networks.
4. Design, configure, and program fieldbus networks. Program the communication among industrial automation controllers.

Prerequisite: Process automations basic

Course Content

Unit No.	Description	Hrs.
1.	**Industrial Control Systems and Networking**: Course introduction, Basic Elements of an Automated System, Levels of Automation, Process Industries vs. Discrete Manufacturing Industries, Continuous Control, DCS Systems, Networking: Process Control, Supervisory Control, enterprise Control.	04
2.	**Introduction to Communication & Networking Fundamentals**: Communications Process, Interface Standards, Coding, Protocols, Common Communication Protocols, Communication Channels and Properties, Data Transmission Modes. Encoding Methods, Error Detection, Network Communication and Components, Types of Networks, Interoperability and Internetworking, Protocols and Protocol Standards, IEEE/ISO Standards, Network Topologies, Media Access Methods, Industrial Ethernet & TCP/IP 10, 100 & Gigabit Ethernet, troubleshooting Ethernet Networks, TCP/IP Introduction, Internet Layer Protocols, Design of Ethernet based Networks, Node Addressing, LAN, Sub-Networks, TCP and UDP, Troubleshooting, Socket	06

	programming, Automation Trends, TCP/IP Based Factory Automation, Thin Servers, Network Security	
3.	**Ethernet IP** Topics covered: ODVA, OSI reference model, EtherNet/IPTerms & Definitions, Design of Ethernet IP Networks, Web Compatible SCADA Systems, Modbus, Modbus Plus and Modbus TCP Topics covered: Modbus Overview, Modbus Protocol Structure, Modbus Function Codes, Troubleshooting, Modbus Plus Technical Overview	**06**
4.	**CANBUS and DeviceNet** CAN Technical Overview, Application Layers, CANopen, DeviceNetTechnical Overview, ODVA **AS-I Interface** Reduced IOS reference model, ASinterface, Technical Overview, AS-i Applications, AS-i Consortium, AS-i Troubleshooting	**08**
5	**Profibus:** Introduction to Profibus, Profibus-PA (Process Automation), Profibus-DP (Decentralized Periphery), Network design and configuration **Foundation Fieldbus & HSE** Foundation Fieldbus, FF Wiring and Signalling,FF Intrinsic Safety and Power Delivery, Fault Tolerance and Single-Loop Integrity, FF Protocol, FF Function Blocks, FF Troubleshooting, High Speed Ethernet-HS	**06**
6.	**Proprietary Communication Protocols** Smart wire, IO-Link, OSI reference model, wiring, configuration, Gateways	**04**

References-

1. A Practical Approach to Industrial System Integration, by Tom Wanyama

K.E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)

Department of Mechanical Engineering

Curriculum Structure and Evaluation Scheme of

M. Tech. Mechanical- (Manufacturing Engineering)

With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: **F.Y. M. Tech**	Semester-**I**
Course Code: **MMF106**	Course Name: **Metal Cutting & Tool Design**

L	T	P	Credits
3	--	--	3

Course Description:
Mechanics of metal cutting, Machine stability & vibration analysis, design of tools for given component.

Course Learning Outcomes:
After successful completion of the course, students will be able to,

1. Analyze fundamental phenomena in metal cutting and grinding, through application of the principles of mechanics, materials, and allied engineering fields.
2. Develop quantitative and qualitative skills necessary to address practical issues pertaining to machining productivity and innovation and machine stability.
3. Design of press tools for given component.

Prerequisite: Fundamentals of tool engineering

Course Content

Unit No.	Description	Hrs.
1.	**Mechanics of metal cutting:** Essential features of metal cutting, mechanisms of chip formation, chip control, Mechanics of orthogonal cutting: Forces, stresses, energy consumption in the primary and secondary cutting zones, measurement and prediction, shear strain and shear stress in cutting, current trends in metal cutting research.	04
2.	**Tribological aspects of metal cutting:** Friction: Mechanisms and theories, stress distribution on tool face, friction at the tool/chip interface, Tool wear and tool life: Wear mechanisms and theories, application of theory to tool design, Heat in metal cutting: Cutting temperatures, energy dissipation in cutting, heat transfer models and analyses, effect of cutting conditions and tool geometry,Cutting fluids: Cutting fluid requirements for low speed and high speed applications, effect of cutting fluid on mechanism of chip formation	08
3.	**Material considerations in machining**: Tool materials: Conflicting requirements, selection of tool material, compatibility with workpiece for minimum tool wear, design and performance of coatings, Workpiece materials: Machining characteristics of alloy and hard steels, cast iron, aluminum, titanium and nickel-based alloys, and new materials, **Integrity of machined surfaces**: Surface finish: specification, measurement,	08

	effect of cutting conditions, Machining-induced residual stresses	
4.	**Principles of abrasive machining**: Abrasives and grinding wheels, mechanics of grinding, grinding forces and specific energy, wheel wear and grinding performance, grinding temperature, surface generation in grinding.	08
5.	**Machine vibration and stability analysis:** Classification of vibration in machining, stability analysis for machining process, diagnosis and reduction of chatter	04
6.	**Design of cutting tools:** Properties required for tooling materials, various tool materials, Jigs and fixtures, Design of cutting tools, Selection of carbide cutting tools **Design of press tools:** Die-design fundamentals; Material of die components, Design of Blanking and Piercing die, Progressive die, Strip-layout, Deep drawing die	08

References-

1. Boothroyd and Knight, Fundamentals of Machining and Machine Tools, Marcel Dekker (1989)
2. Ghosh and A. K. Malik, Manufacturing Science, Affiliated East West Press Pvt. Ltd., New Delhi, 2008.
3. H. El Hofy, Fundamentals of Machining Processes, Taylor and Francis, 2006.
4. G. C. Sen and A. Bhattacharyya, Principles of Machine Tools, New Central Book Agency (P) Ltd., Calcutta, 2nd Revised Edition, 2009
5. M. C. Shaw, Metal Cutting Principles, Oxford University Press, 2nd edition, 2008.
6. Cyril Donaldson, George H. Lecain and V. C. Goold, Tool design, 4th edition, TataMcGraw Hills, 2010.

K.E. Society's
Rajarambapu Institute of Technology, Rajaramnagar
(An Autonomous Institute affiliated to Shivaji University, Kolhapur)
Department of Mechanical Engineering
Curriculum Structure and Evaluation Scheme of
M. Tech. Mechanical- (Manufacturing Engineering)
With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: - **F.Y.M. Tech.**	Semester-I
Course Code: **MMF107**	Course Name: **Applied Data Analytics**

L	T	P	Credits
3	-	--	3

Course Description:
Data Analytics is the science of analyzing data to convert information to useful knowledge. This knowledge could help us understand our world better, and in many contexts enable us to make better decisions. While this is broad and grand objective, the last 20 years has seen steeply decreasing costs to gather, store, and process data, creating an even stronger motivation for the use of empirical approaches to problem solving. This course seeks to present you with a wide range of data analytic techniques and is structured around the broadcontours of the different types of data analytics, namely, descriptive, inferential, predictive, and prescriptive analytics

Course Learning Outcomes:
After successful completion of the course, students will be able to,
1. Explain need of Data analytics in real time application.
2. Apply ANOVA to the given data set.
3. Apply machine learning to the given data set.
4. Explain and apply different supervised learning techniques.

Prerequisite:
Linear algebra, and calculus. Knowledge of probability theory, statistics, and programmingis desirable.

Course Content		
Unit No	**Description**	**Hrs**
1.	**Introduction to Data Analytics:** Relevance and scope of data analytics. Descriptive Statistics, Probability Distributions.	**06**
2.	**Inferential Statistics:**	**06**

	Inferential Statistics through hypothesis tests Permutation & Randomization Test	
3.	**Regression & ANOVA:** Regression, ANOVA (Analysis of Variance)	04
4.	**Machine Learning:** Introduction and Concepts Differentiating algorithmic and model-based frameworks Regression: Ordinary Least Squares, Ridge Regression, Lasso Regression, K Nearest Neighbors Regression & Classification.	08
5.	**Supervised Learning with Regression and Classification techniques -1:** Bias-Variance Dichotomy, Model Validation Approaches Logistic Regression Linear Discriminant Analysis Quadratic Discriminant Analysis Regression and Classification Trees Support Vector Machines.	08
6.	**Supervised Learning with Regression and Classification techniques -2:** Ensemble Methods: Random Forest Neural Networks Deep learning	04

References -

Reference Books:

1. Hastie, Trevor, et al.The elements of statistical learning. Vol. 2. No. 1. New York: springer, 2009
2. Montgomery, Douglas C., and George C. Runger.Applied statistics and probabilityfor engineers. John Wiley & Sons, 2010.

K.E. Society's
Rajarambapu Institute of Technology, Rajaramnagar
(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)
Department of Mechanical Engineering
Curriculum Structure and Evaluation Scheme of
M. Tech. Mechanical- (Manufacturing Engineering)
With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: -**F. Y. M.Tech.**	Semester-**I**
Course Code: **MMF108**	Course Name: **Advanced Manufacturing Technology**

L	T	P	Credits
03	-	--	03

Course Description:
Advanced manufacturing technologies are key enablers in modern manufacturing and play a significant role in increasing the efficiency, competitiveness and profitability of modern manufacturing industry.
The course is designed to expand the knowledge of new manufacturing technologies and their application in modern manufacturing
This course will provide you with an understanding of specific advanced and emerging manufacturing technologies and skills relating to the implementation of these technologies in modern industry within both global and local contexts. The focus is on both conventional & non-conventional methods.

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Select appropriate process for manufacturing products.
2. Have appropriate degree of competency in the evaluation of various manufacturing technologies and their applications in modern manufacturing processes.

Prerequisite:

Basics of machining at UG level

Course Content		
Unit No	**Description**	**Hrs**
1.	**Fundamentals of Metal Forming:** Introduction to forming processes. Average stress and strain. Elastic andPlastic Behavior., Tensile deformation of ductile metal. Classification of	**06**

	material forming processes, True Stress-True strain, Strain hardening, flowstress determination, Theory of plasticity, Yield criteria for ductile materials: Von-Mises criteria, Tresca criteria. Effect of temperature, strain rate, friction, metallurgical microstructure. Concept of Formability, formability limits and formability diagram.	
2.	**Forging:** Classification of forging processes. Forging equipment's - Hammers,presses, Up setter etc., construction, working, capacities and selection of equipment. Basic forging operations such as fullering, edging, drawing, blocking, finishing etc., Open die and closed die forging. calculation of forging loads in closed die forging., Forging defects and remedies, residual stresses in forgings	**06**
3.	**Advances in Metal Forming:** High Energy Rate Forming process (HERF), High Velocity Forming (HVF) - principles, comparison with conventional forming processes. Explosive forming, Magnetic pulse forming, Electro hydraulic Forming. Petro-forge forming, Micro forming, Micro coining, micro extrusion, Micro bending, stretch forming, coining embossing, curling spinning, flow forming advantages, limitations and application of the process,	**06**
4.	**Micromachining:** Diamond turn mechanism, material removal mechanism, applications. Advanced finishing processes: - Abrasive Flow Machining, Magnetic Abrasive Finishing. Magneto rheological AbrasiveFlow Finishing, Magnetic Float Polishing, Elastic Emission Machining. Material addition process: - stereo-lithography, selective laser sintering, 3D Printing, fused deposition modeling, laminated object manufacturing, , laser engineered net-shaping, laser welding, LIGA process.	**06**
5.	**Electric Discharge Machining (EDM):**- Mechanism of metal removal, dielectric fluid, spark generation, recast layer and attributes of process characteristics on MRR, accuracy, HAZ etc, Wire EDM, applications and accessories. Ultrasonic Machining (USM):-mechanics of cutting, effects of parameters on amplitude, frequency of vibration, grain diameter, slurry, tool material attributes and hardness of work material, applications. Electro chemical machining (ECM):- Mechanism of metal removal attributes of process characteristics on MRR, accuracy, surface roughness etc, application and limitations.	**06**
6.	Laser Beam Machining (LBM), Electron Beam Machining (EBM), Plasma arc Machining (PAM), Ion beam Machining (IBM) - Mechanismof metal removal, attributes of process characteristics on MRR, accuracyetc and structure of HAZ compared with conventional process; application, comparative study of advantages and limitations of each	**06**

	process. Abrasive Jet Machining (AJM), Abrasive Water Jet Machining (AWJM) - Working principle, Mechanism of metal removal, Influence of process parameters, Applications, Advantages & disadvantages.	

References –

1) Dieter, "Mechanical Metallurgy" ISBN0071004068
2) P.N. Rao, "Manufacturing Technology", Tata-McGraw Hill
3) Juneja B. L., "Fundamentals of metal forming processes", New Age International Ltd.
4) Dr. R. Narayanswamy, Metal Forming Technology, Ahuja Book Co.,
5) Willer, "Non- traditional Machining Processes", SME publications.
6) G.F.Benidict, "Advanced Manufacturing Processes", Marcel Dekker Publisher
7) "Non-Conventional Machining", – P.K.Mishra (IIT, Kharagpur), Narosa Publishing House
8) "Manufacturing Science" - A. Ghosh and Malik – Affiliated East West Press Pvt. Ltd

K.E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)

Department of Mechanical Engineering

Curriculum Structure and Evaluation Scheme of

M. Tech. Mechanical- (Manufacturing Engineering)

With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: - **F. Y. M. Tech.**	Semester-I
Course Code: **MMF109**	Course Name: **Finite Element Methods in Manufacturing**

L	T	P	Credits
3		--	3

Course Description:

The finite element method is a numerical approach that can be used to obtain solutions to the large class of engineering problems. This course focuses on 1 D and 2 D problems based on mechanical systems. This course also deals with modelling of metal forming and microstructure evaluation.

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Apply finite element method to solve problems in solid mechanics.
2. Formulate FE characteristic equations for two dimensional elements and analyze plain stress, plain strain, axi-symmetric and plate bending problems.
3. Apply principles of FEM to solve heat transfer and fluid mechanics problems.
4. Analyze deformation processes using finite element principles

Prerequisite:

Fundamentals of mechanics

Course Content

Unit No	Description	Hrs
1.	**Introduction to FEA** Review of elasticity, mathematical models for structural problems, Equilibrium of continuum-Differential formulation, Energy Approach-Integral formulation, Principle of Virtual work - Variational formulation. Overview of approximate methods for the solution of the mathematical models; Ritz, Rayleigh-Ritz and Gelarkin's methods.	06
2.	**FEA in 1 D problems** Element division, Numbering scheme, coordinates and shape functions, Assembly of the global stiffness matrix and load vector, 1 D Problems, Temperature effects. Boundary conditions and their incorporation: Elimination method, Penalty Method	06

3.	**FEA in 2 D problems** Interpolation in two dimensions, natural coordinates, Iso-parametric representation, Concept of Jacobian. Finite element formulation for plane stress plane strain and axi-symmetric problems; Triangular and Quadrilateral elements, higher order elements, sub-parametric, Iso-parametric and super-parametric elements.	**06**
4.	**FEA in Heat Transfer and Fluid Mechanics problems** Finite element solution for one dimensional heat conduction with convective boundaries. Formulation of element characteristics and simple numerical problems. Formulation for 2-D and 3-D heat conduction problems with convective boundaries. Finite element applications in potential flows; Formulation based on Potential function and stream function. Problems.	**06**
5.	**FEA in Metal forming** Plasticity and Viscoelasticity – Stress, strain and strain rate – Yield Criteria – Equilibrium and Virtual Work Rate Principle – Plastic potential and flow rule – Strain Hardening – Effective stress and strain – Few Case studies.	**06**
6.	**Modelling of microstructure evolution** Nucleation and growth kinetics -Classical cellular automaton models - Simulation of solidification grain structures by classical cellular automaton models - Simulation of dendritic growth by modified cellular automaton models	**06**

References –

Text books

1. S.S. Rao, The Finite Element Method in Engineering, 4th Edition, Elsevier 2007.
2. Seshu P, Textbook of Finite Element Analysis, PHI. 2004
3. Reddy, J.N., Finite Element Method in Engineering, Tata McGraw Hill, 200

Reference Books

1. Henry S Valberg, Applied Metal Forming: Including FEM Analysis, Cambridge Press. 2010.
2. Shiro Kobayashi, Metal Forming and the Finite Element Method, Oxford University Press,
3. Chun-Pyo Hong, Computer Modelling of Heat and Fluid Flow in Materials Processing, 2004, IOP Publishing.
4. C. R. Boer· N. Rebelo H. Rydstad .G. Schroder, Process Modelling of Metal Forming and Thermomechanical Treatment, Springer-Verlag, 1986.

K.E. Society's
Rajarambapu Institute of Technology, Rajaramnagar
(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)

Department of Mechanical Engineering

Curriculum Structure and Evaluation Scheme of

M. Tech. Mechanical- (Manufacturing Engineering)

With effective from 2021-23 [2021-22 & 2022-23 Batch]

Semester I: Program Electives (PE-II)

Class: -**F. Y. M.Tech.**	Semester-I
Course Code: **MMF1101**	Course Name: **Solidification Processes**

L	T	P	Credits
03	-	--	03

Course Description:

Today's manufacturing scenario is characterized by Growing demand for high performance parts made of very hard, high strength materials. As per syllabus of **Solidification Processes**, the work hardness has a direct bearing on the productivity of the process. Larger the work hardness, lower would be the manufacturing productivity. In addition, it is difficult to specify a material for economic casting & welding of materials such as, nonferrous metals, super alloys, cast irons, alloy steels, tungsten carbides, composites etc. Use of high-performance parts made from extremely hard materials is on the increase. Aero-space, transport, automobiles, electronics etc. are some of the industries which are required to use high performance, complex shaped parts manufactured to very close tolerances and high surface finish.

Solidification processes course based on the direct application of modern methods of casting, plasticprocessing, glass & rubber product manufacturing. Also it contains full fledge information on design of welds & advanced methods of welding.

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Design gating & Risering system for casting.
2. Select the proper advanced casting method.
3. Develop plastic shaping process for new product.
4. Select suitable manufacturing method for glass & rubber products.
5. Use appropriate welding technique as per application.

Prerequisite:

Fundamental knowledge of casting, welding, plastic, rubber & glass manufacturing.

Rajarambapu Institute of Technology Mech. Engg. Dept. 415 414

K.E.S. Rajarambapu Institute of Technology Rajaramnagar Campus 415 414 Dist. Sangli M.S.

Course Content		
Unit No	**Description**	**Hrs**
1.	**Metal casting & Solidification –** Overview of the casting technology, casting process, sand casting molds, melting practice, Heating the metal & molten metal pouring, pouring equipment & pouring temperature, pouring practice, engineering analysisof pouring, fluidity, solidification & cooling, cooling curves, concept of solidification of metals, nucleation, homogeneous & heterogeneous nucleation, growth, solidification of alloys, solid solution & solid solution alloys, types of segregations, solute distribution, phase diagrams(ferrous & nonferrous), rules of solid solubility, Phase transformation, solidification phenomenon & grain structure, solidification rate, solidification time, shrinkage, Chvorinove's rule, progressive & directional solidification, control of solidification to obtain sound casing.	06
2.	**Casting Processes & Product design considerations-** Sand Casting-Pattern & cores, mold & mold making, the casting operation, Other Expendable-mold casting processes- shell moulding, vacuum moulding, expanded polystyrene process, plaster mold & ceramic-mold casting, Permanent mold casting processes-the basic permanent mold process, variations of permanent mold casting, die casting, centrifugal casting, Foundry practice-furnaces, Pouring, cleaning& heat treatment, heat treatment furnaces, Casting quality, casting defects, testing & inspection, Metals for casting, Product design considerations.	06
3.	**Design of Gating & Risering System:** **Gating System design-** Requirement, purpose of function of the gating system, basic elements of gating system, design of gating system,objective achieved, from good design, turbulence in gating system, metal flow rate & velocity calculations, pouring time, design criteria forpouring basin, sprue, runner & gates, pressurized & unpressurised gatingsystem, elimination of slag & dross for various metals. **Risering system design-** Types of risers, Riser & directionalsolidification, increasing riser efficiency & promoting directional solidification, insulating material, exothermic material, chills, padding etc., feeder head design, riser shape, size, location & feeding distance, risering practice for alloys & heat loss from open riser.	
4.	**Solute Redistribution:** Solid-Liquid Interface, Fluid Feed ability (Capillarity), Diffusion and Convection/Advection, Solid/Liquid Interface Characteristics, Constitutional Undercooling, Stability of solidifying interface, Mullins- Sekerka Stability Criterion, Interface gradient and velocity relationship, Perturbation Analyses of S/L Interface Analytical Models of Solute Redistribution	06

5.	**Solidification Microstructure:** Growth of Perturbed Interface, Ivantsov's Proposition, The Mushy Zone, Planar/Cellular/Dendritic Growth, Macro segregation, Solute Micro segregation, Atomically Rough and Smooth Interface, Growth Directionality and Morphology (Interface Surface Stiffness), S/L Interface Undercooling, Polyphase solidification, Eutectic Solidification, Peritectic Solidification, Solute Trapping, Rapid Solidification. **Nucleation:** Homogeneous Nucleation, Heterogeneous Nucleation, Grain Refinement **Fluid Dynamics:** Fluid Flow during Mould Filling (Macro), Ten rules for Good Casting, Micro Scale Fluid Flow, Effect of Forced Convection on Microstructure, Non-Dendritic Castings	06
6.	**Welding methods & procedures-** Overview of welding technology, the weld joints & types of welds, physics of welding, features of a fusion welded joints, **Arc welding-** general technology, arc welding processes-consumable & non consumable electrodes, **Resistance welding-** power source, resistance welding processes, **Oxyfuel gas welding, Other fusion welding processes-** electron beam welding, laser beam welding, electro slag welding, hermit welding, **Solid-state welding-** general considerations &solid-state welding processes, **Weld quality-** residual stress es & distortion, welding defects, inspection & testing methods, **Weldability, Design consideration in welding.**	06

Reference:
Suggested Studies:

1. O. P. Khanna, *Foundry technology*, Khanna Publishers, New Delhi
2. P L Jain, *Principles of foundry technology*, Tata McGraw-Hill, New Delhi. Sinha
3. O.P., Welding Technology -Dhanpat Rai & Sons, 1983.
4. Parmar, Dr. D.S., Welding & Welding Technology - Khanna Publishers, 1999.
5. Mikell P. Groover, Fundamentals of Modern Manufacturing, 3E, Wiley India
6. Production Technology, P. C. Sharma, S, Chand publication
7. Barry Hull and Vernoni John, Non-Destructive Testing, ELBS,1999.
8. Gourd L.M., Principles of Welding Technology.
9. Manufacturing Technology, R.K. Rajput, Laxmi Publication ltd. New Delhi.

K.E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)

Department of Mechanical Engineering

Curriculum Structure and Evaluation Scheme of

M. Tech. Mechanical- (Manufacturing Engineering)

With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: **F.Y. M. Tech.**	Semester-**I**
Course Code: **MMF1111**	Course Name: **Digital ProcessControl**

L	T	P	Credits
3	--	--	3

Course Description:

The purpose of this course is to provide an advanced treatment of the theory and practice of process modeling and control. An emphasis of this course is on model-based control system design and implementation. The SIMULINK simulation package (based on MATLAB) will be used for dynamic process simulation and control system development.

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Design, model & tune digital PID controllers.
2. Analyze system variables using MATLAB/SIMULINK.

Prerequisite: Basics of process control at undergraduate level, Matlab/Simulink Basics

Course Content

Unit No.	Description	Hrs.
1.	Review of incentives for process control, control block diagrams, designingand tuning PID controllers. Review of MATLAB/SIMULINK.	04
2.	Detailed comparison of PID algorithms. Derivative action on process output vs. error. Problems with proportional "kick" and reset "wind-up", Review of continuous-time Internal Model Control (IMC), and IMC-based PID.	08
3.	Introduction to digital control. Implementation of digital PID algorithms, Identification of discrete models for digital control, Digital model-based control - IMC and Dahlin's method.	08

4.	Analysis of multivariable systems. Review of RGA and introduction to singular value analysis, The impact of process design on process control. Reactor scale-up example. Analysis of the effect of recycle on chemical process dynamics and control.	08
5.	Frequency response techniques for control system design. Bode and Nyquistplots for SISO systems, singular value analysis for MIMO systems.	04
6.	Special course project involving a detailed study of a process.	04

References-

1. Process Systems analysis and Control', D.R. Coughanour, McGraw-Hill, 2ndEdition, 1991.
2. 'Process Dynamics and Control', D.E. Seborg, T.F. Edger, and D.A. Milli champ,John Wiley and Sons, 2nd Edition, 2004

K.E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)

Department of Mechanical Engineering

Curriculum Structure and Evaluation Scheme of

M. Tech. Mechanical- (Manufacturing Engineering)

With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: **F.Y. M. Tech.**	Semester-I
Course Code: **MMF1121**	Course Name: **Machine Vision & Applications**

L	T	P	Credits
3	--	--	3

Course Description:

An introduction to the analysis of images and video in order to recognize, reconstruct and model objects in the three-dimensional world. Course includes study of the geometry of image formation; basic concepts in image processing such as smoothing, edge and feature detection, colour, and texture; motion estimation; segmentation; stereo vision; 3-D modeling; and statistical recognition

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Demonstrate image processing techniques.
2. Identify various stages in applying the technique.

Prerequisite:

Numerical computation, Basic programming experience (Python, Matlab, or (C)

Course Content		
Unit No.	**Description**	**Hrs.**
1.	**Digital Image formation and low-level processing:** Overview and State-of-the-art, Fundamentals of Image Formation, Transformation: Orthogonal, Euclidean, Affine, Projective, etc; Fourier Transform, Convolution and Filtering, Image Enhancement, Restoration, Histogram Processing	06
2.	**Depth Estimation & Multi Camera View:** Perspective, Binocular Stereopsis: Camera and Epi polar Geometry; Homography, Rectification, DLT, RANSAC, 3-D reconstruction framework; Auto-calibration. Apparel.	06
3.	**Feature Extraction:** Edges - Canny, LOG, DOG; Line detectors (Hough Transform), Corners - Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space Analysis- Image Pyramids and Gaussian derivative filters, Gabor Filters and DWT.	06

Rajarambapu Institute of Technology Mech. Engg. Dept. 415 414 Rajaramnagar

K.E.S. Rajarambapu Institute of Technology Rajaramnagar Autonomous MS 414 Dist. Sangli M.S.

4.	**Image Segmentation:** Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs, Texture Segmentation; Object detection	**06**
5.	**Pattern Analysis:** Clustering: K-Means, K-Medoids, Mixture of Gaussians, Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised; Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA, ICA; Non-parametric methods. **Motion Analysis:** Background Subtraction and Modeling, Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation.	**06**
6.	**Shape from X:** Light at Surfaces; Phong Model; Reflectance Map; Albedo estimation; Photometric Stereo; Use of Surface Smoothness Constraint; Shape from Texture, colour, motion and edges. Applications: Inspection – Factory monitoring: Analyse components for deviations – Character recognition for mail delivery, scanning, Biometrics (face recognition, etc.), surveillance, Image databases: Image search on Google, etc, Medicine – Segmentation for radiology – Motion capture for gait analysis, Entertainment – 1st down line in football, virtual advertising – Matchmove, rotoscoping in movies – Motion capture for movies, video games Architecture, archaeology: Image-based modelling, etc, Robot vision – Obstacle avoidance, object recognition – Motion compensation/image stabilization	**06**

	Applications: Inspection – Factory monitoring: Analyse components for deviations – Character recognition for mail delivery, scanning, Biometrics (face recognition, etc.), surveillance, Image databases: Image search on Google, etc, Medicine – Segmentation for radiology – Motion capture for gait analysis, Entertainment – 1st down line in football, virtual advertising – Match move, rotoscoping in movies – Motion capture for movies, video games Architecture, archaeology: Image-based modelling, etc, Robot vision – Obstacle avoidance, object recognition – Motion compensation/image stabilization	

References-

1. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London Limited 2011.
2. Computer Vision:A Modern Approach,D.A.Forsyth,J.Ponce,Pearson Education 2003

K.E. Society's
Rajarambapu Institute of Technology, Rajaramnagar
(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)
Department of Mechanical Engineering
Curriculum Structure and Evaluation Scheme of
M. Tech. Mechanical- (Manufacturing Engineering)
With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: -**F. Y. M.Tech.**	Semester-I
Course code: **MMF1131**	Course Name: **Advanced MEMS Fabrication & Microfluidics**

L	T	P	Credits
03	-	--	03

Course Description:

To provide a detailed look into the various planar and non-planar fabrication methods employed for MEMS device design. To provide an in-depth look at the various methods andtechniques employed for microfluidic actuation and control and its applications

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Design MEMS device using basic planer & non-planer microfabrication method.
2. Demonstrate use of various methods & techniques for microfluidics actuation control.

Prerequisite:

Basics of fluidics at undergraduate level.

Course Content

Unit No	Description	Hrs
1.	Introduction to MEMS and Microfabrication	02
2.	**Conventional Microfabrication**: Silicon based: Surface Micromachining, Bulk Micromachining, Glass Micromachining	08
3.	**Non-conventional Microfabrication**: Electro discharge machining, Laser Micromachining, LIGA, Microstamping and soft lithography, Stereo lithography, Focused Ion Beam machining	08
4.	**Microfluidics**: **Microchannels**: Flow in Microchannels, Fabrication methods. Micro Mixing: Passive Mixers: Surface modification mixers, Spatial mixers, Concentration gradient generation. Active Mixers, Electro kinetic mixers, Ultrasonic mixers. **Microvalves**: Passive Valves: Structural design. Active valves: Piezoelectric, Bimorph, Thermo pneumatic, Large scale integration, Thermal and pH	06

	responsive. **Micropumps**: Micro-displacement pumps, Electric-field assisted pumps, Magnetohydrodynamic pumps, Acoustic streaming (ultrasonic) pumps, Pumping based on interfacial tension, Rectified pumping, Knudsen pump. **Droplet motion**: Electrowetting, Di-electrophoresis, Traveling wave methods, Droplet generation	
5.	**Integrated Microsystems** for biological applications: Lab on chip systems, Polymerase chain reaction microchips	06
6.	**Applications & Case Studies:** Designing MEMS device -case study	06

References –

Microfluidics:

1. G. Karniadakis, A. Beskok, N. Aluru Microflows and Nanoflows: Fundamentals and Simulation, Springer 2005.
2. N. T. Nguyen, S. Wereley Fundamentals and Applications of Microfluidics, Artech House Publishers, 2002.
3. O. Geschke, Microsystem Engineering of Lab-on-a-chip Devices, Wiley, 2008.
4. G.A. Urban, BioMEMS, Springer, 2012 (e-book) 5. J. Berthier, The physics of microdroplets, Wiley, 2012.

Design:

1. Stephen D. Senturia, Microsystem Design, Kluwer Academic Publishers, 2000.
2. G.T.A. Kovacs, Micromachined Transducers Sourcebook, McGraw-Hill, 1998.
3. Mohamed Gad-el-Hak, The MEMS Handbook, CRC Press, 2002

Microfabrication:

1. S. A. Campbell, Science and Engineering of Microelectronic Fabrication, Oxford University Press, 2005.
2. M. Madou, Fundamentals of Microfabrication, New York: CRC Press, 1997.
3. M. Elwenspoek, H. Jansen, Silicon Micromachining, Kluwer Academic Publishers, 2001

K.E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)

Department of Mechanical Engineering

Curriculum Structure and Evaluation Scheme of

M. Tech. Mechanical- (Manufacturing Engineering)

With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: **F. Y. M.Tech.**	Semester-I
Course Code: **MMF114**	**Course Name: Industrial Surface Engineering**

L	T	P	Credits
3		--	3

Course Description: The course on Surface Coating Technology, Some-times called as surface engineering, which defines as "treatment of the surface and near-surface regions ofa material to allow the surface to perform functions that are distinct from those functions demanded from the bulk of the material." These surface- specific functions include protecting the bulk material from mild to aggressive corrosive environments, providing improved fatigue resistance, providing low- or high-friction contacts with other material such as Friction Lubricating & Wear Resistance coating technologies, providing thermal barrier Coating and providing a particular aesthetic appearance.

This course on Surface Coating Technologies covers the various techniques of surface modifications for applications such as engineering components, in which the substrate / bulk material properties are the primary consideration and the surface properties must be modified for aesthetics, oxidation resistance, hardness, wear resistance, fatigue resistance or other considerations. This course shall be very helpful to the engineering student to develop essential skill & knowledge of the surface coating technologies in demand.

Course Learning Outcomes:

After successful completion of the course, students will be able to

1. Select the surface preparation methods suitable for different substrate materials.
2. Describe suitable method for testing &evaluation of metallic coatings.
3. Explain importance of specific coatings & its applications on specific Engineering Components.
4. Explain the effect of process parameters on the properties & microstructure of The Surface coating processes.
5. Describe the importance & role of surface modifications to achieve several Technological Properties.

Course Content		
Unit No.	**Description**	**Hrs.**
1.	**Surface engineering:** Introduction to surface engineering, Scope of surface engineering for different engineering materials, Surface Preparation methods such as Chemical, Electrochemical, Mechanical: Sand Blasting, Shot peening, Shot blasting, Hydro-blasting, Vapor Phase Degreasing etc., Coatings: Classification, Properties and applications of Various Coatings.	06
2.	**Chemical Conversion Coating:** Chromating, Phosphating, Anodizing, Thermo chemical processes: Methodology used, mechanisms, important reactions involved, Process parameters and applications.	06
3.	**Metallic coating:** Hot Dipping, Galvanizing, Electrolytic and Electro less plating: Methodology used mechanisms, important reactions involved, Process parameters and applications. Testing/ evaluation of metallic coatings.	06
4.	**Coating from Vapour Phase:** PVD, and CVD: Various Methods used, mechanisms, important	06
5.	**Different methods for surface modification:** Surface modification by use of directed energy beams, Plasma, Sputtering & Ion Implantation. Surface modification by Friction stir processing. Surface composites.	06
6.	**Thermal spray coatings: Processes**, Types of spray guns, Comparison of typical thermal spray processes, Surface Preparation, Finishing Treatment, Coating Structures and Properties, Applications, Diffusion Coating: Carburizing, Carbonitriding, Siliconizing, Chromizing Aluminizing, Boronizing, Boronitriding: Various Methods used, mechanisms, important reactions involved, Process parameters and applications	06

Reference Books:

1. J. R. Davis-Surface Engineering for Corrosion and Wear Resistance.
2. George J. Rudzki -Surface Finishing Systems. metal and non-metalfinishing handbook-guide, Metals Park: ASM, 1983
3. James A. Murphy- Surface Preparation and Finishes for Metal,McGraw-Hill, New York 1971
4. P. G. Sheasby and R. Pinner - Surface treatment and finishing of Aluminium and its alloy, Volume-2, 5th ed., ASM, Metals Park, 1987
5. K. E. Thelning -Steel and its Heat Treatment Bofor Handbook, London: Butterworths, 1975
6. Surface Engineering Hand Book, edited by Keith Austin, London: Kogan Page, 1998
7. Friction Stir Welding and Processing, Rajiv Sharan Mishra, Partha Sarathi De, Nilesh Kumar,Springer, ISBN: 978-3-319-07042-1 (Print)
8. Friction Stir Welding and Processing, R.S. Mishra and M.W. Mahoney, ASM International, 2007, ISBN: 978-0-87170-840-3
9. Advances in Friction-Stir Welding and Processing, M-K Besharati-Givi and P. Asadi, Elesevier, ISBN: 978-0-85709-454-4

K.E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)

Department of Mechanical Engineering

Curriculum Structure and Evaluation Scheme of

M. Tech. Mechanical- (Manufacturing Engineering)

With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: -**F. Y. M.Tech.**	Semester-I
Course Code: **MMF115**	Course Name: **Composite Materials & Processing**

L	T	P	Credits
3	-	--	3

Course Description:

Imagine a material that offers mechanical properties that are competitive with aluminum and steel but are at fractions of their weight – these materials are termed as composites. Composites are defined as materials composed of two or more constituents with significantlydifferent physical or chemical properties that, when combined, produce a new material withcharacteristics different from the individual components. Composite materials are used for many applications such as spacecrafts, aircrafts, racing car bodies, and many others for theircapability to be stronger, lighter, and cheaper when compared to traditional materials. In thisclass, students will delve into the theory and micromechanics on how to design composite structures, processing techniques on how to manufacture them, and structural testing methodsfor validation. Starting from traditional composite materials (such as fiber-reinforced), this course will also bring in concepts of new composite designs inspired by nature and developedby algorithms. At the same time, students will gain exposure to a broad range of composite applications with seminars and hands-on experience on actually designing, fabricating, and experimentally testing a composite component.

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Explain Manufacturing methods of composites.
2. Discuss the nature of various forms of composite reinforcement and matrix.
3. Select an appropriate processing method for variety of composite and products.

Prerequisite:

Fundamentals of material science & Metallurgy.

Course Content

Unit No	Description	Hrs
1.	**Introduction:** Classifications of Engineering Materials, Concept of composite materials, Matrix materials, Functions of a Matrix, Desired Properties of a Matrix, Polymer Matrix (Thermosets and Thermoplastics),Metal matrix, Ceramic matrix, Carbon Matrix, Glass Matrix etc. Types ofReinforcements/Fibers: Role and Selection or reinforcement materials, Types of fibres, Glass fibers, Carbon fibers, Aramid fibers , Metal fibers, Alumina fibers, Boron Fibers, Silicon carbide fibers, Quartz and Silica fibers, Multiphase fibers, Whiskers, Flakes etc., Mechanical properties of fibres. Material properties that can be improved by forming a composite material and its engineering potential	06

2.	**Various types of composites:** Classification based on Matrix Material: Organic Matrix composites, Polymer matrix composites (PMC), Carbon matrix Composites or Carbon-Carbon Composites, Metal matrix composites (MMC), Ceramic matrix composites (CMC); Classification based on reinforcements: Fiber Reinforced Composites, Fiber Reinforced Polymer (FRP) Composites, Laminar Composites, Particulate Composites, Comparison with Metals, Advantages & limitations of Composites	06
3.	**Processing of Composite Materials:** Overall considerations, Autoclave curing, Other Manufacturing Processes like filament welding, compression molding, resin-transplant method, pltrusion, pre-peg layer, Fiber-only performs, Combined Fiber-Matrix performs, Manufacturing Techniques: Tooling and Specialty materials, Release agents, Peel plies, release films and fabrics, Bleeder and breather plies, bagging films	06
4.	**Defects in manufacturing**– nondestructive evaluation of polymer composite-interface- statistical distribution of fiber strength – shear strengthof interfacial bond evaluation by fiber pull out etc – fracture and toughness of composites – mechanical testing of composite and constituents – fiber test – neat resin test – composite material testing for tensile, compression, in plane shear, inter laminar shear, flexural, inter laminar fracture, creep, vibration etc.	06
5.	**Laminates:** Plate Stiffness and Compliance, Assumptions, Strains, Stress Resultants, Plate Stiffness and Compliance, Computation of Stresses, Typesof Laminates -, Symmetric Laminates, Antisymmetric Laminate, Balanced Laminate, Quasi-isotropic Laminates, Cross-ply Laminate, Angleply Laminate. Orthotropic Laminate, Laminate Moduli, Hygrothermal Stresses.	06
6.	**Joining Methods and Failure Theories:** Joining –Advantages and disadvantages of adhesive and mechanically fastened joints. Typical bond strengths and test procedures.	06

References –

Text Books:

1. R.F. Gibson, Principles of Composite material mechanics, McGraw-Hill, Inc, Newyork, International edition 1994.
2. Robert M Jones, Mechanics of composite material, Taylor & Francis 2nd edition, Newyork, Indian Print 2010.

Reference Books:

1. A.K. Bhargava and C.P.Sharma, Mechanical Behaviour and testing of materials, PHI Publication New Delhi, 2011.
2. Autar K Kaw, Mechanics of composite materials, Taylor and Francis, 2nd edition, Indian Print 2009.
3. Bryan Harris, Engineering composite materials, Woodhead publishing limited, 2ndedition,

K.E. Society's
Rajarambapu Institute of Technology, Rajaramnagar
(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)
Department of Mechanical Engineering
Curriculum Structure and Evaluation Scheme of
M. Tech. Mechanical- (Manufacturing Engineering)
With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: -**F. Y. M.Tech.**	Semester: **I**
Course Code: **MMF1161**	Course Name: **Software Proficiency-I**

L	T	P	Credits
-	-	04	02

Course Description: AUTOCAST-X1- CASTING SIMULATION SOFTWARE

Auto CAST provides platform to design the ideas for feeding and gating system. With simplest line drawing technique, Auto CAST gives automatic gating design based on the gating ratio. Auto CAST supports Quick Analysis, which helps to get the right layout with less iteration. Simulation analysis from Auto CAST offers temperature history, liquid metal fraction, solidification time, cooling curves, and air fraction. Major defects like misrun cold shut, air blow hole, shrinkage porosity, and hard zonecan be predicted. Auto CAST don't allow tobe just satisfied with good Quality, It helps to aim for YieldImprovement with Feeder, Gating and Layout Optimization. Auto CAST provides a complete solution for casting methods design, with simulation and complete

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Develop/ select appropriate orientation of the casting & parting plane.
2. Calculate modulus of the casting & number of cavities in the mould.
3. Calculation of riser & gating system design.

Prerequisite:

Pre requisite for this subject from student's end is that, they must have undergone Types of patterns & pattern design. Also, it requires the knowledge of melting practice & different types of molding processes.

Course Content		
Experiment No	**Description**	**Hrs**
1.	**Part Analysis:** Geometric and mass properties, Sectional thickness analysis, Cored feature recognition	**7**

2.	**Mold Cavity Design**: Part orientation, stepped parting line, Horizontal and vertical molding, Core and print design, plug drilledhole, Mold size and multi-cavity layout	7
3.	**Feeder Design & Optimization**: Multi-sprue, gate, runner layout, Automatic gating optimization, Pressurized and non-pressurized gating design.	7
4.	**Simulation:**Coupled mold filling and casting solidification, Results include temperature history, liquid metal fraction, cooling curves, and air fraction, Major defects like misrun, air blow hole, shrinkage porosity, and hard zone	7
5.	**Layout Optimization:** Easy and Quick Iterations, Tracks yield ateach layout, Detailed method report for each layout	7
6.	**Revision**	1

Reference: AUTOCAST Manuals

K.E. Society's
Rajarambapu Institute of Technology, Rajaramnagar
(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)

Department of Mechanical Engineering

Curriculum Structure and Evaluation Scheme of

M. Tech. Mechanical- (Manufacturing Engineering)

With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: **-F. Y. M.Tech.**	Semester-**I**
Course Code: **MMF1171**	Course Name: **Manufacturing Simulation Lab**

L	T	P	Credits
-	-	04	02

Course Description:

This Lab. introduces Discrete-Event Simulation as a design and analysis tool for manufacturing systems. Students will learn how to conduct a simulation project using manufacturing-oriented software such as WITNESS, /Arena. Topics in simulation methodology include: building valid models, selecting input probability distribution, statisticalanalysis of output, design of simulation experiments, and variance reduction techniques in simulation. Competence is demonstrated by each student conducting a simulation project of amanufacturing system.

Course Learning Outcomes:
After successful completion of the course, students will be able to,

1. Demonstrate the broad applicability of discrete-event simulation to solve complex manufacturing systems problems
2. apply the essential steps of the simulation methodology
3. Learn to use the WITNESS 13/Arena Simulation Software Tool to build credible valid simulation models, design and run simulation experiments, and critically evaluate decision-support simulation results.
4. Learn analytical techniques for interpreting input data and output results pertinent to simulation models.
5. Gain insight into system behavior by measuring the performance characteristics of proposed new manufacturing system or the impact of proposed changes for existing

Course Content

Unit No	Description	Hrs
1.	Input Data Analysis for Modeling and Simulation	08
2.	Product Mix Modeling	08
3.	Transporter, and Conveyor Modeling	08

4.	Research Paper Review	**08**
5.	Course Project A project is required from all students and should be related on real life applications where the course materials could be used for the project. However, the project should be beyond class material. The main purpose of the project is to use simulation for real -life applications. The project will be based on Systems Modeling and Simulation for actual or planned in the applications of manufacturing systems	**16**
6.	All the practical are based on the software and students are expected to model the physical systems and analyze through simulation.	01

References -

1) Banks, J., J. S. Carson II, B.L. Nelson, and D. M. Nicol.2001. Discrete-Event SystemSimulation, 3rdEdition, Prentice Hall.
2) Banks, J. 1998. Handbook of Simulation, Editor John Wiley.
3) Evans, J.R. and D.L. Olson, 2002. Introduction to Simulation and Risk Analysis, 2nd Edn., Prentice Hall.
4) Law, A M. and W. David Kelton.1999. Simulation Modeling and Analysis, 3rdEdition. McGraw-Hill.

K.E. Society's
Rajarambapu Institute of Technology, Rajaramnagar
(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)
Department of Mechanical Engineering
Curriculum Structure and Evaluation Scheme of
M. Tech. Mechanical- (Manufacturing Engineering)
With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: - **F. Y. M.Tech.**	Semester-**I**
Course Code: **SHP5511**	Course Name: **Technical Communication**

L	T	P	Credits
02	-	--	**Audit Course**

Course Description:

This course is designed to help students in improving skills that will enable them to produce well designed technical documents and to deliver impressive oral presentations. The course focuses on principles of effective writing and on types of documents common in technical fields. While the emphasis will be on writing, oral communication of technical information will form an important component of the course, as well. The course assists students in preparing them for oral

Course Learning Outcomes:
After successful completion of the course, students will be able to,
1. Acquire skills required for good oral and written communication
2. Demonstrate improved writing and reading skills
3. Ensure the good quality of oral and written communication

Course Content

Unit No	Description	Hrs
1.	Planning and Preparation, Word Order, breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness	06
2.	Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism,	06
3.	Sections of a Paper, Abstracts, Introduction, Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.	06
4.	key skills needed when writing a Title, key skills needed when writing an Abstract, key skills needed when writing an Introduction, skills needed when writing a Review of the Literature,	06
5.	Key skills needed when writing the Methods, skills needed when writing the Results, skills needed when writing the Discussion, skills needed when writing the Conclusions, useful phrases, how to ensure good quality of the paper at the time of submission	06

6.	**Professional skills:** Resume Writing, e-Mails, Interview skills, Dos and Don'ts while Answering, FAQs, GROUP DISCUSSION: Structured and Unstructured GD, Opening and Closure, Showing Agreement and Disagreement.	**06**

Reference:
Suggested Studies:

1. Goldbort R ,Writing for Science, Yale University Press (available on Google Books),2006
2. Day R , How to Write and Publish a Scientific Paper, Cambridge University Press, 2006
3. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook, 1998 .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
5. John Seely, Oxford Guide to Effective Writing and Speaking; Oxford University Press, 2009.
6. Thomas N. Huckin and Leslie A. Olsen, Technical Writing and Professional Communication for Nonnative Speakers of English; Tata McGraw Hills, International Edition, 1991.
7. Jeff Butterfield, Soft Skills for Everyone, Cengage Learning India Private Limited,

K.E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)

Department of Mechanical Engineering

Curriculum Structure and Evaluation Scheme of

M. Tech. Mechanical- (Manufacturing Engineering)

With effective from 2021-23 [2021-22 & 2022-23 Batch]

Semester-II

Class: - **F. Y. M.Tech.**	Semester-II
Course Code: **MMF201**	Course Name: **Robotic & Automation**

L	T	P	Credits
03	-	--	03

Course Description:

This course introduces fundamental concepts in robotics & automation. The objective of the course is to provide an introductory understanding of robotics. Students will be exposed to a broad range of topics in robotics with emphasis on basics of manipulators, coordinate transformation and kinematics, trajectory planning, control techniques, sensors and devices, robot applications and economics analysis. Also various aspects of automation like FMS, AGV will be covered.

Course Learning Outcomes-

After successful completion of the course, students will be able to,

1. Evaluate the different mechanical configurations available for a modern industrial robot.
2. Analyze complex robot kinematic theory and devise kinematic calculations for a given case study.
3. Program an industrial robot off-line using kinematic simulation software to perform a specified task.
4. Appraise the impact of automation, both economic and social, on modern industry and future applications in industry.

Prerequisite:

Undergraduate mathematics

Unit No	Description	Hrs
1.	**Kinematics and dynamics of Robot Manipulator**: 2D, 3D Transformation, Scaling, Rotation, Translation, and Homogeneous coordinates, multiple transformations, Matrix representation, Forward and Reverse Kinematics Of Three Degree of Freedom, Homogeneous Transformations, Inverse kinematics of Robot, Robot Arm dynamics, D-H representation of robots, Basics of Trajectory Planning. Use of MATLAB to demonstrate kinematics.	06

2.	**Robot Control, Programming and Applications Robot controls**-Point to pointcontrol, Continuous path control, Intelligent robot, Control system for robotjoint, Control actions, Feedback devices,Encoder, Resolver, LVDT,Motion Interpolations, Adaptive control. Introduction to Robotic Programming, On-line and off-line programming, programming examples. Robot applications-Material handling, Machine loading and unloading,assembly, Inspection, Welding, Spray painting	06
3.	**Robot Sensing & Vision**: Various Sensors and their Classification, Use ofSensors and Sensor Based System in Robotics, Machine Vision System, Description, Sensing, Digitizing, Image Processing and Analysis and Application of Machine Vision System, Robotic Assembly Sensors and Intelligent Sensors. Industrial Applications: Objectives, Automation in Manufacturing, RobotApplication in Industry, Task Programming, Robot Intelligence and TaskPlanning, Modern Robots, Future Application and Challenges and Case Studies.	06
4.	**Analysis of Automated Flow Lines**: General Terminology and Analysis, Analysis of Transfer Lines without Storage, Partial Automation, Automated FlowLines with Storage Buffers. **Assembly Systems and Line Balancing**: The Assembly Process, Assembly Systems, Manual Assembly Lines, The Line Balancing Problem, Methods of Line Balancing, Computerized Line Balancing Methods, Other ways to improve the Line Balancing, Flexible Manual Assembly Lines. **Automated Assembly Systems**: Design for Automated Assembly, Types of Automated Assembly Systems, Vibratory bowl feeder and non-vibratory bowl feeder, Part Orienting Systems, Feed tracks, Escapements and part placing mechanism, Analysis of Multi-station Assembly Machines, Analysis of a Single Station Assembly Machine.	06
5.	**Automated Materials Handling**: The material handling function, Types of Material Handling Equipment, Analysis for Material Handling Systems, Design of the System, Conveyor Systems, Automated Guided Vehicle Systems. **Automated Storage Systems**: Storage System Performance, Automated Storage/Retrieval Systems, Carousel Storage Systems, Work-in-process Storage, Interfacing Handling and Storage with Manufacturing.	06
6.	**Automated Inspection and Testing**: Inspection and testing, Statistical Quality Control, Automated Inspection Principles and Methods, Sensor Technologies forAutomated Inspection, Coordinate Measuring Machines, Other Contact Inspection Methods, Machine Vision, Other optical Inspection Methods. **Modeling Automated Manufacturing Systems**: Role of Performance Modeling, Performance Measures, and Performance Modeling Tools: Simulation Models, Analytical Models.	06

References -

1. Mikell P Groover, Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, "Industrial Robotics, Technology programming and Applications", McGraw Hill, 2012
2. MikellP.Grover, "Automation, Production Systems and Computer Integrated Manufacturing", Pearson Education Asia, 2001.
3. Craig. J. J. "Introduction to Robotics- mechanics and control", Addison- Wesley, 1999.
4. C.RayAsfahl, "Robots and manufacturing Automation", John Wiley and Sons New York, 1992.
5. Robotics, control vision and intelligence-Fu, Lee and Gonzalez. McGraw Hill International, 2nd edition, 2007.
6. N.Viswanadham and Y.Narahari, "Performance Modeling of Automated Manufacturing Systems", Prentice Hall India Pvt. Ltd, 1992.
7. Stephen J. Derby, "Design of Automatic Machinery", Special Indian Edition, MarcelDecker, New York, Yesdee publishing Pvt. Ltd, Chennai, 2004.

K.E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)

Department of Mechanical Engineering

Curriculum Structure and Evaluation Scheme of

M. Tech. Mechanical- (Manufacturing Engineering)

With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: - **F. Y. M.Tech.**	Semester-**II**
Course Code: **MMF202**	Course Name: **Lean Six Sigma**

L	T	P	Credits
3	-	--	3

Course Description:

This course provides the higher order skills of quality control using Six Sigma with Exceland Minitab.

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Explain Six Sigma Methodology
2. Generate process capability indices
3. Perform ANOVA
4. Perform regression analysis
5. Design experiments
6. Perform measurement system analysis

Prerequisite:

Fundamentals of statistics

Unit No	Description	Hrs
1.	**Introduction** Definition of Six Sigma, Six Sigma methodology, Six Sigma project selection methods, balanced scorecards, Role of statistics in quality control and Six Sigma, Statistical definition of Six Sigma.	06
2.	**Statistical Process Control** Control charts, monitoring a production process using control charts, differentiate between variable and attribute control charts. **Process Capability Analysis** Difference between the purpose of a Statistical Process Control and theone of a process capability analysis, Method of generating process capability indices, difference between Taguchi's indices and the *Cpk* and *Cp*, Analyze the capability of a process.	06

3.	**Analysis of Variance (ANOVA)** ANOVA and hypothesis testing, completely randomized experimentaldesign, Randomized block design, Analysis of means **Regression Analysis** Simple linear regression, multiple regression analysis	06
4.	**Design of Experiments (DOE)** Factorial design with two factors, Factorial design with more than twofactors.	06
5.	**The Taguchi Method** Assessing the cost of quality, Taguchi's loss function, variability reduction.	06
6.	**Measurement System Analysis (MSA)** MSA: is your measurement process lying to you? Variation due to precision, Gauge run chart, Variation due to accuracy.	06

References -

1. Six sigma statistics with Excel and Minitab, Issa Bass, McGraw Hill.
2. The Six Sigma manual for small and medium businesses, Craig W. Baird, Atlantic publishing group.
3. Lean Six Sigma in Service Applications and Case Studies, Sandra L. Furterer, CRC Press.
4. Six Sigma: SPC and TQM in Manufacturing and Services, Geoff Tennant, Gower Publishing Ltd.

K.E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)

Department of Mechanical Engineering

Curriculum Structure and Evaluation Scheme of

M. Tech. Mechanical- (Manufacturing Engineering)

With effective from 2021-23 [2021-22 & 2022-23 Batch]

Program Elective-III

Class: -**F. Y. M.Tech.**	Semester-**II**
Course Code: **MMF2031**	Course Name: **Material Characterization & Failure Analysis**

L	T	P	Credits
03	-	--	03

Course Description:

This course deal with to understand the principles of optical and electron microscopy for study of macro and micro-structure of materials. To gain knowledge in understanding the tools and techniques for studying the substructure and atomic structure of materials. To build an expertise in characterization of engineering materials. Also, to understand the different type of materials failure

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Interpret various materials characterization techniques.
2. Select the characterization tool for specific application
3. Analyze the characterization results by various equipment

Prerequisite:

Fundamentals of Metallurgy

Course Content

Unit No	Description	Hrs
1.	**Optical Microscopy (Light Microscopy):** Optical microscope - Basic principles & components, Different examination modes (Bright field illumination, Oblique illumination, Dark field illumination, Phase contrast, Polarized light, Hot stage, Interference techniques), Specimen preparation, Applications.	06
2.	**Electron Microscopy:** Interaction of electrons with solids, scanning electron microscopy Transmission electron microscopy and specimen preparation techniques, Scanning transmission electron microscopy, Energy dispersive spectroscopy, Wavelength dispersive spectroscopy.	06
3.	**Diffraction Methods:** Fundamentals of crystallography, X-ray diffraction techniques, Electron diffraction, Neutron diffraction. **Surface Analysis:** Atomic force microscopy, scanning tunneling microscopy, X-ray photoelectron spectroscopy.	06

4.	**Spectroscopy:** Atomic absorption spectroscopes, UV/Visible spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy. **Thermal Analysis:** Thermo gravimetric analysis, Differential thermalanalysis, Differential Scanning calorimeter.	**06**
5.	**Aims of failure analysis:** Methodology of failure analysis, Tree analysis. Prime factors in the premature failure of metallic components and structures,Tools and techniques in failure analysis (Non-destructive testing), Sources of Failures, Steps in Failure Analysis, preservation and preparation of samples for failure analysis.	**06**
6.	**Types of failures:** ductile, brittle, fatigue, creep, corrosion, wear etc., (Destructive testing methods), fractography, mixed mode and fatigue failures, Failure mechanisms, Embrittlement phenomena, environmental Effects, Failures due to faulty heat treatments, Failures in metal forming and weldments.	**06**

References -

1) Yang Leng: Materials Characterization-Introduction to Microscopic and V. T. Cherapin and A. K.Mallik: Experimental Techniques in Physical Metallurgy, Asia Publishing House, 1967.
2) Das A.K., Metallurgy of Failure Analysis, Tata McGraw Hill (1986).
3) ASM Handbook: Materials Characterization, ASM International, 2008
4) Yang Leng: Materials Characterization-Introduction to Microscopicand Spectroscopic Methods,John Wiley & Sons (Asia) Pte Ltd., 2008.
5) Wulpi, D.J., Understanding How Components Fail, ASM International Technical Books (2004).

K.E. Society's
Rajarambapu Institute of Technology, Rajaramnagar
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Department of Mechanical Engineering
Curriculum Structure and Evaluation Scheme of
M. Tech. Mechanical- (Manufacturing Engineering)
With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: **F. Y. M. Tech.**	Semester-**II**
Course Code: **MMF2041**	Course Name: **System Modelling & Simulation**

L	T	P	Credits
3	--	--	3

Course Description:

The aim of this course is to introduce various system modeling and simulation techniques, and highlight their applications in different areas. It includes modeling, design, simulation, planning, verification and validation. After learning the simulation techniques, the studentsare expected to be able to solve real world problems which cannot be solved strictly by mathematical approaches.

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Model any system from different fields.
2. Implement numerical algorithm to meet simple requirements, expressed in English
3. Discuss the simulation methods and select the suitable technique on the problems.

Prerequisite: Basic knowledge of numerical mathematics, probability and statistics, and Programming skills in one or more of the following programming languages: Java, C, or C++

Course Content

Unit No.	Description	Hrs.
1.	**Introduction to mathematical modelling:** Statistical Models – - Concepts – Discrete Distribution- Continuous Distribution - Poisson Process- Empirical Distributions - Queuing Models – Characteristics- Notation– Queuing Systems - Markovian Models- - Generation of Pseudo Random numbers- Properties of random numbers, Techniques for generating random numbers - Testing random number generators- - Generating Random-Variates- Inverse Transform technique– Acceptance- Rejection technique - Composition & Convolution Method.	04

2.	**Introduction to Simulation**: - Introduction – Simulation Terminologies - Application areas - Model Classification - Types of Simulation - Steps in a Simulation study - Concepts in Discrete Event Simulation - Simulation Examples	08
3.	**Analysis of Simulation Data:** Input Modeling - Data collection - Assessing sampleindependence – Hypothesizing distribution family with data - Parameter Estimation – - Goodness-of-fit tests - Selecting input models in absence of data - Output analysis for a Single system - Terminating Simulations– Steady state simulations	08
4.	**Verification and Validation:** Model Building – Verification of Simulation Models - Calibration and Validation of Models - Validation of Model Assumptions - Validating Input – Output Transformations	08
5.	**Simulation of Computer Systems and Case Studies:** Simulation Tools - Model Input - High level computer system simulation - CPU Memory Simulation - Comparison of systems via simulation - Simulation Programming techniques -Development of Simulation models.	04
6.	Case Studies	04

References-

1. Jerry Banks and John Carson, "Discrete Event System Simulation", Fourth Edition, PHI, 2005.
2. Geoffrey Gordon, "System Simulation", Second Edition, PHI, 2006 (Unit – V).
3. Frank L. Severance, "System Modeling and Simulation", Wiley, 2001.
4. Averill M. Law and W. David Kelton, "Simulation Modeling and Analysis, Third Edition, McGraw Hill, 2006.
5. Jerry Banks, "Handbook of Simulation: Principles, Methodology, Advances, Applications and Practice", Wiley, 1998.
6. Sheldon M. Ross: Introduction to Probability Models 7th Edition, Academic Press, 2002
7. Donald E. Knuth: The Art of Computer Programming - Volume 2: Semi Numerical Algorithms, 2nd Edition, PEARSON
8. Education, Reading MA, USA 2000
9. Sheldon M. Ross: Simulation 3rd Edition, Academic Press, 2002
10. M. Law and W. D. Kelton. Simulation Modeling and Analysis, 3rd Edition, McGrawHill, New York, USA, 1998

K.E. Society's
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(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)

Department of Mechanical Engineering

Curriculum Structure and Evaluation Scheme of

M. Tech. Mechanical- (Manufacturing Engineering)

With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: -**F. Y. M.Tech.**	Semester-**II**
Course Code: **MMF205**	Course Name: **Polymer Processing & Die Design**

L	T	P	Credits
03	-	--	03

Course Description: This course is designed to provide the background for an understanding of the wide field of polymer processing, and provide a strong foundation including fundamentals and applications of polymer processing. Topics include: fundamentals of polymers, extrusion, die forming, mixing, injection molding, and other common plastics processes such as fiber spinning, blow molding, rotational molding, coating, etc. This course also provides learning about die design fundamentals, design of molds & computer application for flow analysis

Prerequisite: Elementary knowledge about mechanical design

Course Learning Outcomes:
After successful completion of the course, students will be able to,

1. Demonstrate the key practical theory with the operation principles of polymer processing technologies and their potential limitations.
2. Select and justify appropriate processing technologies for specific applications.
3. Demonstrate the constructional features and working of basic elements in injection molds, extrusion and blow molding dies
4. Design the mold for optimum performance

Course Content

Unit No	Description	Hrs
1.	**Polymers** Classification of plastic materials, their physical and mechanical properties, selection of plastics for various applications, advantages and limitations of using plastics.	06
2.	**Melt Processing Techniques:** Polymer processing techniques such as extrusion, compression and transfer molding. Injection molding, blow molding, thermoforming, rotational	06

	molding, calendaring, Bag molding reaction molding. Classification of polymer processing operations. Simple model flows for analyzing processingoperations with examples	
3	**Constructional Features of basic molds:** constructional features of core and cavity plates, mold size and strength, cavity material, and fabrication, mold placement, constructional features andlayout of runners and gates.	06
4	**Classification of dies and die geometry**: types of dies, extrusion die design: basic considerations in die design; constructional and design features of rod die, in-line pipe die, cross-head pipe die, offset pipe die, centre-fed blown film die, side-fed blown film die, spiral mandrel blown film die, flat film& sheet dies, fishtail sheet die, coat hanger sheet die, wire and cable coating die, parison dies, various types of profiledies	06
5	**Design of Molds for Plastic Processing** Methodical mold design, determination of economical number of cavities, melt rheology, temperature control of injection molds, calculation of mold opening force and ejection force. Detail design of cooling system, ejection system and gating system. Molding thermoplastics, thermo sets, expandable polystyrene, foamed engineering plastics, molds for reaction injection molding.	06
6	**Computer Applications in Plastic Molding** Use of various software packages for mold flow analysis, optimum gate location and defect analysis, design of component for balanced flow, optimization of process parameters of plastic molding.	06

References –

1. A.W. Birley, B. Howarth, Hana, "Mechanics of plastics processing properties",
2. J.E. Mark, R. West, (1992), "Inorganic Polymers", H.P. Alocock, Prentice Hall,
3. Fried, "Poly. Science and Technology", Prentice Hall
4. Frados, "Plastic Engg. Hand Book"
5. Patton , "Plastic Technology"
6. Glanill , "Plastic Engg. Data Book"

K.E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)

Department of Mechanical Engineering

Curriculum Structure and Evaluation Scheme of

M. Tech. Mechanical- (Manufacturing Engineering)

With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: - **F. Y. M.Tech.**	Semester-**II**
Course Code: **MMF206**	Course Name: **Product Lifecycle Management**

L	T	P	Credits
3	-	--	3

Course Description:

This course will enrich the students with the knowledge of PLM & benefits of PLM. It willmake the student set the company's PLM vision & set the strategy to achieve it. Studentwill plan for an integrated product development process to implement PLM effectively.

Students will be able do the product structure modeling so that variant products can be stored with relationships between components. Students will know how to create product data and manage it securely with access to authorized people. The recent development inPLM will make the students choose suitable PLM software for his career.

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Understand & explain the concept of PLM, set PLM Vision and Prepare PLM Strategy.
2. Plan for Integrated Product Development Process.
3. Plan for Collaborative Product Development Process.
4. Perform Product Structure Modelling with relationships between different components of the product and their versions.
5. Create Product Data & Manage it
6. Implement Digital Manufacturing Technique.

Prerequisite:

Knowledge of Product Design and Development

Course Content		
Unit No	**Description**	**Hrs**
1.	**PLM, PLM Vision & PLM Strategy:** Concept of Product Life Cycle. Benefits of PLM, Components/Elements of PLM. Company's PLM vision. Principles for PLM strategy, Preparing for the PLM strategy. Change Management for PLM.	06
2.	**Product Development Process & Approaches:**	06

	Integrated Product Development Process: Conceive, Design, Realize, Sales & Service or Use & Operate, Dispose or Recycle. Product Data andProduct Workflow. Concurrent Engineering.	
3.	**Collaborative Product Development:** Mapping requirements to Specifications, Part Numbering, Engineering Vaulting, Product Reuse, Engineering Change Management, Digital Mock-up and Prototype Development, Virtual Testing and Validation.	06
4.	**Product Structure Modelling:** Product Modeling concepts. Role of Process chains and product models. Types of product models. Model standardization. Types of Process chains. Foundation technologies and standards (e.g. visualization, collaboration and enterprise application integration).	06
5.	**Product Data Management (PDM) Technology:** Product Data Management –Concepts, Benefits, PDM functions, definition and architectures of PDM systems, product data interchange, PDM acquisition and implementation. Information authoring tools, Core functions (data vaults, document and content management, workflow and program management), Functional applications (configuration Management).	06
6.	**Digital Manufacturing:** Digital Manufacturing, Benefits of digital manufacturing, Manufacturing the First One, Process Planning & Reuse, Machine, Tool & Fixture Development and Process, Robotics & PLC Simulation and Programming, Ergonomics, Factory Flow Simulation. The Virtual Learning Curve, ECO Simulation & Implementation, Manufacturing the rest, Production Planning.	06

References -
Text Books:

1. Grieves, Michael. Product Lifecycle Management, McGraw-Hill, 2006. ISBN 0071452303.
2. Antti Saaksvuori, AnselmiImmonen, Product Lifecycle Management
3. Stark, John. Product Lifecycle Management: Paradigm for 21st Century Product Realisation,Springer-Verlag, 2004. ISBN 1852338105.

4. Karl Ulrich and Steven D. Eppinger, Product Design & Development, McGrawHill International Edition, 1999.

Reference Books:

1. Stephen Rosenthol Effective Product Design and Development, Business OneOrwin, Homewood, 1992 ISBN 1-55623-603-4.
2. Burden, Rodger PDM: Product Data Management, Resource Pub, 2003. ISBN 0970035225.
3. Clement, Jerry; Coldrick, Andy; & Sari, John. Manufacturing Data Structures, John Wiley &Sons, 1992. ISBN 0471132691.
4. Clements, Richard Barrett. Chapter 8 ("Design Control") and Chapter 9 ("Document Control") in Quality Manager's Complete Guide to ISO 9000, Prentice Hall, 1993.

K.E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)

Department of Mechanical Engineering

Curriculum Structure and Evaluation Scheme of

M. Tech. Mechanical- (Manufacturing Engineering)

With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: - **F. Y. M.Tech.**	Semester-**II**	**L**	**T**	**P**	**Credits**
Course Code: **MMF207**	Course Name:**Metrology4.0**	**3**	**-**	**--**	**3**

Course Description:

The usage of metrology will be essential to get the starting point towards this change in manufacturing. As companies will try to get economic advantages in the early stages of adopting smart manufacturing, metrology will offer the way forward with the presented possible applications. Different solutions can be presented as how both researchers and companies handle the change towards a smart manufacturing business. The objective is to make the transition as lucrative as possible from a business perspective but also make it as soon as possible to make operator's work and managers decision easier, quicker and with more precision than before. The work towards digitalization in the manufacturing will take efforts also from the people involved, as previously mentioned. Changes in equipment may be expensive but are instantaneous. Changes in people and workforce requires more time to accept the transformation that will take place in production. There still exist a substantial need for initiative from the large corporations to further push us towards new technologies and to not adhere to the old philosophy of how to produce wares

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Explain the basics of coordinate metrology as well as the application of the methods of mechanical (tactile) and non-contact probing in 3D coordinate metrology.
2. Demonstrate the concept of reverse engineering
3. Use software to generate data for analysis

Fundamentals of metrology

Course Content

Unit No	Description	Hrs
1.	**Manufacturing metrology and Industry 4.0**-Correlation between era industry models and manufacturing measurements, Model of cyber physical manufacturing metrology (CMM), Metrology Processes-mapping of manufacturing metrological processes and link to Industry 4.0 model **Measuring Instruments/devices for Cyber-Physical Systems (CPS)-Smart Sensors and Their Grids**-Sensors Network and Middleware, Specifics of Smart Measuring Instruments. **Verification of Measuring Instruments and Their Software**-Metrological Verification of Software, Key Moments in the Development of Measurement Technology, In-Situ Verification of Measuring Instruments and their Software. Cyber physical manufacturing metrology model (CP3M)- research results	06

2.	**3 D Scanning-** **Contact measurement**-collecting single points relative to each other in small or large volumes used for evaluation, inspection, layout or basic geometric reverse engineering. For capturing localized or small volume information, digitizing or articulating arms are ideal. For larger volumetric projects, optical solutions like laser trackers and photogrammetry portable CMMs perform best. **Short range contact measurement**-use of portable coordinate measuring machine (PCCM) **Non-contact measurement**-3 D laser scanning, CT scanners	06
3.	**3D Inspection (Dimensional Inspection)**-measurement for inspection & analysis-3D laser mapping, first article inspection reports, statistical process reports and 3D models for computer simulation and analysis programs. **Product & tool inspection**-First article inspections-First-off inspections (sampling)-In-process inspection-Die try outs-Tool and die duplication-Statistical sampling. **Performance simulation & analysis**-Mesh for FEA, mesh for CFD, models for kinematic analysis **Problem diagnosis & troubleshooting**-Root cause analysis, process variation-tool rework	06
4.	**Industrial Computer Tomography (CT Scanning)**-introduction-primary benefits-only non-destructive technique for 3 D views of inside of parts-use for doing void analysis, inspection, volume. porosity, reverse engineering etc. Evaluation software for 3 D points cloud	06
5.	**3 D scanning for Reverse Engineering-** **Product design & manufacturing**-Legacy part repair & re-manufacturing, product benchmarking, product redesign **Facilities maintenance & plant engineering**-site documentations & measurements, As-is analysis. equipment replacement and installation, documentation & archival **Custom Manufacturing**-custom-fit products, medical devices	06
6.	**Measurements in additive manufacturing:** Photopolymerization & metal powder consolidation-Physical and Digital Elements of Additive Manufacturing, Machine Errors, Shape and Shape Deformations, Posttreatment Errors, Surfaces in Photopolymer Components	06

References -
Reference Books:

1. Wai Gao, Metrology, Springer reference.2019
2. S. Yatsyshyn, B.Stadnyk, Cyber-Physical Systems and Metrology 4.0, International Frequency Sensor Association Publishing
3. X. JANE JIANG, PAUL J. SCOTT,Advanced Metrology,Academic Press
4. Cyber Physical Manufacturing Metrology, V D Majstorovic and S Stojadinovic, IOP Conf. Series: Materials Science and Engineering 968 (2020)

K.E. Society's
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(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)
Department of Mechanical Engineering
Curriculum Structure and Evaluation Scheme of
M. Tech. Mechanical- (Manufacturing Engineering)
With effective from 2021-23 [2021-22 & 2022-23 Batch]

Program Elective-IV

Class: **F.Y. M. Tech.**	Semester-II
Course Code: **MMF2081**	Course Name: **Sustainable Manufacturing Processes**

L	T	P	Credits
3	--	--	3

Course Description:

Sustainable manufacturing, is "the creation of manufactured products that use processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers and are economically sound." Even though this definition exists, sustainable manufacturing still has many meanings in many contexts, industries, and forums. This course is designed to introduce the fundamental concepts of sustainable manufacturing. While the focus of the course will be on sustainable manufacturing, the course will also look at the connections of sustainable design, environmental sciences, and the social sciences with sustainable manufacturing.

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Understand the three pillars of sustainability and how they are manifested in sustainable manufacturing.
2. Incorporate economic, environmental, and social aspects into decision making processes using multi-criteria decision-making methods.
3. Identify the link between manufacturing process models and sustainable manufacturing metrics for product and process improvement
4. Identify manufacturing system level sustainability issues and how they are linked with manufacturing process level issues.

Prerequisite: Undergraduate Management Techniques

Course Content

Unit No.	Description	Hrs.
1.	Introduction to sustainability and drivers for sustainable development and sustainable manufacturing, Fundamentals of sustainable manufacturing. Case study discussion, Sustainable manufacturing metrics; overview, Societal and economic metrics, Environmental metrics	06

2.	Principles of Life Cycle Assessment (Goal, Scope and Life Cycle Inventory), Lifecycle assessment with Simapro.	**06**
3.	Sustainable design (DFX), Sustainable design's impact on sustainable manufacturing, Case study discussion	**06**
4.	Multi-criteria decisions in sustainable manufacturing, Multi-Criteria Decision- Making tools, Intro to sustainable manufacturing processes Manufacturing process modelling for sustainability.	**08**
5.	Sustainable manufacturing systems: closed loop production systems Sustainable manufacturing systems: reverse supply chain, Sustainable manufacturing systems: product acquisition management	**06**
6.	Value recovery: remanufacturing, recycling, reuse, scrap, Energy in manufacturing (assessment and minimization), Case study/article discussion	**04**

References-

1. Dornfeld, David. Green Manufacturing. Springer-Verlag, New York, US, 2012.

K.E. Society's
Rajarambapu Institute of Technology, Rajaramnagar
(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)
Department of Mechanical Engineering
Curriculum Structure and Evaluation Scheme of
M. Tech. Mechanical- (Manufacturing Engineering)
With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: -**F. Y. M.Tech.**	Semester-**II**
Course Code: **MMF2091**	Course Name: **Logistic & Supply Chain Management**

L	T	P	Credits
03	-	--	03

Course Description:

According to Martin Christopher, Supply Chain Management is the management of up-stream and downstream relationships with suppliers and customers to deliver superior customer value at lesser cost. Logistics is the function responsible for all the aspects of movement and storage of materials ontheir journey from original suppliers through to final customers. The syllabus starts with the basics of SCM and discusses the various topics such as Inventory management, Value of information, Distribution strategies and Strategic alliances and MIS and Supply chain management. Prerequisite for this course is operations management and also basic Transportation model of operation research.

Prerequisite:
Industrial management at undergraduate level.

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Discuss and describe the key issues in SCM and logistic network.
2. Demonstrate Bullwhip effect in SCM and Develop physical distribution strategies
3. Decide the location of warehouses and develop various inventory models based on risk and uncertainty.

Course Content		
Unit No	**Description**	**Hrs**
1.	**Introduction** Objectives of Supply Chain Management (SCM), key components of supplychain i.e. sourcing, distribution strategy, customer service strategy; supply chain. Management as Integrated logistics, generic activities, architecture of supply chain, future potential of SCM, Key issues in SCM.	**06**

2.	**Supply chain strategies** Evaluation of supply chain strategies, supply chain performance measures, vendor management, JIT, Link to supply chain, evaluation of SCM strategies, customer focus in SCM, inventory and logistics management, vendor management, Just-in-Time (JIT). Supply chain design considerations. **World-class best practices in SCM:** Supplier tierization, Reverse logistics, Vendor-managed inventory, Milk round system, Hub and spoke, Third and Fourth party logistics (3PL and 4PL), Cross docking, Drop shipping, Trans- shipment, Risk-pooling, RFID, Lean operations.	06
3.	**Logistics & Supply Chain Management:** Evolution of Supply Chain, Classification of Logistics Applications, Total logistics cost, Logistics to Supply Chain Management focus, Objectives of Supply Chain Management, Key factors (Drivers and Obstacles) of SCM, Size andpotential of SCM market in India, Framework for supply chain planning and decision making, Strategic aspects and managing uncertainty.	06
4.	**Warehouse and transport management** Concept of strategic storage, warehouse functionality, warehouse operating principles, developing warehouse resources, material handling and packaging in warehouse, transportation management, transport functionality and principles, transport infrastructure, transport economics and pricing, transport decision making.	06
5.	**Designing distribution networks-** The role of distribution in supply chain, factor influencing Designing distribution networks, Design option for distribution network, **Network design** - Design options for a transport network, warehouse location, service level requirements, integrating inventory positioning and network design, Supply chain integration, Models for facility location and capacity allocation.	06
6.	**SCM Performance Measures:** Implementing SCM, PerformanceMeasurement of SCM – Traditional and Contemporary Approaches (SupplyChain Operations Reference (SCOR) Model, Performance Benchmarking, Balance Scorecard etc.)	06

References

1. Chopra, "Supply Chain Management", Pearson Education Asia, New Delhi
2. Christopher, "Logistics and Supply Chain Management", Pearson Education Asia,New Delhi
3. Taylor and Brunt, "Manufacturing Operations and Supply Chain Management (The LeanApproach)", Business Press Thomson Learning, NY.

K.E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)

Department of Mechanical Engineering

Curriculum Structure and Evaluation Scheme of

M. Tech. Mechanical- (Manufacturing Engineering)

With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: - **F. Y. M.Tech.**	Semester-II
Course Code: **MMF210**	Course Name: **Project Management for Industry4.0**

L	T	P	Credits
3	-	--	3

Course Description: Management of Industry 4.0 Projects: Introduction to Project Management in a new era of digitalization, Industry 4.0 maturity models for students who are familiar with I.4.0

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Discuss Project Management relevance in the context of IND4.0
2. Evaluate the needs of an organization regarding IND 4.0, taking into account maturity / readiness models (Evaluate)
3. Plan, develop and manage projects in the context of IND 4.0, using frameworks of project management, such as PMI, IPMA and Agile/Lean.
4. Support team decision making processes in accordance with the contingencies and uncertain environments of IND 4.0.

Prerequisite:

Course Content		
Unit No	**Description**	**Hrs**
1.	Management of Industry 4.0 Projects: Introduction to Project Management in a new era of digitalization, Industry 4.0 maturity models	06
2.	Project Management Processes of initiating and planning a project for evaluating I4.0 maturity levels. Project Management Processes of planning a project for evaluating I4.0 maturity levels	06
3.	Agile project management for fast adaptation in the era of the fourth industrial revolution – planning, Agile project management for fast adaptation in the era of the fourth industrial revolution	06
4.	Project Management execution – time management and project indicators for assessing projects related to I4.0 maturity levels, Mid term evaluation and module initiation	06
5.	Project communication management in a new era of digitalization, Project team management in a new era of digitalization. Team formation and development of distributed and multicultural teams	06
6.	Software tools for project management in a new era of digitalization, Project Management monitoring and control – coaching for project management,	06

	Decisions under high uncertainty in the context of fast changing environments of the of the fourth industrial revolution	

References -

Reference Books:

1. Schuh, G., Anderl, R., Gausemeier, J., Hompel, M. t. and Wahlster, W. (2017) Industrie 4.0 Maturity Index – Managing the Digital Transformation of Companies: Acatech. Available at: https://en.acatech.de/wp-content/uploads/sites/6/2018/03/acatech_STUDIE_Maturity_Index_eng_WEB.pdf.
2. Oehmen, J. (Ed.). (2012). The Guide to Lean Enablers for Managing Engineering Programs, Version 1.0. Cambridge, MA: Joint MIT PMI INCOSE Community of Practice on Lean in Program Management http://dspace.mit.edu/bitstream/handle/1721.1/70495/Oehmen%20et%20al%202012%20%20The% 20Guide%20to%20Lean%20Enablers%20for%20Managing%20Engineering%20Programs.pdf
3. Jeff Sutherland (2014) SCRUM The Art Of Doing Twice The Work In Half The Time . Leya
4. Harold Kerzner (2009) Project Management: A Systems Approach to Planning, Scheduling, and Controlling; John Wiley & Sons; ISBN: 0470278706.
5. PMI-PMBOK (2013) "A Guide to the Project Management Body of Knowledge (PMBOK Guide 5th ed.)". Pennsylvania, USA: Project Management Institute (PMI).
6. Finocchio Junior, José (2013) Project Model Canvas – Project Management Without Bureaucracy. Elsevier – Campus. ISBN: 978-85-352-7456-1

K.E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)

Department of Mechanical Engineering

Curriculum Structure and Evaluation Scheme of

M. Tech. Mechanical- (Manufacturing Engineering)

With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: - **F. Y. M.Tech.**	Semester-II
Course Code: **MMF211**	Course Name: **Quality and Reliability**

L	T	P	Credits
3	-	--	3

Course Description: The aim of this course is to make students understand and appreciate the importance of quality control and reliability analysis in industrial system. Students can get acquainted with different reliability calculation models.

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Explain the concept of design for Quality
2. Analyze the process and capability using various methods
3. Determine Process and measurement Systems Capability
4. Carry out reliability data analysis.
5. Apply various reliability prediction and evolution methods.

Prerequisite:

Basic of statistics.

Course Content

Unit No	Description	Hrs
1.	**Design For Quality** Quality Function Deployment -House of Quality-Objectives and functions-Targets-Stakeholders-Measures and Matrices-Design of Experiments –design process-Identification of control factors, noise factors, and performance metrics - developing the experimental plan- experimental design –testing noise factors- Running the experiments –Conducting the analysis-Selecting and conforming factor-Set points-reflecting and repeating.	06
2.	**Methods of statistical process control and capability Analysis** Introduction, Statistical Basis of control Chart, Implementing SPC in quality improvement programme, Application of SPC and quality improvement tools in transactional and service business. Variables control charts, Control charts for x bar and s, Schewart control chart for individuals Measurements. Attribute control charts for non-fraction non-conforming, Control charts for non-conformities, Choice between variable and attribute charts	06
3.	**Process and measurement Systems Capability** Process capability analysis, process capabilities ratios, Process capabilities analysis using control chart and attribute data, gauge and measurement system capability study, setting specification limits on discrete components	06
4.	**Reliability Engineering** Reliability function, failure rate, Mean time between failures (MTBF), Mean time to failure (MTTF), mortality curve, useful life availability, maintainability, system	06

	effectiveness. Introduction to probability distributions. Time to failure distributions: Exponential, normal, Gamma, Weibull; ranking of data, probability plotting techniques, Hazard plotting Concept of Bathtub Hazard Rate curve, Reliability evaluation of two-state device networks-series, parallel, k-out-of-m systems; Standby redundant systems, Reliability evaluation of three state device networks-series and parallel.	
5.	**Reliability Determination and Prediction**: Reliability Determination Methods: Network reduction technique, Path tracing technique, Decomposition technique, Delta-Star method. Advanced Reliability Evaluation Concepts: Supplementary variables technique, Interference theory, Common cause failures, Fault trees, and Failure mode and effect analysis. Reliability Prediction Models: Series and parallel systems - RBD approach - Standby systems - m/n configuration - Application of Baye's theorem - cut and tie set method - Markov analysis - FTA - Limitations.	**06**
6.	**Reliability Management:** Reliability programme, Management policies and decisions, Reliability management by objectives, Reliability group, Reliability Data, acquisition and analysis, Managing people for reliability	**06**

References -

Text Books:

1. J.M.Juran , Frank M. Gryna Quality Planning and Analysis TATA McGraw hill 3rd edition
2. Douglas c. Monotgomery Statistical Quality Control Willey India publications 6th edition
3. Shrinath L S, Reliability Engineering" Affiliated East west press.
4. K.C. Kapoor,L.R. Lamberson Reliability Engineering and design, Willey publication
5. E. Balagurusamy, Reliability Engineering, TATA McGraw Hill

Reference Books:

1. Eugenel L Grant Richard S Leavenwort, Statistical Quality Control, TATA McGraw hill 7th edition
2. Connor P.D.T.O. Practical Reliability Engineering", John Wiley.
3. Naikan V N A Reliability Engineering and Life Testing", PHI Learning Private Limited.
4. Prabhakar Murthy D N and Marvin R, "Product Reliability", Springer-Verlag.

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Rajarambapu Institute of Technology, Rajaramnagar

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Department of Mechanical Engineering

Curriculum Structure and Evaluation Scheme of

M. Tech. Mechanical- (Manufacturing Engineering)

With effective from 2021-23 [2021-22 & 2022-23 Batch]

Class: - **F. Y. M.Tech.**	Semester-**II**
Course Code: **MMF212**	Course Name: **Optimization Techniques & Industrial Applications**

L	T	P	Credits
3	-	--	3

Course Description: Operations Research (OR) refers to science of decision making. Every business in the world needs to make complex decisions. Operations Research (OR) provides tools needed to make these decisions rigorously and effectively. The course presents optimization techniques for manufacturing systems. It introduces numerical techniques of design optimization methods. Approaches of various optimization technique to optimize various manufacturing applications. This course also familiarizes students with formulation and solution of Linear Programming problems, dynamic and Linear Programming, assignment and Transportation models, Queering models, game theory and decision theory. It also provides advanced optimization techniques like Genetic Algorithm, Neural Network and fuzzy logic

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Identify and apply mathematical models in optimization method.
2. Recognize the suitable method of optimization in non-linear programming with and without constraints.
3. Apply optimization method for static applications like shafts and springs.
4. Design dynamic applications like linkage mechanism by using optimization method

   Use genetic algorithm, ANN and Fuzzy logic to optimize various manufacturing systems.

Prerequisite:

Basic of statistics.

Course Content		
Unit No	**Description**	**Hrs**
1.	**Introduction of optimization:** Introduction: Classification of optimization problems, mathematical models in engineering optimization. Concepts in linear optimization: General simplex method, revised simplex method, duality, decomposition principle, integer programming, branch and bound technique and the Gomory's algorithm, post optimality analysis.	06
2.	**Decision Theory:** Operations Research and Decision theory. Types of Decisions, decision environment, decision models. Expected monetary value (EMV), EVPI, EOL.Decision making under uncertainty, Decision making under conflict, Decision tree analysis, Decision making under utilities. Case problems on decision theory applications.	06

3.	**Assignment and Transportation models:** Mathematical formulation of assignment problem, Hungarian method for solving assignment problems, unbalanced and maximization problem. Variations in assignment problems, travelling salesman problem. Mathematical statement of Transportation models, Matrix form of Transportation problem. Initial Basic Feasible Solution (IBFS) - Methods, optimum solution to Transportation models (modified distribution method, degeneracy and its resolution, transshipment problem)	06
4.	**Non-linear programming without constraints:** Local and global maxima, minima, Hessian matrix, Fibonacci method, Golden section method, random search method, steepest descent method and conjugate gradient method.	06
5.	**Non-linear programming with constraints:** Lagrange multipliers, Kuhn-Tucker conditions, quadratic programming. Wolfe's and Beale's method, sequential linear programming approach, penalty methods. Interior and exterior penalty function method.	06
6.	**Advanced Optimization Techniques** Multi stage optimization – dynamic programming; stochastic programming; Multi objective optimization, Genetic algorithms and Simulated Annealing techniques; Neural network & Fuzzy logic principles in optimization. MCDM techniques	06

References -
Text Books:

1. S.S.Rao, *Optimization-Theory and Applications, ,* Wiley Eastern, New Delhi, 1978
2. J.C.Pant, Introduction to Optimization, Jain Brothers, New Delhi, 1983
3. Kanthi Swaroop, et.at., *Operations Research,* S. Chand & Co., New Delhi
4. Kalyanmoy Deb, *Optimization for Engineering Design Algorithms and Examples,* Prentice Hall of India, New Delhi, 1995

Reference Books:

1. Rao, Singaresu, S., "Engineering Optimization – Theory & Practice", New Age International (P) Limited, New Delhi, 2000.
2. Johnson Ray, C., "Optimum design of mechanical elements", Wiley, John & Sons.
3. Kalyanamoy Deb, "Optimization for Engineering design algorithms and Examples", Prentice Hall of India Pvt. 1995.
4. Goldberg, D.E., "Genetic algorithms in search, optimization and machine",Barnen, Addison-Wesley, New York, 1989.

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M. Tech. Mechanical- (Manufacturing Engineering)
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Class: - **F. Y. M.Tech.**	Semester-**II**
Course Code: **MMF2131**	Course Name: **Research Methodology & IPR**

L	T	P	Credits
1	1	--	2

Course Description:

This course provides a first coverage of the main concepts of research process, literature review, experimental designs and the associated analysis of variance models. It introduces different types ofexperimental designs to students from all types of disciplines. Statistical methods useful in design andanalysis of experiments in all fields of engineering. The basic idea behind introducing this course is to cultivate the research qualities within the post graduate students so that the knowledge gained in this course will prepare graduate for dissertation work. Course also covers basics about IPR which helps them to know about patents & copy rights etc.

Course Learning

After successful completion of the course, students will be

1. Formulate research
2. Analyze research related information
3. Prepare and present research proposal/paper by following research ethics
4. Make effective use of computers and computing tools to search information, analyze information and prepare report.

Describe nature and processes involved in development of intellectual property

Prerequisite: Basics of Statistics

Course Content

Unit No	Description	Hrs
1.	Meaning of research problem, Sources of research problem, Criteria and Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.	02
2.	Effective literature studies approaches, Plagiarism, Research ethics, Approaches of investigation of solutions for research problem, data collection, Data analysis with software, interpretation, Necessary instrumentations.	02

3.	Effective technical writing, how to write technical report and paper, Developing a Research Proposal, Format of researchproposal, a presentation and assessment by a review committee	02
4.	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property, Procedure for grants of patents, Patenting under PCT.	02
5.	Patent Rights: Scope of Patent Rights, Licensing and transfer of technology, Patent information and databases, Geographical Indications.	02
6.	New Developments in IPR: Administration of Patent System, New developments in IPR; IPR of Biological Systems, Computer Softwareetc., Traditional knowledge Case Studies, IPR and IITs.	02

Tutorials: Based on above topics.

Reference Books:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science& engineering students", Juta& Co Ltd
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction", JutaAcademic
3. Ranjit Kumar, 2nd Edition , "Research Methodology: A Step by Step Guide for beginners",SAGE Publication
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
5. Mayall , "Industrial Design", McGraw Hill, 1992.
6. Niebel , "Product Design", McGraw Hill, 1974.
7. Asimov , "Introduction to Design", Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in NewTechnological Age", Wolters Kluwar,2016.
9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.

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Class: - **F. Y. M.Tech.**	Semester-**II**
Course Code: **MMF2141**	Course Name: **CAM Lab.**

L	T	P	Credits
-	-	04	02

Course Description:

This laboratory course is offered to develop the skills of creating a part model of the components andto generate the tool path and part program for the component using CAM software.

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1. Develop sketches using suitable CAD software.
2. Develop part models using suitable CAD software.
3. Develop Assembly model using suitable CAD software.
4. Develop 2D drawings using suitable CAD software.
5. Generate tool path and part program for plain milling operation.

Prerequisite:

Basics turning & milling operations

Course Content		
Experiment No	**Description**	**Hrs**
1.	**Developing sketches in NX CAD:** Create a sketch using sketch tools like profile, circle, mirror, quick trim etc. Add geometric constraints like parallel, perpendicular, tangent, concentric etc. Add dimensions to the sketch. Create a sketch using sketch tools like profile, circle, mirror, quick trim etc.	**06**
2.	**Developing Solid Models** Develop the base model using extrude, revolve and similar tools. Create datum planes, datum axis etc. Create detail features and designfeatures like hole, edge blend, threads sweeps etc	**06**
3.	**Developing assembly model** Develop assembly model for the given product	**06**

4.	**Drafting – Developing 2D drawing** Develop 2D drawings using existing assembly model	06
5.	**Generate tool path and part program for plain milling operation** Create the solid model of the component, Open the model in manufacturing environment and create tool, operation method etc. Generate tool path, verify tool path and generate part program	06
6.	**Generate tool path and part program for pocket milling operation**Create the solid model of the component, Open the model in manufacturing environment and create tool, operation method etc. Generate tool path, verify tool path and generate part program	06
7.	**Generate tool path and part program for contour milling operation**Develop solid model of the component. Open the model in manufacturing environment and create tool, method, operation etc. Generate tool path, verify tool path and generate part program.	06
8.	**Generate tool path and part program for turning operation** Develop solid model of the component. Open the model in manufacturing environment and create tool, method, operation etc. Generate tool path, verify tool path and generate part program	06

References -

Sham Tickoo, NX 10.0 for Designers, CADCIM Technologies, 2016

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M. Tech. Mechanical- (Manufacturing Engineering)
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Class: -F. Y.M. Tech.-	Semester: II
Course Code: **MMF2151**	Course Name: **Software Proficiency-II**

L	T	P	Credits
-	-	04	02

Course Description:

The platform for innovation is built on a foundation of design optimization, performance analysis, data management and process automation. In recent years the use of computer simulation packages as a design and development tool has grown rapidly and it becomes integral part of research and development department. Analysis and simulation software provide a tightly integrated suite of best-in-class tool for modeling, analysis and simulation. This software also optimizes the design and provides the simulation and visualization the performance of optimum solution.

Prerequisite:

Pre requisite for this subject from student's end is that, they must have undergone computational techniques. Also, it requires the knowledge of thermal and structural engineering.

Course Learning Outcomes:
After successful completion of the course, students will be able to,
1. Develop/ select appropriate model required for simulation.
2. Apply proper constraints and boundary conditions.
3. Select suitable solver settings of simulation software.

Course Content

Experiment No	Description	Hrs
1.	Introduction to fusion 360, Software interface & Workbenches	02
2.	Demonstration of basic commands in sketcher-View toolbar, Profile, Constraints and Operations	06
3.	Demonstration of toolbars in Part design: Sketch based features.	06
4.	Demonstration of toolbars in Part design: Dress up feature.	06

5.	Demonstration of toolbars in Part design: Transformation Feature	**04**
6.	Demonstration of Various toolbars in assembly workbench for constraining the parts.	**04**
7.	Various commands in drafting workbench for creating the views.	**04**
8.	Introduction to CAM environment.	**04**
9.	Case study on CAM	**04**
10.	Introduction to CAE environment.	**04**
11.	Case study on CAE.	**04**

Reference: Autodesk Manual for FUSION 360

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M. Tech. Mechanical- (Manufacturing Engineering)
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Class: - **F. Y. M.Tech.**	Semester-**II**
Course Code: **MMF2161**	Course Name: **Mini Project**

L	T	P	Credits
-	-	4	2

Course Description:

Mini Project will have mid semester presentation and end semester presentation. Mid semester presentation will include identification of the problem based on the literature review on the topic referring to latest literature available.

End semester presentation should be done along with the report on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data, determining solutions highlighting individuals' contribution.

Course Learning Outcome
After successful completion of the course, students will be to,

1. Identify structural engineering problems reviewing available literature.
2. Study different techniques used to analyze complex structural systems.
3. Work on the solutions given and present solution by using his/her technique

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M. Tech. Mechanical- (Manufacturing Engineering)
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Second Year M. Tech. Mechanical- (Manufacturing Engineering)- Semester – III

Class: -S. Y. M.Tech.	Semester-III
Course Code: **MMF3011**	Course Name: **Industry Internship**

L	T	P	Credits
-	-	2	**Audit Course**

Course Description:

In the field training work, the student is expected to get training in the industry, related to subject specialization for duration of 15 days (minimum) for at least 6 hrs per day. Student should write a report on the field training and submit to department for ISE evaluation at the beginning of third

Course Learning Outcomes:
After successful completion of the course, students will be able to,

1. Identify the real applications and practices of courses studied, at industry level
2. Recognize various modeling, analysis and validation techniques adopted at industries
3. Demonstrate the issues at design, manufacturing and assembly levels
4. Summarize and present technical data in report format.

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Class: **S. Y. M. Tech.**	Semester-**III**
Course Code: **MMF3031**	Course Name: **Dissertation Phase-I**

L	T	P	Credits
-	-	08	04

Course Description:

Dissertation Phase I and Synopsis Approval Presentation:

Under the guidance of faculty called as Supervisor, PG student from second year is required to do innovative and research-oriented work related to various theory and laboratory courses he/she studied during previous semesters. Dissertation work should not be limited to analytical formulation, experimentation or survey-based project. Student can undertake an interdisciplinary type project with the prior permission of DPGC from both departments.

Synopsis:

Student need to carry out exhaustive literature survey with consultation of his/her Supervisor for notless than 25 reputed national international journal and conference papers. Student should make the Synopsis Submission Presentation (SSP) with literature survey report to DPGC and justify about the innovativeness, applicability relevance and significance of the work. At the time of presentation, student shall also prepare Synopsis of the work and submit to department for approval. Student shall
submit synopsis of dissertation as per the prescribed format in 02 copies to department.

Course Learning Outcomes:
After successful completion of the course, students will be able to,

1. contributions of various researchers in the field of design engg after carrying out literaturesurvey from reputed journals
2. Recognize the gap in the research and define a problem statement
3. Explain significance and applicability of problem statement
4. Summarize and present technical data in report format.

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M. Tech. Mechanical- (Manufacturing Engineering)
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Class: **S. Y. M.Tech.**	Semester-**III**
Course Code: **MMF3041**	Course Name: **Dissertation Phase-II**

L	T	P	Credits
-	-	12	06

Course Description:

Phase II evaluation is based on End Semester Examination (ESE) which is based on the work during the semester. It is expected that student shall present preliminary results from his/her work during the semester with report as per prescribed format. DPGC including external examiner as expert will approve the report and progress of student. ISE will be evaluated by DPGC and ESE will be evaluatedby DPGC and one external expert. Student will submit a report (soft bound before 1 week of date of presentation) as per prescribed format and present to DPGC for ISE and ESE. If student is not showingsatisfactory performance, then he /she will be given grace period of 2 week. After 2 weeks, student

Course Learning Outcomes-

After successful completion of the course, students will be able to,

1. Outline the work plan for problem statement
2. Identify the proper modeling and analysis tool
3. Reproduce the preliminary results of problem statement
4. Summarize and present technical

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Class: **S. Y. M.Tech.**	Semester-IV
Course Code: **MMF4011**	Course Name: **Dissertation Phase-III**

L	T	P	Credits
-	-	12	06

Course Description:

Student is required to make a presentation on the progress of his/her dissertation work in front of supervisor and DPGC. It is expected that up to this stage almost 90% of the dissertation work is completed. Student will make the presentation and seek the suggestions from the supervisor and DPGC. Supervisor and DPGC will ensure that work carried out by the students till this stage is satisfactory and in compliance with synopsis of the dissertation submitted by the student

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1.Explain the issues related to method adopted in solving the problem

2.Select propertechnique in solving the problem

Class: **S. Y. M. Tech.**	Semester-IV
Course Code: **MMF4021**	Course Name: **Dissertation Viva-Voce**

L	T	P	Credits
-	-	20	10

Course Description:

This is the final presentation i.e. viva voce of the dissertation. Student will be allowed to make this presentation only if he has submitted duly completed and certified dissertation report. Students will make the presentation in front of supervisor, DPGC and external supervisor. Examiners will check whether the dissertation work is in full compliance with synopsis of dissertation or not. Dissertation will assess on the bases quality of dissertation work, efforts taken by the student, quality of the paper(s) published on the dissertation work etc.

Course Learning Outcomes:

After successful completion of the course, students will be able to,

1.Design new methodology to address the problem

2.Justify the results obtained from new methodology

3.Write the project report.