रतीय सूचना प्रौद्योगिकीअभिकल्पना एवं विनिर्माण संस्थान कर्नूल

INDIAN INSTITUTE OF INFORMATION TECHNOLOGY, DESIGN AND MANUFACTURING KURNOOL

Jagannathagattu, Kurnool – 518008, Andhra Pradesh, INDIA
(An Institute of National Importance under Ministry of Education, Govt. of India)

Syllabus for

M. Tech. in Smart Manufacturing

(From AY 2020-21)

DEPARTMENT OF MECHANICAL ENGINEERING

INDIAN INSTITUTE OF INFORMATION TECHNOLOGY, DESIGN AND MANUFACTURING KURNOOL

Jagannathagattu, Kurnool-518008, Andhra Pradesh

(An Institute of National Importance under Ministry of Education, Govt. of India)

Institute Vision

To become a leading institute of higher learning in Information Technology enabled design & manufacturing to create technologies and technologists befitting the industries globally.

Institute Mission

To become a centre of excellence pioneering in education, research & development, and leaders in design & manufacturing.

Department Vision

To build an academic and research eco system with the innovation mindset and global perspectives to cater the needs of the society in the discipline of Mechanical Engineering with prime focus in the fields of design and manufacturing.

Department Mission

To enable the graduates with technically sound and state-of-the-art curriculum leading to entrepreneurial spirit and carrying out cutting edge research in collaboration with industry and research organizations.

M.Tech. in Smart Manufacturing

- A New Post Graduate Program for Next Generation Industries

Overview

Indian Institute of Information Technology Design & Manufacturing Kurnool (IIITDM Kurnool) was announced in 2014 after receiving the assent of President of India to the Institutes of Information Technology Act, 2014, and its subsequent publication in the Gazette of India, Extraordinary, Part- II, Section I, on December 08, 2014. The institute was announced by Government of India to give effect to its obligation under the Andhra Pradesh reorganization act 2014. IIITDM Kurnool is fully funded by Ministry of Education. IIITDM Kurnool launched its academic program with the support of its mentor Institute, IIITDM Kancheepuram, Tamil Nadu, on August 2015 from the Kancheepuram campus. Consequent upon the approval of parliament, IIITDM Kurnool was accorded the status of Institute of National Importance by making an amendment in the IIIT act 2014 on August 03, 2017. In 2015, the Andhra Pradesh government allocated an area of around 200 acres for the establishment of a permanent campus in Kurnool.

The institute had initially started B. Tech. programs in Computer Science Engineering, Electronics and Communication Engineering and Mechanical Engineering with a total annual intake of 120 students.

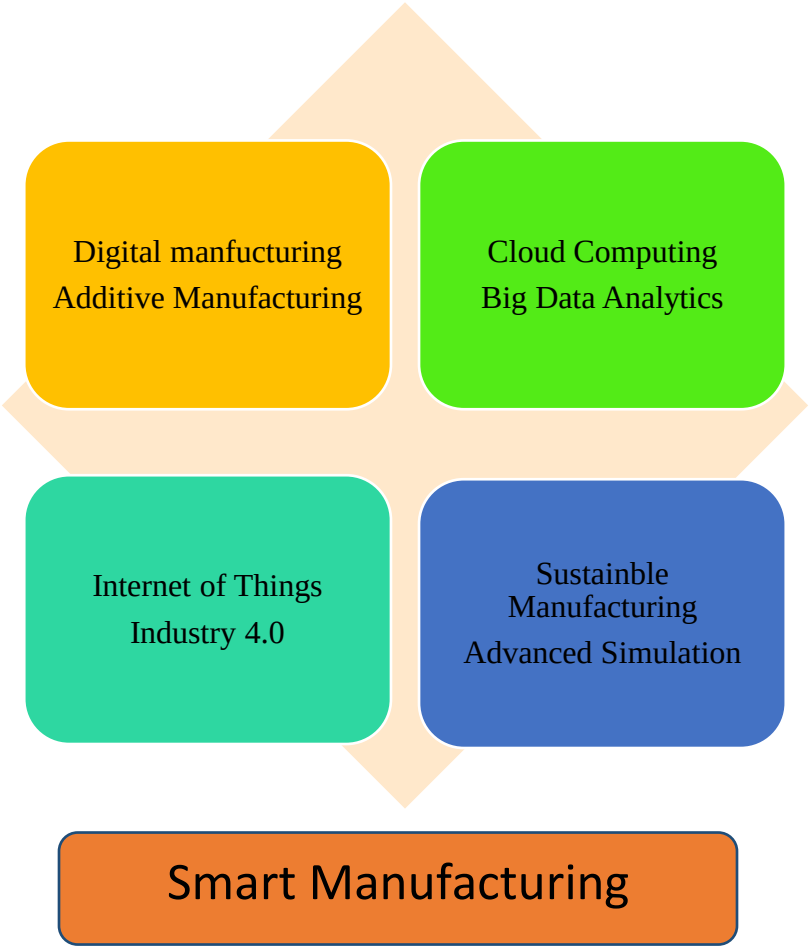
IIITDM Kurnool is planning to roll out a new post graduate program from **July 2020**, namely **M.Tech in Smart Manufacturing** under the **Department of Mechanical Engineering**. The objectives of the program is to train workforce catering to needs of 21st century manufacturing industries which are increasingly becoming smart and connected. The curriculum for the program has been carefully crafted by conducting many brainstorming sessions with Industry and Academic leaders in Manufacturing. The courses for the program are interdisciplinary in nature. Smart Manufacturing is an amalgamation of Information technology, Networks, Data Science, Sensors for adaptive control and Managing the manufacturing enterprises.

M.Tech in Smart Manufacturing will adopt a faceted approach to manufacturing education by giving equal importance to basic sciences & engineering courses. Students will be trained in fundamental manufacturing processes, manufacturing systems, systems engineering, IT, Networks and basic shop floor communications. Experiential learning approach will be followed and students will be gaining hands-on experience in many spheres of technology related to smart manufacturing. Students will also undergo a comprehensive project work for a duration of one year and will be exposed to real world problems of the present-day industry.

What is Smart Manufacturing?

Smart manufacturing is a broad category of manufacturing with the goal of optimizing concept generation, production, and product transaction. While manufacturing can be defined as the multi-phase process of creating a product out of raw materials, smart manufacturing is a subset

that employs computer control and high levels of adaptability. Smart manufacturing aims to take advantage of advanced information and manufacturing technologies to enable flexibility in physical processes to address a dynamic and global market. There is an increased workforce training for such flexibility and use of the technology rather than specific tasks as it is customary in traditional manufacturing.



Need for Smart Manufacturing

The 21st century manufacturing facilities have ushered a new wave of manufacturing with an amalgamation of technologies from advanced robotics to fully integrated production systems. With smart manufacturing or Industry 4.0, manufacturers are moving towards a new level of interconnected and intelligent manufacturing system which incorporates the latest advances in sensors, robotics, big data, and controllers.

To keep pace with the evolution of these "smart factories' requires highly skilled and nimble engineers to manage the increasing complexity and shorter mind-to market product cycles. The goal of this program is to train future manufacturing engineers with basic knowledge on IT in

addition to the strong problem-solving skills that are imparted in today's programs. Students will be trained in manufacturing processes, manufacturing systems, systems engineering, IT, Networks and basic shop floor communications. Experiential learning approach will be followed and students will be gaining hands-on experience in many spheres of technology related to smart manufacturing.

Why IIITDM Kurnool?

The recent initiatives of Govt. of India, such as '**Make in India**', '**Skill India**', '**Digital India**', '**Start up India**' and '**Stand up India**', are expected to transform the manufacturing into a hotbed of new jobs and lead to overall economic growth.

Manufacturing is not only the backbone of the economy but also the muscle behind national security. Keeping this in view, a few manufacturing sectors have been identified as strategic for strengthening the national capabilities from the long-term point of view. With increasing and rapidly changing customer demand, less product life cycle multiplied by a drop in planning time, and highly competitive nature, the industries, all over the world, are in need of talented engineers who can run their enterprises in an optimum way. IIITDM Kurnool has taken this step in our country to offer a post graduate program in Smart Manufacturing to augment the Government Initiatives, after IIITDM Kancheepuran and IISc Bangalore.

Indian Institute of Information Technology Design and Manufacturing Kurnool (IIITDM Kurnool) is an Institute of National Importance for Technical Education and Research established in 2015 by the Ministry of Education (MoE), Government of India to pursue design and manufacturing oriented engineering education and industry based research to promote the competitive advantage of Indian products in global markets. The institute offers academic and research programs that integrate engineering design, manufacturing and management with information technology. The institute offers undergraduate, and doctoral research which focus on IT, design and manufacturing in engineering sectors, which is outcome based and Industry oriented.

Scheme/Structure for
M.Tech in Smart Manufacturing

Semester I						
S. No.	Course Code	Course Name	Category	I	P	C
1	ME601T	Introduction to Smart Manufacturing	PEC	3	0	3
2	ME602T	Applied AI for Manufacturing	BSC	3	0	3
3	ME602P	Applied AI for Manufacturing Practice	BSC	0	3	2
4	ME603T	Mechatronic Product Design	PEC	3	0	3
5	ME603P	Mechatronic Product Design Practice	PEC	0	3	2
6	ME604T	Advanced Manufacturing Processes	PEC	3	0	3
7	ME604P	Advanced Manufacturing Practice	PEC	0	3	2
8	XXxxxT	Elective-I	PEC	3	0	3
9	ME651P	Seminar	PCD	0	3	2
Total				15	12	23
Semester II						
S. No.	Course Code	Course Name	Category	I	P	C
1	ME605T	Industrial IoT and Cloud Computing	PEC	3	0	3
2	ME605P	Industrial IoT and Cloud Computing Practice	PEC	0	3	2
3	ME606T	Modelling and Simulation of Manufacturing Systems	PEC	3	0	3
4	ME606P	Manufacturing Simulation Practice	PEC	0	3	2
5	ME607T	Micro and Nano Manufacturing Technology	PEC	3	0	3
6	ME6xxT	Elective-II	PEC	3	0	3
7	XXxxxT	Elective-III	PEC	3	0	3
8	ME652P	Comprehensive Viva-Voce	PEC	0	3	2
Total				15	9	21
Semester III						
1	ME653P	Dissertation Work-I	PCD	0	25	10
Total				0	25	10
		Semester IV				
1	ME654P	Dissertation Work-II	PCD	0	25	20
Total				0	25	20

LIST OF ELECTIVES

Department Electives

S. No.	Course Code	Course Name	Category	I	P	C
Department Electives						
1	ME608T	Information Systems in Manufacturing	PEC	3	0	3
2	ME609T	Inspection and Testing in Manufacturing	PEC	3	0	3
3	ME610T	Lasers in Manufacturing	PEC	3	0	3
4	ME611T	Digital Manufacturing	PEC	3	0	3
5	ME612T	Smart Materials and Structures	PEC	3	0	3
6	ME613T	Product Design and Development	PEC	3	0	3
7	ME614T	Design for Manufacturing and Assembly	PEC	3	0	3
8	ME615T	Additive Manufacturing	PEC	3	0	3
9	ME616T	Materials Fabrication and Characterization	PEC	3	0	3

Free Electives

S. No.	Course Code	Course Name	Category	I	P	C
Free Electives						
1	ME621T	Advanced Engineering Mathematics	PEC	3	0	3
2	ME622T	Applied Operations Research	PEC	3	0	3
3	ME623T	Design and Analysis of Experiments	PEC	3	0	3
4	ME624T	Computational Tools for Engineers	PEC	3	0	3
5	ME511T	Industry 4.0	PEC	3	0	3
6	ME625T	Soft Computing Techniques	PEC	3	0	3
7	ME626T	Big Data Analytics	PEC	3	0	3
8	ME627T	Total Quality Management	PEC	3	0	3
9	ME628T	IC Engines and Gas Turbines	PEC	3	0	3

Course Title	**Introduction to Smart Manufacturing**	Course Number	ME601T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Core
Prerequisite	Basic Concepts of Manufacturing Processes	Effective from	July 2020
Course Objective	The objective of the course is to provide a strong orientation to the students on the new advancements in manufacturing in general and the relevant features of Smart Manufacturing to the global context, in particular.		
Course Outcomes	The students will be able to: 1. Analyse implemented automated manufacturing systems and describe their components; 2. Identify automation tasks in manufacturing plants and name the components, which are necessary for the implementation of each automation task; 3. Design and select components for a given use case of the categories: Handling Technology, Industrial Robotics, Sensors, and Controls; 4. Distinguish different concepts for multi-machine systems and select a suitable one for a given use case.		
Contents of the course	Module 1: Introduction to Smart Manufacturing Module 2: Analyzing Data and Modeling to Make Sense of Data Module 3: Sensors & IoT Module 4: Control of Manufacturing Processes Module 5: Machine Vision and Applications of Machine Vision Module 6: Model Fitting and Sensitivity Analysis Module 7: Statistical Process Control and Data Analysis		
Textbooks	1. Luo, ZongWei, Smart Manufacturing Innovation and Transformation: Interconnection and Intelligence: Interconnection and Intelligence, IGI Global, 2014. 2. R. C. Gupta, Statistical Quality Control, 8th edition, Khanna Publishers, 2008, ISBN: 8174091114.		
References	1. Fei Tao, Meng Zhang, A.Y.C. Nee, Digital Twin Driven Smart Manufacturing, Academic Press, 2019.		

Course Title	**Applied AI for Manufacturing**	Course Number	ME602T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Core
Prerequisite	Basic Concepts of Manufacturing Processes	Effective from	July 2020
Course Objective	An in-depth look at how artificial intelligence (AI) is transforming the manufacturing sector by optimizing digital operations and driving efficiencies, enabling new products and services, and allowing for safer work environments.		
Course Outcomes	The students will be able to: 1. Understand the capability of AI for production planning and decision making. 2. Understand the fundamental concepts of manufacturing scheduling. 3. Understand the role of robot control system in manufacturing.		
Contents of the course	Module 1: Application of Machine Learning to Industrial Planning and Decision Making, Special Purpose Resource Design in Planning to Make More Efficient Plans; Module 2: Geometric Reasoning Using a Feature Algebra, Backward Assembly Planning Symmetry Groups in Solid Model-Based Assembly Planning, Module 3: An Expert System Approach for Economic Evaluation of Machining Operation Planning, Interactive Problem Solving for Production Planning, Module 4: An Abstraction-Based Search and Learning Approach for Effective Scheduling, ADDYMS: Architecture for Distributed Dynamic Manufacturing Scheduling, An Architecture for Real Time Distributed Scheduling, Exploiting Local Flexibility During Execution of Pre-computed Schedules Module 5: An Architecture for Integrating Enterprise Automation; An Intelligent Agent Framework for Enterprise Integration; Teamwork Among Intelligent Agents: Framework and Case Study in Robotic Service Module 6: Symbolic Representation and Planning for Robot Control Systems in Manufacturing; Integrated Software System for Intelligent Manufacturing; Enterprise Management Network Architecture: A Tool for Manufacturing Enterprise Integration; Design and Manufacturing: Integration through Quality Module 7: Introduction to Digital Twin and Cyber Physical Manufacturing Systems.		
Textbooks	1. A. Fazel Famili (Editor), Dana S. Nau (Editor), Steven H. Kim (Editor); Artificial Intelligence Applications in Manufacturing, AAAI Press.		
References	1. Ellen Friedman, Ted Dunning, AI and Analytics in Production; O'Reilly Media, Inc., 2018 (ISBN: 9781492044116) 2. Çağlayan Arkan, The Future Computed: AI and Manufacturing; Global Lead, Manufacturing and Resources Industry, Microsoft, 2019.		

Course Title	**Applied AI for Manufacturing Practice**	Course Number	ME602P
Specialization	Mechanical Engineering	Structure (IPC)	0-3-2
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Core
Prerequisite	Basic Concepts of Manufacturing Processes	Effective from	July 2020
Course Objective	An in-depth practical knowledge along with hands-on sessions, at how artificial intelligence (AI) is transforming the manufacturing sector by optimizing digital operations and driving efficiencies, enabling new products and services, and allowing for safer work environments.		
Course Outcomes	The students will be able to: 1. Realize application of Machine Learning to Industrial Planning and Decision Making 2. Develop a practical understanding of effective scheduling. 3.Integrated Software System for Intelligent Manufacturing. 4. Planning for Robot Control Systems in Manufacturing.		
Contents of the course	These Laboratory classes aims at: 1. Understanding the phenomena involved 2. Study of influencing parameters 3. Develop setup, instrumentation, equation, product, etc. 4. Modelling& Simulation of the process 5. Simple project 6. Creation of concept 7. Application to real problem 8. Assignments suggested by the instructor.		
Textbooks	1. A. Fazel Famili (Editor), Dana S. Nau (Editor), Steven H. Kim (Editor); Artificial Intelligence Applications in Manufacturing, AAAI Press.		
References	1. Ellen Friedman, Ted Dunning, AI and Analytics in Production; O'Reilly Media, Inc., 2018 (ISBN: 9781492044116) 2. Çağlayan Arkan, The Future Computed: AI and Manufacturing; Global Lead, Manufacturing and Resources Industry, Microsoft, 2019.		

Course Title	**Mechatronics Product Design**	Course Number	ME603T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Core
Prerequisite	Nil	Effective from	July 2020
Course Objective	To provide a hands-on introduction to design of mechatronic systems, namely sensors, actuators, interfaces, computer hardware, and control software, and enable understanding of the theory and practice of mechatronic systems integration.		
Course Outcomes	The students will be able to: 1. Understand the basic concepts of the main sensors used in electromechanical systems 2. Understand the fundamental concepts of mechanical power transmission components, and pneumatic and hydraulic actuators 3. Use the common analog and digital interfaces between sensors/actuators and the systems under control using open source microcontrollers 4. Understand the integration of mechanisms, sensors, actuators, interfaces and software in the design of mechatronic systems.		
Contents of the course	**Introduction:** Mechatronics, history, applications, and trends. **Sensors and transducers:** Characterization, sensors for position, velocity, proximity, force, pressure, temperature and light. **Signal conditioning:** Amplification, filtering, multiplexing, and telemetry. Data acquisition with A/D, D/A and digital I/O. **Mechanical components:** Types of motion, kinematic chains, cams, gears and other power transmission mechanisms. **Software development:** program structures for embedded systems, software design process, inter-processor communication, microcontrollers and peripherals. **Pneumatic and hydraulic actuators:** Basics of fluid flow, control valves, cylinders and rotary actuators for pneumatics and hydraulics. **Microcontrollers:** Introduction to use of open source hardware (Arduino & Raspberry Pi); shields/modules for GPS, GPRS/GSM, Bluetooth, RFID, and Xbee, integration with wireless networks, databases and web pages. **Basic closed-loop control:** open-loop, on-off, PID control, Mechatronic systems integration, rapid prototyping of mechanical and electrical systems. Demonstrations of mechatronic systems in class.		
Textbooks	1. J. Edward Carryer, et al., Introduction to Mechatronic Design, Prentice Hall, 1st edition, 2010, ISBN: 978-8131788257.		
References	1. W. Bolton, Mechatronics, Pearson India, 4th edition, 2010, ISBN: 978-8131732533. 2. D. G. Alciatore and M. B. Histand, Introduction to Mechatronics and Measurement Systems, McGraw-Hill, 4th edition, 2014, ISBN: 978-9339204365.		

Course Title	**Mechatronics Product Design Practice**	Course Number	ME603P
Specialization	Mechanical Engineering	Structure (IPC)	0-3-2
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Core
Prerequisite	Nil	Effective from	July 2020
Course Objective	Students will gain a practical knowledge of various advanced manufacturing processes in a hands-on environment through experiments and simulations.		
Course Outcomes	The students will be able to: 1. Understand the basic concepts of the main sensors used in electromechanical systems 2. Understand basics of open source hardware/software, Mechaphonics, and mobile/web apps 3. Hands-on laboratory experiments and team projects involving the above concepts.		
Contents of the course	These Laboratory classes aims at: 1. Arduino microcontroller I/O and interfacing 2. Basic sensors interfacing with Arduino 3. GPS and data logging with Arduino 4. Networking with Arduino: GSM and Bluetooth 5. Raspberry Pi microcomputer I/O and interfacing 6. Simple project 7. Creation of concept 8. Application to real problem 9. Assignments suggested by the instructor.		
References	1. W. Bolton, Mechatronics, Pearson India, 4th edition, 2010, ISBN: 978-8131732533. 2. D. G. Alciatore and M. B. Histand, Introduction to Mechatronics and Measurement Systems, McGraw-Hill, 4th edition, 2014, ISBN: 978-9339204365.		

Course Title	**Advanced Manufacturing Processes**	Course Number	ME604T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Core
Prerequisite	Basic Concepts of Manufacturing Processes	Effective from	July 2020
Course Objective	To inculcate specialized knowledge and skill in advanced manufacturing processes using the principles and methods of engineering analysis and design.		
Course Outcomes	The students will be able to: 1. Model the material removal in various advanced manufacturing processes. 2. Analyze the processes and evaluate the role of each process parameter during machining of various advanced materials.		
Contents of the course	**INTRODUCTION TO ADVANCED MANUFACTURING PROCESSES**: Introduction to manufacturing processes. Overview of non-conventional machining processes with (AJM, USM, ECM, EDM, EBM, LBM, AFM, MRF, MAF, MFP and MRAFF etc.). Introduction to use of non-conventional processes for micro-machining. **MECHANICAL MATERIAL REMOVAL PROCESSES**: ***Abrasive Jet Machining (AJM)*** – Introduction, process parameters, estimation of MRR and Modeling of MRR. Components of AJM and Numerical approach. *Water Abrasive jet machining (WAJM):* Basic principle, estimation of MRR WAJM process video. ***Ultrasonic Machining (USM)*** – Introduction, process parameters, estimation of MRR, modeling of MRR. Design of acoustic ultrasonic head and feed mechanism in USM. Numerical approach. **ELECTROCHEMICAL MACHINING PROCESS:** ***Electrochemical Machining (ECM):***Basic Principle, Estimation of MRR, MRR in multiphase alloys, Modeling of Kinematics and Dynamics for ECM process, Tool design, Surface Finish and Numerical approach. ***Different Electrochemical Machining:*** Grinding, drilling, Milling, Turning and boring (basic principle and process parameters) **THERMAL MATERIAL REMOVAL PROCESSES:** ***Electro-discharge machining (EDM):***Basic Principle, Process parameters, Estimation of MRR, Modeling of depth of melting temperature, Role of cavitation and melting temperature of the work-piece material, Surface finishing and machining accuracy Electrode and dielectric fluid, EDM turning and Wire EDM. ***Electron Beam Machining (EBM):*** Introduction, Comparison of E-beam machining with other thermal processes, Setup for EBM, Power requirement in E-Beam, Mechanics of EBM process, Derivation of functional characteristics in EBM by using Buckingham's Pie theorem. ***Laser Beam Machining (LBM):*** Introduction, types of lasers and feedback mechanisms, MRR, Numerical modeling on semi-infinite surface and with circular beams, Estimation of machine time, Steady state hole penetration model in LBM.		

Textbooks	1. Advanced manufacturing processes, Hassan Abdel, Gabad El Hoffy, McGraw Hill. 2. V.K.Jain, Advance Machining Processes, Allied Publisher Bombay. 3. Ghosh and Mallik, Manufacturing Science, EWP Private Ltd. 4. Pandey P.C., Shan H.S., Modern machining processes, Tata McGraw-Hill Education.
References	1. Weller E.J., Nontraditional machining processes, Society of Manufacturing Engineers, Publications. 2. The Science and Engineering of Micro-fabrication, Stephen P. Campbell, Oxford University press.

Course Title	**Advanced Manufacturing Practice**	Course Number	ME604P
Specialization	Mechanical Engineering	Structure (IPC)	0-3-2
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Core
Prerequisite	Basic Concepts of Manufacturing Processes	Effective from	July 2020
Course Objective	Students will gain a practical knowledge of various advanced manufacturing processes in a hands-on environment through experiments and simulations.		
Course Outcomes	The students will be able to: 1. Realize products using advanced manufacturing processes 2. Develop a practical understanding of advanced manufacturing processes and capabilities of each. 3. Identify and rectify defects in parts and manufacturing processes related problems. 4. Analyze data from experiments performed and reach conclusions.		
Contents of the course	These Laboratory classes aims at: 1. Understanding the phenomena involved 2. Study of influencing parameters 3. Develop setup, instrumentation, equation, product, etc. 4. Modeling & Simulation of the process 5. Simple project 6. Creation of concept 7. Application to real problem 8. Assignments suggested by the instructor.		
References	1. Advanced manufacturing processes, Hassan Abdel, Gabad El Hoffy, McGraw Hill. 2. V.K.Jain, Advance Machining Processes, Allied Publisher Bombay. 3. Ghosh and Mallik, Manufacturing Science, EWP Private Ltd. 4. Pandey P.C., Shan H.S., Modern machining processes, Tata McGraw-Hill Education.		

Course Title	**Industrial IoT and Cloud Computing**	Course Number	ME605T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Elective
Prerequisite	Nil	Effective from	July 2020
Course Objective	This course introduces the concepts of Industrial Internet of Things, and Cloud Computing. The students are exposed to the architectures, and various frameworks in IIoT and Cloud Computing.		
Course Outcomes	The students will be able to: 1. Understand the existing IoT and Cloud architectures 2. Design an IoT system with cloud infrastructure 3. Implement a prototype of the IoT/cloud system design		
Contents of the course	Introduction, Physical design of IoT, Logical design of IoT, IoT enabling technologies, Domain specific IoTs IoT design methodology, logical design IoT physical devices (such as Raspberry Pi, pcDuino, Beaglebone black, Cubieboard) Introduction to cloud computing: cloud models, cloud service examples, cloud based services & applications Virtualization, load balancing, scalability, deployment, replication, monitoring, SDN, network function virtualization, MapReduce, identity and access management, SLAs. Cloud service and platforms: Commercial clouds (such as Amazon elastic compute cloud, Google Compute engine, Windows Azure), Storage services, database services, application services, content delivery services, analytics services, Open source private clouds. case studies: Industrial automation, Cloud for IoT		
Textbooks	1. A. Bahga and V. Madisetti, Internet of Things, A hands-on approach, CreateSpace Independent Publishing Platform, 1st edition, 2014, ISBN: 978-0996025515. 2. A. Bahga and V. Madisetti, Cloud Computing, A hands-on approach, CreateSpace Independent Publishing Platform, 1st edition, 2013, ISBN: 978-1494435141		
References	1. S. Jeschke, C. Brecher, H. Song, and D. B. Rawat, Industrial Internet of Things: Cybermanufacturing Systems, Springer, 1st edition, 2017, ISBN: 978-3319425580. 2. T. Erl, Z. Mahmood, and R. Puttini, Cloud Computing: Concepts, Technology & Architecture, Prentice Hall, 1st edition, 2013, ISBN: 978-0133387520.		

Course Title	**Industrial IoT and Cloud Computing Practice**	Course Number	ME605P
Specialization	Mechanical Engineering	Structure (IPC)	0-3-2
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Core
Prerequisite	Nil	Effective from	July 2020
Course Objective	At the end of this course, the students are expected to 1. Understand the existing IoT and Cloud architectures 2. Design an IoT system with cloud infrastructure 3. Implement a prototype of the IoT/cloud system design		
Course Outcomes	This course introduces the concepts of Industrial Internet of Things, and Cloud Computing. The students are exposed to the architectures, and various frameworks in IIoT and Cloud Computing along with some hands-on sessions.		
Contents of the course	These Laboratory classes aims at: 1. Understanding the phenomena involved 2. Study of influencing parameters 3. Develop setup, instrumentation, equation, product, etc. 4. Modelling & Simulation of the process 5. Simple project 6. Creation of concept 7. Application to real problem 8. Assignments suggested by the instructor. Practice: (practice exercises can be mini projects) Using IoT devices small systems like classroom automation, smart parking, environment monitoring can be designed and implemented Also, hadoop cluster can be setup and studied. Cloud computing with IoT for healthcare and industrial automation can be studied		
References	1. S. Jeschke, C. Brecher, H. Song, and D. B. Rawat, Industrial Internet of Things: Cyber manufacturing Systems, Springer, 1st edition, 2017, ISBN: 978-3319425580. 2. T. Erl, Z. Mahmood, and R. Puttini, Cloud Computing: Concepts, Technology & Architecture, Prentice Hall, 1st edition, 2013, ISBN: 978-0133387520.		

Course Title	**Modelling and Simulation of Manufacturing Systems**	Course Number	ME606T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Elective
Prerequisite	Basics of simulation and modelling	Effective from	July 2020
Course Objective	To develop an in-depth understanding on the concepts of Modelling and Simulation in a real time manufacturing system.		
Course Outcomes	The students will be able to: 1. Design and evaluate a given manufacturing system using simulation. 2. Generate random numbers and variants to execute a simulation model. 3. Evaluate queuing networks and markov chains in the context of manufacturing		
Contents of the course	Introduction to System and simulation: Concept of system and elements of system, Discrete and continuous system, Models of system and Principles of modeling and simulation, Monte carlo simulation, Types of simulation, Steps in simulation model, Advantages, limitations and applications of simulation, Applications of simulation in manufacturing system. Review of statistics and probability: Types of discrete and continuous probability distributions such as Geometric, Poisson, Uniform, Geometric distribution with examples, Normal, Exponential distribution with examples Random numbers: Need for RNs, Technique for Random number generation such as Mid product method, Mid square method, and Linear congruential method with examples Test for Random numbers: Uniformity - Chi square test or Kolmogorov Smirnov test, Independency- Auto correlation test Random Variate generation: Technique for Random variate generation such as Inverse transforms technique or Rejection method Analysis of simulation data: Input data analysis, Verification and validation of simulation models, Output data analysis Simulation languages: History of simulation languages, Comparison and selection of simulation languages Design and evaluation of simulation experiments: Development and analysis of simulation models using simulation language with different manufacturing systems Queueing models: An introduction, M/M/1 and M/M/m Models with examples, Open Queueing and Closed queueing network with examples Markov chain models and others: Discrete time markov chain with examples, Continues time markov chain with examples, stochastic process in manufacturing, Game theor		
Textbooks	1. Jerry Banks, John S. Carson, Barry L. Nelson, David M. Nicol, and P. Shahabudeen, Discrete Event System Simulation, PHI, New Delhi, 2008.		
References	1. Averill M. Law and W. David Kelton, Simulation Modeling and Analysis, Tata McGraw Hill, New Delhi, 2006. 2. N. Viswanadham and Y. Narahari, "Performance Modeling of Automated Manufacturing Systems", PHI, New Delhi, 2007.		

Course Title	**Manufacturing Simulation Practice**	Course Number	ME606P
Specialization	Mechanical Engineering	Structure (IPC)	0-0-2
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Core
Prerequisite	Basic Concepts of Manufacturing Processes	Effective from	July 2020
Course Objective	Students will gain a practical knowledge of various advanced manufacturing processes in a hands-on environment through experiments and simulations.		
Course Outcomes	The students will be able to: 1. Design complete range of statistical distribution options to accurately model process variability. 2. Develop object paths and routes for simulation 3. Modelling of statistical analysis and report generation 4. Realistic 2D and 3D animation capabilities to visualize results beyond numbers 5. Analyse Performance metrics and dashboards		
Contents of the course	Predict the course and results of certain actions. Gain insight and stimulate creative thinking. Visualize your processes logically or in a virtual environment. Identify problem areas before implementation. Explore the potential effects of modifications. Confirm that all variables are known. Optimize your operations. Evaluate ideas and identify inefficiencies. Understand why observed events occur. Communicate the integrity and feasibility of your plans. Improve visibility into the effect of a system or process change. Explore opportunities for new procedures or methods without disrupting the current system. Diagnose and fix problems. Reduce or eliminate bottlenecks Reduce operating costs. Improve financial forecasting. Better assess hardware and software requirements. Reduce delivery times. Better manage inventory levels, personnel, communications systems, and equipment. Increase profitability through overall improved operations.		
References	1. Averill M. Law and W. David Kelton, Simulation Modeling and Analysis, Tata McGraw Hill, New Delhi, 2006. 2. N. Viswanadham and Y. Narahari, "Performance Modeling of Automated Manufacturing Systems", PHI, New Delhi, 2007. 3. Jerry Banks, John S. Carson, Barry L. Nelson, David M. Nicol, and P. Shahabudeen, Discrete Event System Simulation, PHI, New Delhi, 2008.		

Course Title	**Micro and Nano Manufacturing Technology**	Course Number	ME607T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Core
Prerequisite	Nil	Effective from	July 2020
Course Objective	To inculcate specialized knowledge and skill in advanced manufacturing processes using the principles and methods of engineering analysis and design.		
Course Outcomes	The students will be able to: 1. Model the material removal in various micro manufacturing processes. 2. Analyze the processes and evaluate the role of each process parameter during machining of various advanced materials. 4. Select the best process out of the available various advanced manufacturing processes for the given job assignment. 5. Understand requirements to achieve maximum material removal rate and best quality of machined surface while machining various industrial engineering materials.		
Contents of the course	**Introduction**: Introduction to the Course & Classification of MicromanufacturingProcesses. Challenges in Meso-, Micro-, and Nanomanufacturing. **Introduction to Traditional and Advanced Micromachining Processes**: Microturning, Micromilling, Microgrinding, Biomachining, Micro- and Nano-manufacturing by Focused Ion Beam, Electric discharge micromachining, Electrochemical micromachining, Abrasive water jet micromachining. **Microcasting and Micromolding:** Microcasting, Micromolding – A soft Lithography Technique. **Microforming:** Introduction to Microforming, Micro- and Nanostructured Surface Development by Nano Plastic Forming and Roller imprinting, Microextrusion, Microbending with Laser. **Microjoining:** Introduction to microjoining, Laser Microwelding, Electron Beams Microwelding and Applications. Fabrication of Microelectronic Devices. **Nanofinishing:** Magnetorheological and Allied Finishing Processes and their theoretical analysis,Theoretical Analysis of Abrasive Flow Finishing, An Integrated Wafer Surface Evolution Model for Chemical Mechanical Planarization (CMP).		
Textbooks	1. Micromanufacturing, V. K. Jain (Ed.), CRC press, 2012. 2. Micromanufacturing& Nanotechnology, N. P. Mahalik, Springer.		
References	1. Microfacbrication & Nanomanufacturing, Mark J. Jackson, CRC press. 2. Introduction to Micromachining, V. K. Jain (Ed.), Narosa publisher, 2010.		

Course Title	**Information Systems in Manufacturing**	Course Number	ME608T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Elective
Prerequisite	Nil	Effective from	July 2020
Course Objective	This course is designed to give students an appreciation for the management issues surrounding the development and use of information technology in organizations, with a particular focus on manufacturing applications.		
Course Outcomes	The students will be able to: 1. Understand/implement computer models of common engineering information types. 2. Understand the importance and be able to critically discuss the role of management information systems for design, engineering and manufacturing. 3. Discuss and evaluate engineering data management issues across the extended enterprise. 4. Demonstrate an appreciation of the complex relationship between information systems and organization.		
Contents of the course	Manufacturing organizations, management, and the networked enterprises, Globalization challenges and opportunities, Dimensions of Information systems, Approaches to study information system, Technical and Behavioural approach. Organizations, management, and the networked enterprise: Information systems in global business today, Global e-business: Use of information systems in manufacturing functions, information system, organizations, and strategy, ethical and social issue in information systems. Information Technology Infrastructure: IT Infrastructure and Emerging Technologies, Foundations of Business Intelligence: Databases and Information Management, Telecommunications, the Internet, and Wireless Technology, Securing Information Systems, shop floor communications. Key System Applications: Achieving Operational Excellence and Customer Intimacy: Enterprise Applications, E-Commerce: Digital Markets, Digital Goods, Managing Knowledge and Collaboration, Enhancing Decision Making. Smart manufacturing and connected enterprise, ISA 95, Functional and physical sub-divisions, Global connected supply chain, mass customization, customer co-creation. Case studies of information systems for key manufacturing functions: Life cycle, supply chain, enterprise, quality, maintenance, materials, energy and sustainability information systems.		
Textbooks	1. K. Laudon and J. Laudon, Management Information Systems, 14th edition, Pearson Higher Education, 2016, ISBN: 9780136093688. 2. F. Cecelja, Manufacturing Information and Data Systems, 1st edition, Butterworth Heinemann, 2002, ISBN: 9781857180312.		
References	1. T. O. Boucher and A. Yalçin, Design of Industrial Information Systems, 1st edition, Elsevier, 2006, ISBN: 9780123704924. 2. K. E. Kurbel, Enterprise Resource Planning and Supply Chain Management: Functions, Business Processes and Software for Manufacturing Companies, 1st edition, Springer, 2013, ISBN: 9783662509869. 3. R. Zurawski, Integration Technologies for Industrial Automated Systems, 1st edition, CRC Press, 2006, ISBN: 9780849392627.		

Course Title	**Inspection and Testing in Manufacturing**	Course Number	ME609T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Elective
Prerequisite	Engineering Metrology	Effective from	July 2020
Course Objective	1. To develop skill in understanding and testing of manufactured components.		
Course Outcomes	The students will be able to: 1. Students will be able to understand the importance of testing and inspections. 2. Students will be able to draw the suitability and purpose of different testing methods.		
Contents of the course	Types and purposes of testing of manufactured components, Precautions in inspections, Accuracy of measurement and important terms; Destructive Physical Analysis (DPA): Suitability and purpose; Review of Mechanical testing methods; Tensile Testing (TT); Compression test, Charpy Impact test, Hardness Testing (HT) - Micro and Nano-hardness test, Stress Rupture Testing (SRT); Toughness, Fatigue and Fracture toughness test, Bend test, Creep test, Chemical tests, Macrographs study; ASTM standard test methods : Tensile test, Charpy Impact test, Micro-hardness evaluation, Fracture toughness test, Crack growth rate study, Flexural strength of beam; Introduction to NDT,Visual Optical methods, Dye penetrant testing, Methods of application, Developer; Magnetic particle testing, Magnetization methods, Field indicators, Particle application, Inspection; Eddy current testing, Faraday's law, Inductance, Lenz's law, Self and Mutual Inductance, Impedance plane, Inspection system; Ultrasonic testing: Basics of ultrasonic waves, Pulse and beam shapes, Ultrasonic transducers, Distance and Area calibration, Weld inspection by UT; Acoustic emission testing: Sources of acoustic emission, Source parameters, Kaiser-Felicity theory, Equipment and Data analysis; Radiography: X-rays and their properties, X-ray generation, X-ray absorption and atomic scattering; Image formation, Image quality, Digital Radiography, Image interpretation, Radiation Shielding; ASTM standard test method for NTD tests, like Radiographic, Ultrasonic, Electromagnetic (eddycurrent), X-ray, Acoustic and Tomographic techniques; and Comparison and selection of NDT methods.		
Textbooks	1. Nondestructive Testing, Louis Cartz, ASM International 2. Nondestructive Evaluation and Quality Control, ASM Handbook, Vol. 17. 3. Non-Destructive Test and Evaluation of Materials By J Prasad, McGraw Hill, 2017 4. Welding Inspection, American Welding Society,3rdEd.,2000 5. The Mechanical Testing of Metals and Alloys By foster, P. Field, Cousens Press , 2007 6. Metals Handbook: Mechanical testing, American Society for Metals, 1978		
References	1. ASTM standards for mechanical test, such as: ASTM E8/E8M (Tension test for metals), 2. ASTM D6110-10 (Charpy impact test), ASTM E9-09 (Compression test), ASTM E139-11 (Creep test) 3. ASTM standards for various non-destructive tests		

Course Title	**Lasers in Manufacturing**	Course Number	ME610T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Elective
Prerequisite	Basic concepts of manufacturing processes	Effective from	July 2020
Course Objective	1. To understand the essential characteristics of lasing materials and principles of lasers. 2. To understand the properties of lasers and identify their suitability for various applications.		
Course Outcomes	The students will be able to: 1. Identify the lasers based on their functionality for different applications. 2. Determine the requirement of laser components in different configurations. 3. Differentiate the lasers required for various material processes and manufacturing.		
Contents of the course	Introduction to Lasers: Basic principle of laser generation, Stimulated Emission; Properties of laser beam, Industrial, medical and scientific applications of Laser; Basic concept of the Laser System: Gain Medium, Optical Resonator, Pump Source, Laser beam delivery systems; Introduction and basic fundamentals and characteristics of different industrial lasers: He-Ne, CO2, Nd:YAG, Excimer, Fiber, Diode and Ultra-short pulse lasers; Laser processing fundamentals: Laser beam interaction with metal, semiconductor and insulator; Ultra-short laser pulse interaction; heat flow theory; Laser Material Processing Applications; process characteristics, mode of material removal: Laser Cutting and Drilling; Laser Welding; Laser Surface Modifications; Laser Additive Manufacturing; Laser Metal Forming; Laser shock peening; Laser Etching and Paint Striping; LCVD and LPVD; Laser hybrid machining; Liquid assisted laser machining: applications and advantages; Overview of Industrial & Scientific Applications of laser: Metrological applications, Holography (Non-destructive Testing), Laser Isotope Separation, Laser fusion ; Theoretical modeling of laser material processing; and Economics of Laser Applications in Manufacturing, Laser safety standards and safety procedures.		
Textbooks	1. Laser Fundamentals By William T. Silfvast, Cambridge University Press, New Delhi, 2nd South Asian Edition, 2004. 2. Principles of Lasers By SveltoOrazio, Springer, 5th Ed. 2010 3. Laser Material Processing By W. M. Steen and J. Mazumder, Springer, 4th Ed. 2010.		
References	1. Laser Materials Processing By Elijah Kannatey–Asibu, Jr, Wiley, 2009 2. Laser Fabrication and Machining of Materials By Narendra B. Dahotre&Sandip P. Harimkar, Springer, 200		

Course Title	**Digital Manufacturing**	Course Number	ME611T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Elective
Prerequisite	Basic concepts of manufacturing processes	Effective from	July 2020
Course Objective	1. The course objective is to make students learn about the digital description that is required for direct fabrication of products from raw materials.		
Course Outcomes	The students will learn concepts of digital design, additive and subtractive digital manufacturing and shape digitization and manufacturing in a single course for comprehensive understanding of the technology and to feel its potential in modern manufacturing practices.		
Contents of the course	Digital design: Geometrical design of curves, Surfaces and solids, Introduction to computer aided engineering analysis and optimum design. Consideration of manufacturing and assembly aspects in design; Shape digitization: 3D object scanning, Solid reconstruction from point cloud and tessellated data, Downstream applications; Digital manufacturing: Subtractive manufacturing: Basic architecture, Control hardware and software details, Tooling, Sculptured surface machining; Additive Manufacturing: Basics, Hardware details and capabilities of commercial systems, Planning of material addition, Rapid tooling solutions; Computer Aided Process Planning: CAPP and route sheet development, CAPP system, Computer aided plant layout, Computer Aided Production Planning and Control, Algorithms for CAPP; Product Database Management Systems: Types, Management Information System, Manufacturing data preparation, Shop-floor control, automatic identification systems (sensors, trackers), Product life cycle management; and Introduction of Industry 4.0.		
Textbooks	1. Fundamentals of Digital Manufacturing Science, by Z.Zhou, S.Xie, D. Chen, Springer, 2012.		
References	1. Rapid Prototyping: Principles and Applications By C.K. Chua, K.F. Leong, C.S. Lim, John Wiley, 2010. 2. Mastering CAD CAM By Ibrahim Zeid, McGraw Hill, 2005. 3. Automation, production systems, and computer-aided manufacturing By M P Groover, Pearson, 2016.		

Course Title	**Smart Materials and Structures**	Course Number	ME612T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Elective
Prerequisite	Material Science	Effective from	July 2020
Course Objective	1. To understand the concept of smart materials and smart structures. 2. To develop familiarity with piezoelectric materials and their use as sensors and actuators in various configurations.		
Course Outcomes	The students will be able to: 1. Design sensors & actuators using piezoelectric materials. 2. Analyse vibration control and damping structures using piezoelectric materials.		
Contents of the course	**Overview of Smart Materials** Introduction to Smart Materials, Principles of Piezoelectricty, PerovskytePiezoceramic Materials, Single Crystals vs Polycrystalline Systems, Piezoelectric Polymers, Principles of Magnetostriction, Rare earth Magnetostrictive materials, Giant Magnetostriction and Magneto-resistance Effect, Introduction to Electro-active Materials, Electronic Materials, Electro-active Polymers, Ionic Polymer Matrix Composite (IPMC), Shape Memory Effect, Shape Memory Alloys, Shape Memory Polymers, Electro-rheological Fluids, Magneto Rhelological Fluids. **High-Band Width, Low Strain Smart Sensors** Piezeoelctric Strain Sensors, In-plane and Out-of Plane Sensing, Shear Sensing, Accelerometers, Effect of Electrode Pattern, Active Fibre Sensing, Magnetostrictive Sensing, Villari Effect, Matteuci Effect and Nagoka-Honda Effect, Magnetic Delay Line Sensing, Application of Smart Sensors for Structural Health Monitoring (SHM), System Identification using Smart Sensors. **Smart Actuators** Modelling Piezoelectric Actuators, Amplified Piezo Actuation – Internal and External Amplifications, Magnetostrictive Actuation, Joule Effect, Wiedemann Effect, Magnetovolume Effect, Magnetostrictive Mini Actuators, IPMC and Polymeric Actuators, Shape Memory Actuators, Active Vibration Control, Active Shape Control, Passive Vibration Control, Hybrid Vibration Control. **Smart Composites** Review of Composite Materials, Micro and Macro-mechanics, Modelling Laminated Composites based on Classical Laminated Plate Theory, Effect of Shear Deformation, Dynamics of Smart Composite Beam, Governing Equation of Motion, and Finite Element Modelling of Smart Composite Beams. **Advances in Smart Structures & Materials** Self-Sensing Piezoelectric Transducers, Energy Harvesting Materials, Autophagous Materials, Self-Healing Polymers, Intelligent System Design, Emergent System Design.		
Textbooks	1. Brian Culshaw, Smart Structures and Materials, Artech House, 2000 2. Gauenzi, P., Smart Structures, Wiley, 2009		
References	1.Cady, W. G., Piezoelectricity, Dover Publication		

Course Title	**Product Design and Development**	Course Number	ME613T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Elective
Prerequisite	Nil	Effective from	July 2020
Course Objective	1. This course is intended to introduce overall awareness of the product design process. 2. It introduces the methods, tools and principles applied in industries for the design and development of the product.		
Course Outcomes	The students will be able to: 1. Emphasise on methodologies for various steps of product design such as user study. 2. Realise the need/problem identification, competitive benchmarking, and aspects of human factors in product design, creative concept generation, and prototyping/model making and evaluation techniques.		
Contents of the course	Design methodology and philosophy- types of designs, design models, concurrent engineering, and product life cycle. Design Teams – Organizations & product Planning. Need Analysis & Scope- mission statement, customer study, Kano diagram-Establishing Product Function- functional decomposition, FAST and SOP, function structure. Product Tear down- reverse engineering. Product Specifications- product design tools, QFD, Computer Aided Design, Robust design, DFX, DFM, DFA, DFMA, DFSS. Design guidelines for metallic and non-metallic products to be manufactured by various processes. Generation and evaluation of concepts – TRIZ, Decision matrix etc. Industrial Design – aesthetics and ergonomic aspects of product design. Value Engineering. Failure mode and effects analysis.		
Textbooks	1. Eppinger, S, Ulrich, K, Product design and development, McGraw-Hill, (2000). 2. Kevin Otto, Kristin Wood, Product design, Pearson, (2004).		
References	1. George E. Dieter, Engineering Design, McGraw Hill, (2000). 2. David G Ullman, The Mechanical Design Process, McGraw Hill, (2003).		

Course Title	**Design for Manufacturing and Assembly**	Course Number	ME614T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Elective
Prerequisite	Basic concepts of manufacturing processes	Effective from	July 2020
Course Objective	To develop an in-depth understanding on the concepts of Design for Manufacturing (DFM) of a product with a careful contemplation on the selection of materials, shapes and manufacturing processes, consideration of manufacturability and ease or difficulty in assembly of parts and assessment of quality, reliability, and cost-effectiveness.		
Course Outcomes	The students will be able to: 1. Outline the appropriate design for economical production and select the materials. 2. Fabricate basic parts and assemblies using powered and non – powered machine shop equipment in conjunction with mechanical documentation. 3. Integrate the knowledge of compliance analysis and interference analysis for assembly and also use visco-elastic and creep in plastics.		
Contents of the course	Introduction - Need Identification and Problem Definition, Concept Generation and Evaluation; Selection of Materials and Shapes - Properties of Engineering Materials, Selection of Materials, Selection of Shapes, Co-selection of Materials and Shapes; Selection of Manufacturing Processes - Review of Manufacturing Processes, Design for Casting, Design for Bulk Deformation Processes, Design for Sheet Metal Forming Processes, Design for Machining, Design for Powder Metallurgy, Design for Polymer Processing, Co-selection of Materials and Processes; Design for Assembly - Review of Assembly Processes, Design for Welding, Design for Brazing and Soldering, Design for Adhesive Bonding, Design for Joining of Polymers, Design for Heat Treatment; Design for Reliability and Quality - Failure Mode and Effect Analysis, Design for Quality, Design for Reliability, Approach to Robust Design, Design for Optimization.		
Textbooks	1. Ashby M.F., Materials Selection in Mechanical Design, Butterworth-Heinemann, (2016). 2. Swift K.G., Booker J.D., Process Selection: From Design to Manufacture, Butterworth-Heinemann , (2003)		
References	1. Dieter G.E., Schmidt L.C., Engineering Design, McGraw-Hill higher education, (1991). 2. Bralla J.G., Handbook for Product Design for Manufacture: A practical guide to low cost production, McGraw-Hill, (1986). 3. Ashby M.F., Johnson K., Materials and Design – the art and science of materials selection in product design, Butterworth-Heinemann, (2014). 4. Courtney T.H., Mechanical Behaviour of Materials, McGraw Hill, (2000).		

Course Title	**Additive Manufacturing**	Course Number	ME615T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Elective
Prerequisite	Basic Concepts of Manufacturing Processes	Effective from	July 2020
Course Objective	To acquaint students with the concept of AM, various AM technologies, selection of materials for AM, modeling of AM processes, and their applications in various fields. The course will also cover AM process plan including building strategies and post-processing.		
Course Outcomes	The students will be able to: 1. Demonstrate the knowledge of Additive Manufacturing and Rapid Prototyping technologies. 2. Describe different Additive Manufacturing techniques. 3. The studen also will gain the ability to manufacture a 3D part by using some of the methods of additive manufacturing.		
Contents of the course	**Introduction to Additive Manufacturing (AM)**: General overview, Introduction to reverse engineering Traditional manufacturing vis AM, Computer aided design (CAD) and manufacturing (CAM) and AM, Different AM processes and relevant process physics, AM process chain Applicationlevel: Directprocesses–RapidPrototyping, Rapid Tooling. Rapid Manufacturing; Indirect Processes - Indirect Prototyping. Indirect Tooling, Indirect Manufacturing. **Materials science for AM**: Discussion on different materials used, Use of multiple materials, multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, Structure propertyrelationship, Grain structure and microstructure. **AM technologies:** Powder-based AM processes involving sintering and melting (selective laser sintering,shaping, and electron beam melting. involvement), Printing processes (droplet based 3DSolid-based AM processes - extrusion based fused deposition modeling object Stereo lithography Micro- and Nano-additive **Process selection, planning, control for AM:** Selection of AM technologies using decision methods, Additive manufacturing process plan:strategies and post processing.Monitoring and control of defects.		
Textbooks	1. Ian Gibson, David W. Rosen, Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing Springer, 2010. 2. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011. 3. L. Lu, J. Fuh and Y.-S. Wong, Laser-induced materials and processes for rapid prototyping, Kluwer Academic Press, 200I.		
References	1. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: principles and applications, 3rd Edition, World Scientific, 2010.		

Course Title	**Materials Fabrication and Characterization**	Course Number	ME616T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Elective
Prerequisite	-	Effective from	July 2020
Course Objective	To know the deposition techniques for the manufacture of products and study the physical, morphological and chemical properties. The students are expected to understand basic principles of the synthesis and characterization techniques presented in the course, specific usage, their advantages and limitations. Furthermore, the student should be able to understand the requirements for samples suitable for each characterization techniques used. They should be able to operate the instruments based on the knowledge gained.		
Course Outcomes	The students will be able to: 1. Understand basic principles of the synthesis techniques and fabrication techniques 2. Interpret various materials characterization techniques. 3. Understand the principle and operation of characterization equipments and the adjustment of operation variables to obtain good images / results 4. Compare the principle and operation of different characterization tools such as optical microscope, Scanning electron microscopes and transmission electron microscope		
Contents of the course	**Nanopowder synthesis** Synthesis of nanomaterials: Gold, Silver, different types of Nano oxides, TiO2, ZnO by using sol-gel method, Co-precipitation, Hydrothermal, Microwave, Solvothermal and bio synthesis methods, Nanotubes and Nanowires, Carbon nanotubes, Graphene preparation, powder syntheses, crystal growth techniques, zone refining, properties and applications. **Alloying methods** Top down and bottom up synthesis- mechanical alloying, Mechanical ball-milling, Ion implantation, Inert gas condensation, Arc discharge, RF-plasma arc technique, Laser ablation, Template assisted synthesis, Clusters, Colloids, Zeolites, Porous silicon. **Deposition Techniques** Chemical vapour deposition (CVD), Metal Organic chemical vapour deposition (MOCVD), Epitaxial growth techniques: Molecular beam epitaxy, Atomic layer deposition, Pulsed laser deposition, Pulsed electrochemical deposition, Magnetron sputtering, Spin coating, Introduction to Lithography techniques. **Material characterization** Principle, Theory, Working and Application; X-Ray Diffraction, Field Emission Scanning Electron Microscopy, High Resolution-Transmission Electron Microscopy, Atomic Force Microscopy, Scanning Tunnelling Microscopy. **Advanced characterization** Photoluminescence Spectroscopy, Raman Spectroscopy, X-Ray Photoelectron Spectroscopy (XPS), Thermal analysis – Differential Scanning Calorimetry (DSC) – Thermogravimetric Analysis (TGA) – Differential Thermal Analysis (DTA) – Dynamic Mechanical Analysis (DMA), Mechanical Testing- Nano Indentation -Vibrating Sample Magnetometer, Zeta Potential and Particle size measurement.		
Textbooks	1. S.P. Gaponenko, Optical Properties of semiconductor nanocrystals, Cambridge University Press, 1980.		

	2. W.Gaddand, D.Brenner, S.Lysherski and G.J.Infrate (Eds.), Handbook of NanoScience, Engg. and Technology, CRC Press, 2002. 3. K. Barriham, D.D. Vvedensky, Low dimensional semiconductor structures: fundamental and device applications, Cambridge University Press, 2001. 4. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties &Applications, Imperial College Press, 2004. 5. J. George, Preparation of Thin Films, Marcel Dekker, Inc., New York.2005. 6. B. D. Cullity, "Elements of X-ray Diffraction", 4th Edition, Addison Wiley,1978. 7. M. H. Loretto, "Electron Beam Analysis of Materials", Chapman and Hall,1984
References	1. ASM Handbook: Materials Characterization, ASM International, 2008. 2. Yang Leng: Materials Characterization-Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia) Pte Ltd., 2008. 3. Robert F. Speyer: Thermal Analysis of Materials, Marcel Dekker Inc., New York, 1994. 4. V. T. Cherapin and A. K. Mallik: Experimental Techniques in Physical Metallurgy, Asia Publishing House, 1967.

Corse Title	**Advanced Engineering Mathematics**	Course Number	ME621T
Specialization	Mathematics	Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Elective
Prerequisite	Basic Engineering Mathematics	Effective from	July 2020
Course Objective	The overall goal of the course is to provide the students with sufficient exposure to advanced mathematical methods and tools that are relevant to theoretical and mathematical aspects of mechanical engineering research.		
Course Outcomes	On successful completion of this course, students will be able to: 1. Apply a range of mathematical theorems and methods to solve routine and complex analytic and applied problems; 2. Analyse data necessary for the solution of engineering problems; and 3. Examine the effectiveness of proposed solutions to identified engineering problems.		
Contents of the course	**Linear Algebra:** Vector space and its basis; Matrices as coordinate-dependent linear transformation; null and range spaces; **Solution of linear algebraic equations**: Gauss elimination and Gauss-Jordon methods, LU Decomposition and Cholesky method, Gauss-Seidel/ Jacobi iterative methods; Condition number; Minimum norm and least square error solutions; Eigenvalues and eigenvectors of matrices and their properties; Similarity transformation; Jordon canonical form and orthogonal diagonalization; Mises power method for finding eigenvalues/eigenvectors of symmetric matrices. Tensor Algebra and Index Notation. **Vector and Tensor Calculus**: Curves and surfaces; Gradient, divergence and curl, Line, surface and volume integrals; Gauss (divergence), Stokes and Green's theorems. Topics in Numerical Methods: Solution of a non-linear algebraic equation and system of equations; Interpolation methods, Regression; Numerical Integration. **Ordinary Differential Equations (ODEs)**: Techniques of the separation of variable and the integrating factor for 1st order ODEs; Solutions of linear, 2nd order ODEs with constant coefficients and Euler-Cauchy ODEs; System of 1st order ODEs; Numerical methods for solving ODEs, Homogeneous, linear, 2nd order ODEs with variable coefficients: power series and Frobenius methods; Sturm-Louville problem; Laplace transform method for non-homogeneous, linear, 2nd order ODEs: discontinuous right-hand sides.		
Textbooks and References	1. Advanced Engineering Mathematics by E. Kreyszig, John Wiley and Sons, International 8th Revised Edition, 1999, 2. Applied Mathematical Methods by B. Dasgupta, Pearson Education, 2006.		

Corse Title	**Applied Operations Research**	Course Number	ME622T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Elective
Prerequisite	Linear Algebra	Effective from	July 2020
Course Objective	1. To identify and develop operational research models from the verbal description of the real system. 2. To understand the mathematical tools that are needed to solve optimisation problems.		
Course Outcomes	The students will be able to: 1. Develop linear programming (LP) models for shortest path, maximum flow, minimal spanning tree, critical path, minimum cost flow, and trans-shipment problems. 2. Construct linear integer programming models and discuss the solution techniques. 3. Set up decision models and use some solution methods for nonlinear optimization problems.		
Contents of the course	Introduction to management decision making and operations research. Fundamentals of linear programming. Alternative ways of formulating practical linear programming models. Their advantages and disadvantages. Case studies and applications of linear programming. Solution approaches, implications of sensitivity analysis. Transportation and assignment programming. Sensitivity analysis in transportation programming; integer programming formulations and applications. Basics of heuristic optimization. Dynamic programming. Applications of dynamic programming.		
Textbooks	1. Anderson,Sweeny,andWilliams,An Introduction to Management Science: Quantitative Approaches to Decision Making,11th Edition. 2. Ackoff, R.L. and Sasini, M. W., Fundamentals of Operations Research, Wiley & Sons, New York.		
References	1. Wagner, H.M., Principle of Operations Research, Prentice Hall, New Jersey. 2. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill. 3. Churchman, C.W.: Introduction to Operations Research John Wiley& Sons New York.		

Course Title	**Design and Analysis of Experiments**	Course Number	ME623T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Elective
Prerequisite	Nil	Effective from	July 2020
Course Objective	1. To develop skill in understanding and testing of manufactured components.		
Course Outcomes	The students will be able to: 1. Students will be able to understand the importance of testing and inspections. 2. Students will be able to draw the suitability and purpose of different testing methods.		
Contents of the course	Introduction to Designed Experiments: Strategy of experimentation, Typical applications, Basic principles and guidelines for designing experiments. Basic statistical concepts: Descriptive Statistics, Sampling and Sampling Distributions, Tests of Hypotheses. Single factor experiments with Fixed Effects: ANOVA, Model Adequacy Tests, and Orthogonal Contrasts. Experiments with Blocking Factors: Randomised Complete and Incomplete Block Designs, Latin Squares Design. Factorial Experiments: 22, 32, and 2k Designs, Blocking and Confounding, and Fractional Factorial Designs. Linear Regression Models: Estimation of Parameters, Tests of Hypothesis, Regression Model Diagnostics. Response Surface Design: Method of Steepest Ascent, Second-Order Response Surface, Experimental Designs, Computer Models, Mixture Experiments, Evolutionary Operations Advanced Design of Experiments: Random Effects Models, Analysis of Covariance, Non-Normal Response, and Taguchi Methods.		
Textbooks	1. Design and Analysis of Experiments, D. C. Montgomery, John Wiley & Sons, Wiley Student Edition, International Student Version, 7th Edition, 2009. 2. Design of Experiments: An Introduction Based on Linear Models, M. Morris, Chapman& Hall/CRC Texts in Statistical Science, First Edition, 2010.		
References	1. Practical Guide to Designed Experiments: A Unified Approach, P. D. Funkenbusch, CRC Press, 2004. 2. The Theory of the Design of Experiments, D. R. Cox and N. Reid, Chapman and Hall/CRC, 200. 3. Design and Analysis of Experiments A. M. Dean and D. Voss, Springer Texts in Statistics, Second Edition, 2001.		

Corse Title	**Computational Tools for Engineers**	Course Number	ME624T
Specialization		Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Elective
Prerequisite	Basics of Computers	Effective from	July 2020
Course Objective	This course provides an introduction to the numerical methods to solve various kinds of equations that students encounter in the field of engineering.		
Course Outcomes	The student will develop his/her own programs/subroutines for the numerical schemes taught in the course.		
Contents of the course	Numerical Methods in Linear Algebra: Direct and iterative solution techniques for simultaneous linear algebraic equations – Gauss elimination, Gauss-Jordon, LU Decomposition, QR Method, Jacobi and Gauss-Seidel Methods Eigenvalues and Eigenvectors – Power and inverse power method, householder transformation, physical interpretation of eigen values and eigen vectors Solution of nonlinear algebraic equations: Bisection method, fixed-point iteration method, Newton-Raphson, Secant method, solution of system of nonlinear algebraic equations Interpolation: Polynomial interpolation, Lagrange interpolating polynomial, Hermite interpolation, interpolation in 2 and 3 dimensions Numerical Differentiation and Integration Finite difference formula using Taylor series, Differentiation of Lagrange polynomials, Simpson's rule, Gauss- quadrature rule, Romberg method, multiple integrals Numerical solution of differential equations Ordinary Differential Equations – Euler, Heun's method and Stability criterion, second order and fourth order Runge-Kutta methods, Adams-Bashforth-Moulton method, system of ODEs and nonlinear ODEs Partial Differential Equations – Classification of PDEs, Elliptic equations, Parabolic equations (Transient diffusion equation), Hyperbolic equations (wave equation)		
Textbooks and References	1. S. P. Venkateshan, Prasanna Swaminathan, Computational Methods in Engineering, Ane Books 2. Steven C. Chapra, Numerical Methods for Engineering, Mc-Graw Hill Education 3. Joe D Hoffman, Numerical Methods for Engineers and Scientists, Second Edition, Marcel Dekker (2001) 4. Gilbert Strang, Computational Science and Engineering, Wellesley-Cambridge Press		

Course Title	**Industry 4.0**	Course Number	ME511T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	Both B.Tech /M.Tech. (All Branches)	Status (Core / Elective)	Elective
Prerequisite	Nil	Effective from	Oct 2020
Course Objective	The objective of the course is to provide a strong orientation to the students on the advancements in Industry 4.0 and various technologies involved in realizing Industry 4.0 manufacturing systems.		
Course Outcomes	The students will be able to: 1. Understand what is Industry 4.0 and Distinguish various components in Industry 4.0 Environment 2. Identify the Challenges of Industry 4.0 3. Analyze the Importance and the role of Big Data and Analytics 4. Importance of Connected Systems and Sensors 5. Understand necessary details of IoT, IIoT, 'Cyber Physical Systems (CPS)', Advanced Robotics, Image Processing Artificial Intelligence (AI), Machine Learning (ML) and Deep Learning (DL).		
Contents of the course	Module 1: Introduction to Industry Revolutions, Details of Industry 4.0 Module 2: Sensors, Machine Vision and Connected Systems Analyzing Data and Modeling to Make Sense of Data Module 3: Data Analysis, the role of Big Data and Analytics, Control of Manufacturing Systems and Processes Module 4: Digital Twin, its importance in Industry 4.0 Module 5: Impact of Industry 4.0 on various industries Module 6: Applications of Collaborative Robots, Image Processing Artificial Intelligence (AI), Machine Learning (ML) and Deep Learning (DL), Augmented Reality and Virtual Reality, in Manufacturing Environment Module 7: Towards Manufacturing as an Autonomous System		
Textbooks	1. Luo, ZongWei, Smart Manufacturing Innovation and Transformation: Interconnection and Intelligence: Interconnection and Intelligence, IGI Global, 2014. 2. Fei Tao, Meng Zhang, A.Y.C. Nee, Digital Twin Driven Smart Manufacturing, Academic Press, 2019.		
References	1. Alp Ustundag and Emre Cevikcan, “Industry 4.0: Managing the Digital Transformation”. 2. Bartodziej, Christoph Jan, “The Concept Industry 4.0”. 3. Klaus Schwab, “The Fourth Industrial Revolution”. 4. Christian Schröder , “The Challenges of Industry 4.0 for Small and Medium-sized Enterprises”		

Course Title	**Soft Computing Techniques**	Course Number	ME625T
Specialization		Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Elective
Prerequisite	Matlab	Effective from	July 2020
Course Objective	1. To exploit different soft computing techniques to solve complex problems associated in real life manufacturing systems.		
Course Outcomes	The students will be able to: 1. Differentiate and classify traditional and non-traditional optimization methods. 2. Formulate an optimization problem to solve complex manufacturing engineering problems.		
Contents of the course	Problem Solving Methods and Tools: Problem Space, Problem solving, State space, Algorithm's performance and complexity, Search Algorithms, Depth first search method, Breadth first search methods their comparison, A*, AO*, Branch and Bound search techniques, p type, Np complete and Np Hard problems. Evolutionary Computing Methods: Principles of Evolutionary Processes and genetics, A history of Evolutionary computation and introduction to evolutionary algorithms, Genetic algorithms, Evolutionary strategy, Evolutionary programming, Genetic programming. Genetic Algorithm and Genetic Programming: Basic concepts, working principle, procedures of GA, flow chart of GA, Genetic representations, (encoding) Initialization and selection, Genetic operators, Mutation, Generational Cycle, applications. Swarm Optimization: Introduction to Swarm intelligence, Ant colony optimization (ACO), Particle swarm optimization (PSO), Artificial Bee colony algorithm (ABC), Other variants of swarm intelligence algorithms. Advances in Soft Computing Tools: Fuzzy Logic, Theory and applications, Fuzzy Neural networks, Pattern Recognition, Differential Evolution, Data Mining Concepts, Applications of above algorithms in manufacturing engineering problems. Artificial Neural Networks: Neuron, Nerve structure and synapse, Artificial Neuron and its model, activation functions, Neural network architecture: single layer and multilayer feed forward networks, recurrent networks. Back propagation algorithm, factors affecting back propagation training, applications.		
Textbooks	1. Tettamanzi Andrea, Tomassini and Marco, Soft Computing Integrating Evolutionary, Neural and Fuzzy Systems, Springer, 2001. 2. Elaine Rich, Artificial Intelligence, McGraw Hill, 2/e, 1990.		
References	3. Kalyanmoy Deb, Multi-objective Optimization using Evolutionary Algorithms, John Wiley and Sons, 2001.		

Corse Title	**Big Data Analytics**	Course Number	ME626T
Specialization		Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/ Elective)	Elective
Prerequisite	Basic statistics	Effective from	July 2020
Course Objective	The course intends to expose computer engineering students to recent advances in storage and analytics involved with big data. Topics related to Mapreduce, globally distributed storage systems and analytics such as feature extraction, learning, similarity, etc. are dealt with to expose the students to current trends in data storage & analytic and will be implemented / simulated.		
Course Outcomes	The course shall equip students with required storage mechanisms / analysis algorithms for data management in distributed & data intensive applications.		
Contents of the course	**Theory:** Map reduce abstraction, Google paper, Google systems, GFS, BigTable, Cluster and Data center network, Distributed Storage, Facebook photo storage, Azure storage systems. Data deduplication storage systems, Venti and DDFS, Data preprocessing, predictive techniques, association rules, classification, clustering, supervised v/s unsupervised learning, algorithms, domain specific feature extraction, similarity measures, Shingles and minhashing, locality sensitive hashing, Dimensionality reduction techniques, Clustering in high dimensional space, Web link analysis. **Practice:** Initial few exercises using R on association rule mining, classification, clustering wherein various existing algorithms are tested over benchmark datasets – This shall expose students to the basics of AI perspective over databases. Mapreduce abstraction using the IDE framework, Hadoop, Architecture, Data deduplication storage systems, Venti and DDFS, Shingles and minhashing, locality sensitive hashing, Latent Semantic Indexing, case study for dimensionality reduction, Support for distributed / parallel computing in R, case studies of Clustering in high dimensional space, Web link analysis, Pagerank algorithm, survey / simulation.		
Textbooks	1. A. Rajaraman, J. Leskovec, J. Ullmann, Mining of Massive Data sets, Cambridge University Press, 2011, ISBN: 1107015359.		
References	1. Papers relating to the various topics mentioned in the syllabus on Facebook photostorage, Google storage systems etc. which are available either as conference proceedings / shared by agencies such as Google. 2. www.cs.princeton.edu/courses/archive/spring13/cos598C/index.htm - Princeton University Course Webpage.		

Course Title	**Total Quality Management**	Course Number	ME627T
Specialization	Mechanical Engineering	Structure (IPC)	3-0-3
Offered to	B.Tech All Branches	Status (Core/Elective)	Elective
Prerequisite	Nil	Effective from	July 2020
Course Objective	The objective of this course is to introduce the main principles of business and social excellence, to generate knowledge and skills of students to use models and quality management methodology for the implementation of total quality management in any sphere of business and public sector.		
Course Outcomes	At the end of the course students should: 1. Know business excellence models and be able assess organization's performance making reference to their criteria. 2. Know the principles of total quality management and peculiarities of their implementation. 3. Be able to use quality management methods analysing and solving problems of organization. 4. Know prerequisites of evolution of total quality management and significance of quality gurus' works to the management of modern organizations.		
Contents of the course (With approximate break up of hours)	Total Quality Management, quality management Philosophies, Leadership, Employee involvement and customer Value Evaluation, Kaizin, Problem Solving and Quality Management, problem solving Fundamentals, Problem Identification, Definition, Diagnosis, Alternative Generation and Evaluation, Elementary concepts related to 7 Old and 7 New Tools for quality Assurance, Basic Statistical Concepts, Control of Accuracy and Precision, Process Capability, SPC, Acceptance Sampling, MIL-STD-105D. Quality Management Systems, ISO 9000, Quality Engineering, Quality Function Development, Introduction to Design of Experiments, Process Optimization and Robust Product Design, Steps to Six Sigma, Management of Service Quality, Management of Software Quality, Course will include projects and industry case studies.		
Textbooks	1. Dale, B. (2015). Total quality management. John Wiley & Sons, Ltd. 2. Oakland G. F. Total Quality Management, Oxford, 2003.		
References	1. S. S. Singh, Total quality control essentials by McGraw Hill Inc.93 Singapore.		

Course Title	**IC Engines and Gas Turbines**	Course No	ME628T
Specialization		Structure (IPC)	3-0-3
Offered to	M.Tech. Smart Manufacturing	Status (Core/Elective)	Core
Prerequisite	Thermodynamics	Effective from	August 2021
Course Objective	The objective of this course is to provide insights on basic principles and concepts of the internal combustion engines. Also, develop the ability to apply them in a systematic way to analyze basic gas turbine cycles.		
Course Outcomes	At the end of the course, the student will be able to: 1. Solve problems on engine performance parameters. 2. Identify different types of dynamometers. 2. Understand the combustion process, carburetion of engines. 3. Understand the working of gas turbines and its performance. 4. Understand the working of jet propulsion and its parameters.		
Contents of the course (With approximate break up of hours)	I.C. Engines: Energy conversion, basic engine components, Working principle of engines - two stroke and four stroke engines, SI and CI engines, Classification of I.C. Engines, Valve and port timing diagrams, comparison of two stoke and four stroke engines, comparison of SI and CI engines, application of I.C engines. Engine Performance Parameters: The First law analysis of engine cycle, Brake power, indicated power, friction power, mean effective pressure, engine efficiencies, performance calculations, Heat balance. Measurements and Testing: Measurement of Brake power – Rope brake, hydraulic, Eddy current and swinging field DC dynamometers; Friction power – Willian‟s line method, Morse test, motoring test and retardation test. Combustion in S.I Engines: Homogeneous and heterogeneous mixtures, principle of carburetion, stages of combustion in S.I Engines, , knocking. Combustion in C.I Engines: Disintegration of fuel jet, stages of combustion, knocking. Super Charging: types of superchargers, advantages and limitations of super charging. Reciprocating air Compressors: Introduction and classification of compressors, mechanical details and working principle of a single stage reciprocating compressor, equation for work, effect of clearance volume, isothermal, adiabatic, and volumetric efficiencies, two-stage compression, Condition for minimum work. Centrifugal& Axial flow Compressors: introduction, essential parts of a centrifugal compressor, principle of operation. – Introduction to axial flow compressor, geometry and working principle. Gas Turbines: Simple Gas Turbine, ideal cycle, essential components, open and closed cycle arrangements, requirements of working medium, applications of Gas Turbines, comparison of Gas Turbines with reciprocating engines, work output and efficiency of a simple Gas Turbine cycle, optimum pressure ratio for maximum specific output, Gas Turbines with regeneration, reheating and intercooling. Jet Propulsion: Introduction to Propeller engines and Gas Turbine engines, working		

	principle of Ramjet engine, Pulse jet engine, Turboprop engine and Turbojet engine, Thrust and thrust equation, specific thrust, parameters affecting flight performance, introduction to Rocket propulsion, classification of Rockets and principle of Rocket propulsion.
Textbooks	1. V.Ganeshan, Internal Combustion Engines, TMH Publishers, 4th Edition, 2017. 2. V.Ganeshan, Gas Turbines, TMH Publishers, 3rd Edition, 2017. 3. Heywood John, , IC Engines Fundamentals, TMH Publishers, 2nd Edition, 2018.
References	1. Ferguson, Internal Combustion Engines, John Wiley Publisher, 2nd Edition, 2009. 2. Herb Saravana muttoo, Gas Turbine Theory, Prentice Hall Publisher, 6th Edition, 2008.