M.Tech. Programme
(Manufacturing Engineering)

School of Mechanical Sciences
IIT Bhubaneswar

M. Tech. Programme (Manufacturing Engineering)
School of Mechanical Sciences, IIT Bhubaneswar

Credit Structure:

Details	Sem. I	Sem. II	Sem. III	Sem. IV	Total Credits
Core Subjects	8	8	-	-	16
Elective Subjects	9/10	9/10	-	-	18/20
Lab. Subjects	4	2	-	-	6
Seminar	2	2	-	-	4
Research Review Paper	-	-	4	4	8
Project	-	-	16	16	32
Total Credits	23/24	21/22	20	20	84/86

INDIAN INSTITUTE OF TECHNOLOGY BHUBANESWAR
Bhubaneswar - 751013
School of Mechanical Sciences

Detailed Curriculum of M. Tech. Programme in Manufacturing Engineering

Semester 1				
Sl. No.	Course No.	Course Name	L-T-P	C
1	ME6L301	Machining Science	3-1-0	4
2	ME6L302	Advanced Manufacturing Processes-I	3-1-0	4
3	ME6LXXX	Elective I	3-0-0	3
4	ME6LXXX	Elective II	3-0-0	3
5	ME6LXXX	Elective III	3-0/1-0	3/4
6	ME6P350	Manufacturing Simulation Lab	0-0-3	2
7	ME6P351	Advanced Manufacturing Laboratory-I	0-0-3	2
8	ME6S301	Seminar I	0-0-3	2
Total L-T-P and Credit			15-2/3-9	23/24
Semester 2				
Sl. No.	Course No.	Course Name	L-T-P	C
1	ME6L303	Advanced Manufacturing Processes-II	3-1-0	4
2	ME6L320	Digital Manufacturing	3-1-0	4
3	ME6LXXX	Elective IV	3-0-0	3
4	ME6LXXX	Elective V	3-0-0	3
5	ME6LXXX	Elective VI	3-0/1-0	3/4
6	ME6P352	Advanced Manufacturing Laboratory-II	0-0-3	2
7	ME6S302	Seminar II	0-0-3	2
Total L-T-P and Credit			15-2/3-6	21/22
Semester 3				
Sl. No.	Course No.	Course Name	L-T-P	C
1	ME6D301	Thesis - Part I	---	16
2	ME6D302	Research Review Paper – I		4
Total L-T-P and Credit			---	20
Semester 4				
Sl. No.	Course No.	Course Name	L-T-P	C
1	ME6D303	Thesis - Part II	---	16
2	ME6D304	Research Review Paper – II		4
Total L-T-P and Credit			---	20

LIST OF ELECTIVES

Elective – 1, 2 & 3 (Semester I)

Electives from School of Mechanical Sciences				
Robotics and Automation	ME6L013	3-0-0	3	3
Manufacturing Planning and Control	ME6L316	3-0-0	3	3
Advanced Tooling Design	ME6L321	3-0-0	3	3
Metrology and Computer Aided Inspection	ME6L322	3-1-0	4	4
Operations Management	ME6L323	3-0-0	3	3
Machine Tool Design	ME6L324	3-1-0	4	4
Advanced Metal Forming	ME6L325	3-1-0	4	4
Design and Alalysis of Welded Structures	ME6L326	3-1-0	4	4
Lasers in Manufacturing	ME6L327	3-1-0	4	4
Dynamics and Control of Mechanical Systems	ME6L051	3-1-0	4	4
Precision and Micro Manufacturing	ME6L329	3-1-0	4	4
Finite Elemement Methods in Engineering	ME6L011	3-1-0	4	4
Mechatronics	ME6L333	3-0-0	3	3
Stream relevant Electives from other Schools				
Materials Characterization	ML6L003	3-1-0	4	4
Optimization Techniques	MA5L013	3-0-0	3	3
Advances in Materials Science	ML6L006	3-0-0	3	3
Data Analytics	ID6L001	3-0-0	3	3

LIST OF ELECTIVES

Elective – 4, 5 & 6 (Semester II)

Electives from School of Mechanical Sciences				
Advanced Casting Processes	ME6L313	3-0-0	3	3
Solid State Joining Processes	ME6L314	3-1-0	4	4
Quality Engineering and Management	ME6L315	3-0-0	3	3
Soft Computing and Application	ME6L060	3-1-0	4	4
Surface Engineering	ME6L317	3-0-0	3	3
Finite Element Techniques for Manufaturing	ME6L318	3-1-0	4	4
Supply Chain Management	ME6L319	3-0-0	3	3
Inspection and Testing in Manufacturing	ME6L330	3-1-0	4	4
Additive Manufacturing	ME6L331	3-0-0	3	3
Factory Automation	ME6L332	3-0-0	3	3
Product Design and Manufacturing	ME6L334	3-0-0	3	3
Stream relevant Electives from other Schools				
Mechanical behavior of Materials	ML6L319	3-0-0	3	3
Biomaterials Processing and Applications	ML6L012	3-0-0	3	3
Powder Materials and Processing	ML6L014	3-0-0	3	3
Design and Analysis of Experiments	ID6L002	3-0-0	3	3

In any semester a student may choose three electives from the the list of electives offered from the School of Mechanical Sciences, as given above. However, for diversification, students are also allowed to take one elective course from other schools (as given in the above list) along with any two elective courses offered by School of Mechanical Sciences.

Syllabi of Core Courses

Subject Code: ME6L301	Subject Name: Machining Science	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s):			

Course objectives:

- The Primary objective of the course is to make the students capable enough to analyze the conventional machining processes using principles of plasticity and shear, taking into consideration the process parameters such as speed, feed and depth of cut, tool geometry, materials and use of coolant.
- Students will be able to analyze the mechanical and thermal aspect of conventional machining through the models based on the laws of physics.
- They will also learn about the types of tool wears and their effect on the process performance and techniques to overcome these issues.

Course content:

Geometry of cutting tools: Turning, milling and drilling in different reference systems;
Mechanism of chip formation by single point tools, drills and milling cutters; chip breakers;
Estimation of cutting force: Theoretical and experimental determination;
Oblique cutting: Direction of chip flow, Merchant's solution for oblique cutting;
Source of heat generation in machining, Measurement and modeling of cutting temperature, cutting fluids and their characteristics;
Cutting tools: Essential properties and various tool materials, Mechanisms of tool wear and failure;
Economics of machining process;
Vibration and chatter in machining and their remedy;
Surface roughness and Surface integrity, Features used assessing surface integrity;
Grinding: Mechanism of chip formation; Modelling of force and specific energy; Temperaturemeasurement and thermal modeling; and
Assessment of residual stress in machining, grinding; instruments and technique of measurement.

Recommended Books:

Metal Cutting : Theory And Practice By A Bhattacharyya, New central book agency, 2010
Metal Cutting Principles By M C Saw, Oxford University Press, 2002
Machining and Machine Tools By A. B. Chattopadhyay, Wiley India, 2011
Fundamentals of Machining and Machine Tools By Boothryd and Knight, 2nd ed., Markel Dekker Inc, 1989
Fundamentals of Machining Processes: Conventional and Nonconventional By Hassan Abdel-Gawad El-Hofy, CRC Press, 2006.
Manufacturing Processes By J. P. Kaushish, PHI Learning, 2010
Manufacturing Processes 1: Cutting By Fritz Klocke, Aaron Kuchle Springer, 2011

Subject Code: ME6L302	Subject Name: Advanced Manufacturing Processes-I	L-T-P: 3-1-0	Credit: 4

Pre-Requisite(s):

Course objectives:

- The primary objective of this course is to make students learn about various advanced casting, welding and forming processes and their application. This will help them to build up the idea about suitability and requirement of each process for specific operations, mainly for precision manufacturing with dimensional and geometrical complexity.
- The students also learn the processing of advanced materials, alloys, MMCs as well as polymers and composites due to their increasing demand in various applications.The pre-requisite of the course would be knowledge of primary manufacturing processes, casting, forming and welding.
- Students will also learn the advancements in powder metallurgy techniques andtheir applications, so that in future they can apply those ideas for manufacturing of components using advanced materials and MMCs, which are otherwise difficult to produce using conventional techniques.

Course content:

Advanced metal casting techniques,Gating and risering,Nucleation,grain growth, and solification;
Advanced Welding techniques: Arc welding through pulsing,Cold metal transfer welding,Plasma arc welding; Electron Beam welding; Laser beam welding etc.;
Advanced forming techniques, High energy rate forming, Superplastic forming; Incremental forming;
Powder metallurgy: Powdered metals and fabrication procedures, Preparation of powders, Compacting and sintering, Hot and cold pressing (HIP, CIP); and
Polymers and composites processing.

Recommended Books:

Metal casting: Computer Aided Design and Analysis by B. Ravi, PHI Learning Pvt. Ltd. 2010
Advanced Welding Processes: Technologies and process control by J Norrish, Woodhead Publishing, 2006
Advanced Methods in Material Forming by D.Banabic**,** Springer, 2007
Powder Metallurgy: Science, Technology and Applications, P.C. Angelo, R. Subramanian, PHI Learning Pvt. Ltd. 2008

Subject Code: ME6P350	Subject Name: Manufacturing Simulation Lab	L-T-P: 0-0-3	Credit: 2
Pre-Requisite(s):			
CAD software (SolidWorks) introduction: Single object modeling, assembly of objects; Numerical simulations and modeling of different manufacturing systems and processes using commercial softwares, like ABAQUS, DEFORM, MATLAB etc. viz.: Modelling of simple processeses, like hardness testing, deflection of beam etc.; Generation and distribution of stress during sheet and bulk forming processes; Modelling of machining process (turning) and chip formation; Modelling of heat transfer and temperature distribution during various thermal processes (heat treatment, thermal non-conventional machining processes); Feature extraction and tool path generation; CNC programming using software like, SolidCAM, CNCSimulator Pro etc.; Network problem and CAPP problem solutions using MATLAB etc.			

Subject Code: ME6P351	Subject Name: Advanced Manufacturing Laboratory-I	L-T-P: 0-0-3	Credit: 2

Pre-Requisite(s):

Advance casting process: casting of a given component through Investment casting;

Advance welding techniques:
Experimental study of the effect of process parameters on the quality of weld nugget in Resistance spot welding;
Experimental study of process performance of pulsing Arc welding with variations in process parameters;
Process performance anlysis of Cold metal transfer welding through experiment.
Experiment on process requirements of Plasma arc welding;
Study of power and scan speed on weld quality & HAZ in Laser beam welding;
Assessment of process performance of Friction Stir welding (FSW) ;
Assessment of residual stress during welding using X-Ray diffraction and through advanced blind hole drilling techniques;

Experimental study of Incremental forming technique;

High deformation techniques such as friction stir processing (FSP) and assessment of residual stress;

Mechanical properties of powder compacts and effect of Hot Isostatic pressing on compact quality;

Study of Various coating techniques, effect of process parameters:
Plasma spray coating; Thermal spray coating; Low velocity oxy-fuel (LVOF) coating; High velocity oxy-fuel (HVOF) coating; Pulsed TIG cladding

Laser surface modification: effect of power and speed on depth of modification.

Subject Code: ME6L303	Subject Name: Advanced Manufacturing Processes-II	L-T-P: 3-1-0	Credit: 4

Pre-Requisite(s): Advanced Manufacturing Processes-I

Course objectives:

- The object of this course is to provide an in-depth knowledge on various non-conventional machining processes, where students will learn the physics behind those processes along with the advantages, limitations and industrial applications.
- This will help them to build up the idea about suitability of each process for specific operations, mainly in precision, micro- and nano fabrication, machining of complex geometries etc.
- This course also contains various hybrid machining processes, the knowledge of which is essential for future research on machining of various morden high strength metals and polymers, where the conventional process alone can't serve the purpose.
- Students will also be familier with various advanced coating techniques and their mechanism.This helps the students to develop knowlege to implement those techniques for micro- or nano-coating on various components, like cutting tools, turbine blades etc.

Course content:

Introduction - Classification and capability based on materials;
Mechanical machining – Types: Ultrasonic machining (USM), Abrasive Jet Machining (AJM), Abrasive Flow Machining (AFM), Water Jet Machining (WJM) –Principle, analysis and applications;
Electro chemical machining - Chemical material removal – Types: Electro chemical machining (ECM), Electro chemical drilling (ECD), Electro chemical honing (ECH), Shaped tube electrolytic machining - Principle, analysis and applications;
Thermo electrical machining – Types: Electrical discharge machining (EDM), Electrical discharge wire cutting (EDWC) - Principle, analysis and applications;
Electron beam machining (EBM); Plasma Arc Machining (PAM); Ion Beam Machining (IBM) - Principle, analysis and applications;
Laser beam machining (LBM) - Principle, analysis and applications; and
Hybrid machining processes, their advantages: ECG, ECDG, Laser assisted hybrid machining etc.
Advanced coating processes: Physical and chemical vapour deposition, Thermal spray techniques such as plasma spraying, High and low velocity oxy-fuel coating technique, Pulsed TIG coating etc.

Recommended Books:

Nontraditional Manufacturing Processes By Gary F. Benedict, CRC Press, 1987
Advanced Machining Processes By Prof. Vijay Kumar Jain, Allied Publisher, 2007.
Machining Science by Ghosh and Mallik
Advanced Analysis of Nontraditional Machining By Hong Hocheng, Hung-Yin Tsai, Paperback, 2012.
Nonconventional Machining BY P. K. Mishra Narosa Publishing House, 1997.
Advanced Machining Processes: Nontraditional and Hybrid Machining Processes By Hassan El-Hof, Mc Graw Hill, 2005.
Manufacturing Processes By J. P. Kaushish, PHI Learning, 2010.
Coating and surface treatment systems for metals: a comprehensive guide to selection, by Joseph Edwards, ASM Intl., 1997

Subject Code: ME6L320	Subject Name: Digital Manufacturing	L-T-P:3-1-0	Credit: 4
Pre-Requisite(s):			

Course objectives:

- The course objective is to make students learn about the digital description that is required for direct fabrication of products from raw materials. The pre-requisite of the course would be knowledge of a broad range of conventional manufacturing processes for making products.
- 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.

Course content:

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, Down stream 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.

Recommended Books:

Fundamentals of Digital Manufacturing Science, by Z.Zhou,S.Xie**,** D. Chen, Springer, 2012

Rapid Prototyping: Principles and Applications By C.K. Chua, K.F. Leong, C.S. Lim, John Wiley, 2010

Mastering CAD CAM By Ibrahim Zeid, McGraw Hill, 2005

Automation, production systems, and computer-aided manufacturing By M P Groover, Pearson, 2016

Subject Code: ME6P352	Subject Name: Advanced Manufacturing Laboratory – II	L-T-P: 0-0-3	Credit: 2
Pre-Requisite(s):			

Conventional Machining:
Measurement of cutting force, torque and temperature in turning, milling, drilling: effect of speed, feed and depth of cut;
Hard turning: effect of process parameters and tool material (insert) on tool life and surface quality;
Assessment of residual stress during machining processes using X-Ray diffraction and through blind hole drilling technique;
Study of microstructural changes after various manufacturing processes;

Non-conventional Machining:
Ultrasonic machining (USM): effect of frequency and amplitude of vibration on MRR;
Die shinking electro discharge machining (EDM): Effect of current, voltage and polarity on MRR and surface roughness;
Wire electro discharge machining (WEDM): Effect of current, voltage and wire feed rate on MRR and surface roughness;
Laser beam machining (LBM): Laser cutting and drilling – effectof power, speed and gas pressure on kerf width and taper of cut; laser forming – effect of power, speed and no. of scan on bending angle;
Electro chemical machining: effect of voltage and current on MRR;
Abrasive water jet machining: effect of process parameters on MRR;

Design and Manufacturing of product for Rapid Prototyping;

Metrology:
Study of surface profile during turning and milling process;
Study of circularity error during drilling using CMM;
Study of microhardness/ nano hardness; assessment of heat affected zone;

Syllabi of Elective Courses
1st Semester (Electives-I, Electives-II & Elective-III):

Subject Code: ME6L013	Subject Name: Robotics & Automation	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Applications of robot and sensors: Introduction to robots, Internal and external sensors;
Actuators: hydraulic, pneumatic and electric actuators, programming of robots;
Homogeneous transformations, D-H parameter notation, direct & inverse kinematics of manipulators: examples of kinematics of some common manipulator configurations;
Jacobian, dynamics of manipulators; trajectory planning; and
Automation, types of automation, analysis of automated assembly systems, line balancing problems, analysis of automated material handling systems, automated storage and retrieval systems.

Recommended Books:

Robotics: Fundamental concepts and analysis By A. Ghosal, Oxford university press, 2006.
Industrial RoboticsBy M P Groover,Pearson Edu, 2008.
Robotics and ControlBy R K Mittal & I J Nagrath, TMH, 2003.
Robotics: Control, sensing, vision and intelligence By K Fu, R Gonzalez, and C S G Lee, McGraw Hill, 1987.
Robotic Engineering By / Richard D. Klafter, Prentice Hall, 1989.
Introduction to RoboticsBy John J Craig, Pearson Edu. Prentice Hall, 2003
Robot Dynamics & ControlBy Mark W. Spong and M. Vidyasagar, John Wiley & Sons (ASIA) Pte Ltd, 1989.
Automation, Production systems and Computer Intigrated Manufacturing By M P Groover, Prentice Hall India, 1987.

Subject Code: ME6L316	Subject Name: Manufacturing Planning and Control	L-T-P:3-0-0	Credit: 3
Pre-Requisite(s):			

Course content:

Introduction to Manufacturing Planning and Control. Forecasting: Delphi method and other statistical techniques;

Enterprise Resource Planning(ERP). Inventory Management, Concept of Economic Ordrer Quantity;

Material Requirements Planning(MRP), Manufacturing resource planning (MRP-II), Distribution Requirements Planning. Just-in-Time philosophy;

Capacity planning and utilization. Production activity control, Advanced concepts in scheduling. Supply chain management, case studies;

Automated material handeling system AS/RS systems; and

Group Technology: part family formation techniques, Classification and coding techniques. Computer Aided Process Planning: Retrival, Generative and hybrid systems.

Recommended Books:

Manufacturing planning and control for supply chain management By VOLLMANN,BERRY and AHYBARK, Tata Mc Grawhill, 2004.

Automation, production systems, and computer-aided manufacturing By M P Groover, Pearson, 2016

Subject Code: ME6L321	Subject Name: Advanced Tooling Design	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s):			

Course content:

Introduction Tool Engineering, Tool Classifications, Tool Design Objectives, Tool Design in manufacturing, Challenges and requirements, Standards in tool design-Tool drawings, Surface finish, Fits and Tolerances, Tooling Materials-Ferrous and Non ferrous Tooling Materials, Carbides, Ceramics and Diamond, Non metallic tool materials, Designing with relation to heat treatment;

Introduction to: Fixed Gauges, Gauge Tolerances, Selection of material for gauges – Indicating gauges, Automatic gages, Principles of location, Locating methods and devices, Principles of clamping, Drill jigs – Chip formation in drilling, General considerations in the design of drill jigs, Drill bushings, Methods of construction, Thrust and Turning Moments in drilling, Drill jigs and modern manufacturing, Types of Fixtures – Vise Fixtures, Milling Fixtures, Boring Fixtures, Broaching Fixtures, Lathe Fixtures, Grinding Fixtures, Modular Fixtures;

Types of Dies,Method of Die operation, Clearance and cutting force calculations, Blanking and Piercing die design, Pilots, Strippers and pressure pads, Presswork materials, Strip layout, Short-run tooling for Piercing, Bending dies, Forming dies, Drawing dies, Design and drafting;

Introduction to Tooling requirements for Numerical control systems, Fixture design for CNC machine tools, Sub plate and tombstone fixtures,Universal fixtures, Cutting tools,Tool holding methods, Automatic tool changers and tool positioners, Tool presetting; and

Flexible tooling and fixturing.

Recommended Books:

Tool Design By Cyrll Donaldson, George H. LeCain, V. C. Goold Tata McGraw Hill Publishing Company Ltd, 1943.
Jig and Fixture Design By E.G.Hoffman, Thomson Asia Pvt Ltd, Singapore, 1980.
Tooling data By Prakash Hiralal Joshi, Wheeler Publishing, 2001.
Design of Jigs, Fixtures andPresstools By Venkataraman K. 2005.
Manufacturing Technology By Haslehurst M., The ELBS, 1978.
An introduction to Jig and tool design by M. H. A. Kempster, Butterworth-Heinemann, 1998

Subject Code: ME6L322	Subject Name: Metrology and Computer Aided Inspection	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s):			

Course content:

Definition, Standards of measurement, Errors in measurement, Interchangeability and Selective assembly, Accuracy and Precision, Calibration of instruments, Linear measurement, Angular measurement;

Definitions and Types of Surface Texture, Surface Roughness Measurement Methods, Comparison, Profilometer, 3D Surface Roughness Measurement, Instruments;

Interferometry: Introduction, Principles of light interference, Interferometers, Measurement and Calibration, Laser Interferometry;

Tool Makers Microscope, Microhite Co-Ordinate measuring machine, Applications, Laser Micrometer, Laser Scanning gauge, Non contact and in-process inspection, Vision system;

Overview of Computer imaging systems, Image Analysis, Preprocessing, Human vision system, Image model, Image enhancement, gray scale models, histogram models, Image Transforms;

Total quality control,Quality assurance, Zero defects, POKA-YOKE Statistical evaluation of data using; and

Ray based scanning techniques, X-ray technique, CT technique.

Recommended Books:

Metrology for engineers By GNGalyer FW and CRSHOTBOLT, ELBS, 1990.
Industrial Metrology By Graham TSmith, Springer, 2002
ASTE Handbook of Industries Metrology, Prentice Hall of India Ltd., 1992.
Image Processing, Analysis, and Machine Vision By Milan Sonka, Vaclav Hlavac and Roger Boyle, Cengage-Engineering; 3 Ed., 2007

Subject Code: ME6L323	Subject Name: Operations Management	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s):			

Course content:

Competitiveness, Operations Strategy, Balance Scorecard, Facility Location, Decision Analysis, Facility Layout;

Product and Services, Quality Function Deployment, Process Planning, Process Selection, Quality Control, Inventory Control, Inventory Models, Lean Production System;

Project Management, Work Design and Measurement;

Resource Planning, Scheduling, Forecasting Methods; and

Sustainable manufacturing.

Recommended Books:

Russel, and Taylor, Operations management, Wiley India, 2011.
Krajewski, Ritzman, and Malhotra, Operations management, Pearson Prenctice Hall, 1993.
Heizer, and Render, Operations management, Pearson Education, 2010.
Stevenson, Operations Management, McGraw Hill, 1982.
Chase and Aquilano, Operations Management, Tata McGraw Hill, 2006.

Subject Code: ME6L324	Subject Name: Machine Tool Design	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s):			

Course content:

Introduction: Classification of Machine Tools and their technological capabilities, Modularity in machine tool design, General requirement of machine tool design;

Machine Tool Drives: Introduction to kinematics of machine tools, Mechanical, hydraulic and electrical drives, Stepped and step less regulations of speed and feed, Layout of spindles drive and feed drive in machine tools, Structural diagram, Ray diagram, Design of speed box and feed box;

Design of Machine tool structures: Function & Requirement of Machine Tool Structure, Design Criteria from Strength & Stiffness considerations, Role of Static & Dynamic Stiffness in the design, Factors affecting stiffness of machine tool structures & methods of improving it, Basic Design procedure of machine tool structures, Design of bed, head stock etc.;

Design of Guideways: Function and Types, Design of hydrostatic, hydrodynamic and antifriction guideways;

Design of spindles and spindle supports: Function & Requirements of Spindle Units, their Materials, Design of Spindle, Requirements of Spindle Supports, Selection of sliding and antifriction bearings;

Dynamics of machine tools: General procedure for assessing the dynamic stability of cutting process, closed loop system, chatter in machine tools;
Control Systems: Functions, requirements & types of machine tool controls, controls for speed & feed change. Automatic and manual Controls. Basics of numerical controls. Machine tool; and

Multi-functional machine tools.

Recommended Books:

Machine Tools By Sen, G.C. and Bhattacharya, A., Central Book Agency (1989)
Machine Tool Design & Numerical Control By Mehta, N. K., McGraw Hill (2012).
Manufacturing Technology: Metal cutting and Machine Tools By Rao P N, McGraw Hill (2013)
Design of Machine Tools By Basu, S. K. and Pal, D.K., Allied Publishers (2008).
Machine Tool Design By Acherkhan N. S., University Press of the Pacific, (2000
Fundamentals of Machining And Machine Tools By Boothroyd G and Knight Wiston A., CRC press (2005)
A Text Book Of Machine Tools & Tool Design By Sharma, P. C., S. Chand Limited, (2005)

Subject Code: ME6L325	Subject Name: Advanced Metal Forming	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s):			

Course content:

Introduction and fundamentals of metal forming, Metal Working,Forming equipments, Presses (mechanical, hydraulic);

Theory of plasticity: Mechanical behavior of metals and alloys under plastic deformation, Stress-strain relationships, Strain hardening and work hardening hypotheses, Flow stress and flow curves; Material incompressibility;

Yield criteria: von Mises' and Tresca's Yield criteria, Levy Mises and Prandtl-Reuss stress-strain relationship, Yield criterion and flow rule for Anisotropic materials;

Introduction to Slab analysis, Slip line theory, Upper bound and Lower bound techniques;

Basic heat treatment processes, Iron-carbon diagram, TTT diagram - Their relation with metal forming;

Different forming processes (Rolling, Drawing, Extrusion, Forging) and their analysis (Slab analysis, Slip line theory, Upper bound and Lower bound techniques)

Sheet Metal Forming: Different processes and analysis, Formability; of sheet, Formability tests, Forming limit diagrams;

Die design; and

Numerical methods in metal forming.

Recommended Books:

Manufacturing Science By Ghosh and Mallik, East West Publisher, 2nd Ed., 2010

Metal Forming, Mechanics and Metallurgy By W F Hosford & R M Caddell, Cambridge University Press, 4th Ed., 2011

Basic Engineering Plasticity: An Introduction with Engineering and Manufacturing Applications By David Rees, Butterworth-Heinemann, 1st Ed., 2006

Theory of Plasticity By J. Chakrabarty, McGrawHill Book Co., International Edition, 1987

Principle of Industrial Metal Working Processes By G. W. Rowe, CBS Publishers, 2005

Mechanical Metallurgy By George E. Dieter, McGraw Hill higher education, 3rd Ed., Indian ed., 2016

Metal Forming: Processes and Analysis By B. Avitzur, McGraw Hill Publication, 1968.

The Mathematical Theory of Plasticity By Hill, R., Oxford, Clarendon Press, 1998.

Finite element plasticity and metal forming analysis By G. W. Rowe, C. E. N. Sturgess, P. Hartley, I. Pillinger, Cambridge University Press, 1991.

Subject Code: ME6L326	Subject Name: Design and Analysis of Welded Structures	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s):			

Course content:

Introduction to design, Engineering properties of steels, Weldability of structural steels, Carbon equivalent, Fatigue and creep properties of welded joints, Theories of failures;

Type of welds and weld joints, Description of welds terminology, Welding symbols, Edge preparation, Sizing of weldsin structure, Type of connections in welded structures, Combined groove and fillet weld connections;

Weld calculations for lap, Butt and fillet welds, Analysis of connections for direct tension or compression and shear loading conditions, Resistance to moment by combined tension and compression;

Fatigue fracture, Residual fatigue strength, Factors affecting fatigue life, Design of welded joints for fatigue loading, Fatigue behaviour of hollow section joints, Methods for improving the fatigue strength of welded joints, Reliability analysis and safety factors applied to fatigue design with reference to fracture toughness; and

Heat flow in welding, Effect of welding parameters on heat distribution, Calculation of peak temperature, Weld thermal cycle, Cooling rate and solidification time, Residual stress distribution, Influence of residual stress in static and dynamic loading, Introduction to stress corrosion.

Recommended Books:

Metal Fatigue in EngineeringBy H. O. Fuchs, and R I. Stephen, , John Wiley & Sons, 2000.
Rational Welding Design By Gray, T. G. F. and Spence, J.,, Butterworths, 1992.
Welding Hand Book, Vol. 2 & 3, 9th Ed., American Welding Society, 2001.
Mechanical Metallurgy By Dieter, G., McGraw Hill, 1988.
Principles of Welding By Messler, R.W. Jr., John Wiley & Sons, 1999.

Subject Code: ME6L327	Subject Name: Lasers in Manufacturing	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s):			

Course content:

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, CO_2, 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.

Recommended Books:

Laser Fundamentals By William T. Silfvast, Cambridge University Press, New Delhi, 2nd South Asian Edition, 2004.

Principles of Lasers By Svelto Orazio, Springer, 5th Ed. 2010

Laser Material Processing By W. M. Steen and J. Mazumder, Springer, 4th Ed. 2010

Laser Materials Processing By Elijah Kannatey–Asibu, Jr, Wiley, 2009

Laser Fabrication and Machining of Materials By Narendra B. Dahotre & Sandip P. Harimkar, Springer, 2008

Subject Code: ME6L051	Subject Name: Dynamics and Control of Mechanical Systems	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s):			

Course content:

Revisit to the history of development of mechanics from Galileo to Newton;

Kinematics of rigid bodies:Coordinate transformation, Angular velocity vector, Description of velocity and acceleration in relatively moving frames. Euler angles, Review of methods of momentum and angular momentum of system of particles, Inertia tensor of rigid body;

Dynamics of rigid bodies: Euler's equation, Application to motion of symmetric tops and gyroscopes and problems of system of bodies;

Kinetic energy of a rigid body, Virtual displacement and classification of constraints, D' Alembert's principle;

Introduction to generalized coordinates, Derivation of Lagrange's equation from D' Alembert's principle;

Small oscillations, matrix formulation, Eigen value problem and numerical solutions, Introduction to MAPLE® and MATLAB®, computer generation and solution of equations of motion;

Introduction to complex analytic functions, Laplace and Fourier transform;

Transfer function and block diagrams, tiMEnd frequency domain system behavior;

Root-locus, Bode and Nyquist plots,Stability and sensitivity, PID controllers, Phase lag and Phase lead compensation;and

Analysis of Control systems in state space, Pole placement, Computer simulation through MATLAB - SIMULINK®.

Recommended Books:

Methods of Analytical Dynamics - Leonard Meirovitch – Dover, 1970.
Classical Dynamics - Donald T. Greenwood – Dover, 1997.
Advanced Dynamics - Donald T. Greenwood – Cambridge University Press, 2003.
Analytical Mechanics - Herbert Goldstein - Addison Wesley, 1996.
Engineering Mechanics: Dynamics – I. H. Shames, Prentice-Hall of India, 1996.
Dynamics: Theory and Applications - T.R. Kane, David A. Levinson - McGraw-Hill, 1985.
System Dynamics - Katsuhiko Ogata - Pearson Education India, 1978.
Modern Control Theory - William L. Brogan - Prentice Hall, 1974.
Modern Control Engineering - Katsuhiko Ogata - Prentice Hall, 1970.
Control Systems Engineering - Norman S. Nise – Wiley, 1992.
Control System Design: An Introduction to State-Space Methods – B. Friedland – Dover, 1986.
Feedback and Control for Everyone - P. Albertos Pérez, Pedro Albertos – Springer, 2010.
Automatic Control Systems - Benjamin C. Kuo, FaridGolnaraghi – Wiley, 1962.
A Mathematical Introduction to Control Theory - ShlomoEngelberg - World Scientific Publishing Company, 2005.
Computational Methods in Multibody Dynamics - Farid M. L. Amirouche - Prentice Hall, 1992.
MATLAB® for Control Engineers - Katsuhiko Ogata - Prentice Hall, 2007.
Dynamical Systems with Applications using Maple® - Stephen Lynch - Birkhäuser Boston, 2001.

** Already approved and running in M.Tech. **Mechnical System Design**

Subject Code: ME6L329	Subject Name: Precision and Micro Manufacturing	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s):			

Course content:

Introduction: Basic definition, Size scales, Scaling analysis, Technology change, Lithographic Processes- Optical and X-ray;

Precision Engineering And Practices: Sources of Error, Machine Tool Variables- accuracy, stiffness, spindle vibration, flatness, straightness and smoothness of motion, Feedback Variables, Cutting Tool Variables, Workpiece Variables, Environment Effects and Thermal Errors;

Introduction To Machining Analysis: Geometry of Cutting Edge, Energy Models, Comparison with Micro-scale Machining;

Diamond Micromachining: Introduction, Diamond as a Tool Material, Compatible Materials, Diamond Machining, Micro-mechanical Applications, Ductile Regime Grinding;

Focused ion beam based Micro-/Nano-fabrication;

Micro-ECM, Micro-EDM etc: Parameter dependencies, Case studies;

Micro-milling: Process and applications, micro-mechanically milled X-ray masks, Mask Absorption Quantification, Exposure Quantification;

Micro-drilling: Micro-drilling and Macro-drilling Techniques;

Laser Micromachining: laser Optics, Laser Ablation, Heat Affected Zone and Laser Polymerisation.

LIGA, S-LIGA Micro Welding: Micro welding in similar and dissimilar materials;

Micro Casting: Casting processes like vacuum, Semi-solid state, Applications;

Processing of Integrated Circuits, Clean rooms, crystal growing and shaping of wafers, Etching, Photo and other lithography techniques, CVD, Metallisation etc.;

Micro Forming: Bulk Forming, Forming of Micro-sheet Metal Components;

Micro Assembly: Mechanical Assembly, Self-assembly of Micro-parts;

Handling for Micro-manufacturing, Robotics in Micro-manufacturing and Micro-robotics; and

Measurement, Testing, and Diagnosis for Micro-manufacturing Systems .

Recommended Books:

Micromanufacturing Processes By V.K. Jain, CRC Press, 2012.

Micromanufacturing Engineering and Technology By Yi Qin, Elsevier, 2000.

Precision Micromanufacturing Process Web Tutorial: By Hongdi Zhang

Micro-Manufacturing: Design and Manufacturing of Micro-Products by Muammer Koc, Tugrul Ozel, Wiley, 2011.

Subject Code: ME6L011	Subject Name: Finite Elements Methods in Engineering	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s):			

Course content:

Integral Formulations and Variational Methods, Second-Order boundary value problems; Bending of Beams; FE Error Analysis; Eigenvalue and Time-Dependent Problems; Numerical Integration and Computer Implementation, Single-Variable Problems; Interpolation Functions, Numerical Integration and Modeling; Plane Elasticity; Flows of Viscous Incompressible Fluids; Bending of Elastic Plates; Computer Implementation, Analysis of Three-Dimensional and Nonlinear Problems.

Recommended Books:

An Introduction to the Finite Element Method – J. N. Reddy (McGraw Hill)
An Introduction to Nonlinear Finite Element Method – J. N. Reddy (Oxford)
Concepts and Applications of Finite Element Analysis – R D Cook (Willey)
The Finite Element Method: Its Basis & Fundamental – O C Zienkiewicz (Elsevier)
The Finite Element Method in Engineering – Rao (Elsevier)
Finite Element Methods for Engineers – U. S. Dixit (Cengage)
Introduction to Finite Elements in Engineering – T. R. Chandrupatla (PHI)

** Already approved and running in M.Tech. **Mechnical System Design**

Subject Code: ME6L333	Subject Name: Mechatronics	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): Basic Electronics, Control Theory (equivalent to courses in B.Tech level)			

Course content:

Introduction: Definition of Mechatronics, Mechatronics in manufacturing, measurement system, control systems, microprocessor based controllers, Products, and design. Comparison between Traditional and Mechatronics approach;

Basic signal processing, different types of sensors, actuators, controllers, DSP, ADC/DAC etc.; Actuation systems, Signal Conditioning, Microprocessors and Microcontrollers;

Modeling and System Response: Modeling of electromechanical systems, block diagrams, control system design, mechanical, electrical, hydraulic and thermal systems, dynamic response of systems, transfer function and frequency response, closed loop controllers.

PLCs and introduction to industrial automation;

Design and Mechatronics: Computer based modular design, remote monitoring and control;

Practical application of mechatronics, design issues, industrial techniques etc.;

Examples of sensor, actuator and controller integration for common micro controllers like atmeag 16, PIC, Arduino, etc..

Recommended Books:

HMT ltd. Mechatronics, Tata Mcgraw-Hill, New Delhi, 1988.

Bolton, W., "Mechatronics", Longman. 1999

Alciatore, D. G. and Histrand, M. B., "Introduction to Mechatronics", Tata McGraw Hill. 2003

Shetty, D. and Richard, A.K., "Mechatronics System Design", PWS Pub. Boston. 1997

Mahalik, N., "Principles, Concept and Applications: Mechatronics", Tata McGraw. 2003

Bolton, W., "Mechatronics: A Multidisciplinary Approach", 4th Ed., Prentice Hall. 2009

Merzouki R., Samantaray A. K., Pathak P.M., Bouamama B. Ould, Intelligent Mechatronic Systems: Modeling, Control and Diagnosis, Springer 2013

Mechatronics, Intl. J. published by Pergamon Press

Subject Code: ML6L003	Subject Name: Materials Characterization	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s):			

Course content:

Importance of characterization studies in materials science – Applications in industry and research, Review of materials science fundamentals;

Mechanical waves and Ultrasonic testing; Principles of image formation and optical aberrations; Sample preparation techniques for optical and scanning electron microscopy; Optical metallographic – phase contrast, Nomarski contrast techniques;

Scanning electron microscopy: beam-sample interaction, Interaction volume concept, WDS, EDS, EPMA techniques and their application;

X-ray diffraction – application in macro-texture, Crystal structure and residual stress determination, Atomic absorption spectroscopy, Optical emission spectroscopy, X-ray fluorescence spectroscopy, Electron energy loss spectroscopy, Gas chromatography –application in dissolved gas analysis, Differential scanning calorimetry, Thermo gravimetric analysis;

Surface analysis methods: AES, XPS;

Transmission electron microscopy: sample preparation, bright field and dark field imaging, Kikuchi line formation and selected area diffraction analysis; and

Orientation imaging microscopy: sample preparation, application in micro-texture, phase, residual stress and grain size determination; Mass spectrometry.

Recommended Books:

Scanning Electron Microscopy and X-ray Microanalysis By J. Goldstein, D.E. Newbury, D.C. Joy, C.E.Lyman, P.Echlin, E. Lifshin, L. Sawyer, J.R. M L Sawyer, J R Michael, Springer, 2003.

ASM Handbooks Online

Transmission Electron Microscopy: A Textbook for Materials Science By David B. Williams, C.Barry Carter, (4 Vol. Set), Springer, 2009.

Differential Scanning Calorimetry By G. Hohne, W.F. Hemminger, H. –j Flammersheim, Springer, 2003.

Introduction to Texture Analysis: Macrotexture, Microtexture, and Orientation Mapping By O. Engler, V. Randle, CRC Press, 2009.

Elements of X-Ray Diffraction By B.D. Cullity, C.R. Stock, Pearson, 2014

** Already approved and running in M.Tech. **Materials Science and Engineering**

Subject Code: ML6L006	Subject Name: Advances in Materials Science	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s):			

Course content:

Fundamentals of structure in crystalline solids, Imperfections in materials, Characterization Techniques, Phase Diagrams (Fe-C, Al-Si, Pb-Sn, Al-Cu etc.), Phase transformations in metals, Solidification in metals and alloys, Diffusion in solids, Mechanical working of metals, Strengthening mechanisms in metals, Mechanical properties of materials, Failure in materials, Non-destructive testing of materials, Composite materials, Corrosion of materials, Electrical properties of materials, Magnetic properties of materials, Thermal properties of materials, Optical properties of materials, Recycling of materials.

Text/Reference Books:

William D. Callister, Jr.Materials Science and Engineering
V. Raghavan, Materials Science and Engineering: A First Course

** Already approved and running in M.Tech. **Materials Science and Engineering**

Subject Code: ID6L001	Subject Name: Data Analytics	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s):			

Course content:

Introduction: Sources, modes of availability, inaccuracies, and uses of data.

Data Objects and Attributes: Descriptive Statistics; Visualization; and Data Similarity and Dissimilarity.

Pre-processing of Data: Cleaning for Missing and Noisy Data; Data Reduction – Discrete Wavelet Transform, Principal Component Analysis, Partial Least Square Method, Attribute Subset Selection; and

Data Transformation and Discretization.

Inferential Statistics: Probability Density Functions; Inferential Statistics through Hypothesis Tests

Business Analytics: Predictive Analysis (Regression and Correlation, Logistic Regression, In-Sample and

Out-of-Sample Predictions), Prescriptive Analytics (Optimization and Simulation with Multiple Objectives);

Mining Frequent Patterns: Concepts of Support and Confidence; Frequent Itemset Mining Methods; Pattern Evaluation.

Classification: Decision Trees – Attribute Selection Measures and Tree Pruning; Bayesian and Rule-based

Classification; Model Evaluation and Selection; Cross-Validation; Classification Accuracy; Bayesian Belief

Networks; Classification by Backpropagation; and Support Vector Machine.

Clustering: Partitioning Methods – k-means Hierarchical Methods and Hierarchical Clustering Using

Feature Trees; Probabilistic Hierarchical Clustering; Introduction to Density-, Grid-, and Fuzzy and Probabilistic Model-based Clustering Methods; and Evaluation of Clustering Methods.

Machine Learning: Introduction and Concepts: Ridge Regression; Lasso Regression; and k-Nearest Neighbours, Regression and Classification.

Supervised Learning with Regression and Classification Techniques: Bias-Variance Dichotomy, Linear

and Quadratic Discriminant Analysis, Classification and Regression Trees, Ensemble Methods: Random

Forest, Neural Networks, Deep Learning

Text/Reference Books:

Han, J., M. Kamber, and J. Pei, Data Mining: Concepts and Techniques, Elsevier, Amsterdam. Textbook. Year of Publication 2012

James, G., D. Witten, T. Hastie, and R. Tibshirani, An Introduction to Statistical learning with Application to R, Springer, New York. Year of Publication 2013

Jank, W., Business Analytics for Managers, Springer, New York. Year of Publication 2011

Williams, G., Data mining with Rattle and R: The Art of Excavating Data for Knowledge Discovery, Springer, New York. Year of Publication 2011

Witten, I. H., E. Frank, and M. A. Hall, Data Mining: Practical Machine Learning Tools and

Techniques, Morgan Kaufmann. Year of Publication 2011
Wolfgang, J., Business Analytics for Managers, Springer. Year of Publication 2011
Montgomery, D. C., and G. C. Runger, Applied Statistics and Probability for Engineers. John Wiley & Sons. Year of Publication 2010
Samueli G., N. R. Patel, and P. C. Bruce, Data Mining for Business. Intelligence, John Wiley & Sons, New York. Year of Publication 2010
Hastie, T., R. T. Jerome, and H. Friedman, The Elements of Statistical Learning: Data Mining, Inference and Prediction, Springer. Year of Publication 2009
Bishop C., Pattern Recognition and Machine Learning, Springer. Year of Publication 2007
Tan, P., M. Steinbach, and V. Kumar, Introduction to Data Mining, Addison-Wesley. Year of Publication 2005

** Already approved and running at **institute level**

** The subject "Optimization Techniques" with code MA5L013 (3-0-0) is already approved and running in M.Sc. **Mathematics**

2nd Semester (Electives-IV, Elective-V& Elective-VI):

Subject Code: ME6l313	Subject Name: Advanced Casting Processes	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): Advanced Manufacturing Processess - I			

Course content:

Features of casting problem, A survey and scope of foundry industry. Solidification of pure metals and al1oys, Nucleation and growth in alloys, Solidification of actual castings, Progressive and directional solidification, Centerline feeding resistance, Rate of solidification, Chvorinov's Rule, Electrical analog of solidification problem, Fluidity- effects of various parameters on fluidity, Measurement of fluidity;

Riser design methodologies, Risering of complex casting, Risering of alloy other than steel, Recent developments in riser design by the application of geometrical programming;

Gating system design, The effects of gates on aspiration, Turbulence and dross trap, Recent trends. Pattern designing for lost wax, Lost foam casting, Single crystal casting ;

Casting design considerations- recent trends;

Selection and control of melting furnaces, Boiling, refining and pouring, Recent trends in cupola design; Review and critical comparison of various established processes, recent developments e.g. low pressure and ferrous die casting, High pressure molding, Full mold process, Flaskless molding, Hot and cold box molding, Ceramic shell molding, V-process, Continuous casting, Squeeze and pressed casting, New casting processes (Nishiyama process, Shaw process, Anitoch process etc.);

Residual stresses, Hot tears and cracks in castings, Stress relief, Defects and their causes and remedies, Various parameters affecting surface finish and related defects e.g. rough casting, sand bumon sand bum-in and metal penetration, Facing and washes, Mold wall movement, Vapour transpol1 zones, Expansion scabbing etc; Gases in metal- methods of elimination and control of dissolved gases in castings; and

Review of X-ray and gamma ray radiography, Magnetic particle, Die penetrant and ultrasonic inspection, Use of statistical quality control in foundry.

Recommended Books:

Fundamentals of Metal Casting By R A Flinn, Addison Wesley Inc., Reading, 1963.

Principles of Metal Casting By R W Heine,C R Loper and P C Rosenthal, Tata McGraw –Hill, 1997.

Modern Manufacturing Process Engineering By B W Niebel and A B Draper, McGraw Hill, 1990.

Metals Handbook-Metal Casting, ASM, 1985.

Foundry Technology By Peter R Beeley, Butterworth-Heinemann, 2001.

Principles of Foundry Technology By P L Jain, Tata Mc. Graw-Hill, 1999.

Subject Code: ME6L314	Subject Name: Solid State Joining Processes	L-T-P: 3-1-0	Credit: 4

Pre-Requisite(s): Advanced Manufacturing Processess - I

Course content:

Fundamental forces involved in joining; Mechanical fastening and integral attachment: using mechanical forces, Adhesive bonding: using chemical forces, Welding: using physical forces;

Overview of fusion and solid state welds, Fundamental principles of solid state welding processes, Classification of solid state/non-fusion welding processes;

Adhesive bonding as a joining process, General description of adhesive bonding, Cementing and mortaring as an adhesive joining process, The functions of adhesives, Mechanisms of adhesion, Failure in adhesive-bonded joints, Adhesive joint designs, Design criteria and analysis of adhesive joints;

Friction welding process,Application of friction welding process,Friction welding process parameters,Radial and orbital friction welding,Direct drive and inertia drive friction welding,Study of friction welds,Joint quality of friction welds;

Overview of Friction Stir Welding (FSW) process principles,Welding tools used for FSW, Parameters' effects; Materials used with FSW,Thermomechanical aspect of FSW, Plastic deformation in relation to material properties, Material flow and property relationships of the resultant FSW joint, Friction stir processing (FSP), Process parameters of FSP, Application of FSW and FSP processes;

Conventional diffusion, Deformation diffusion, Resistance diffusion & continuous seam diffusion welding,Diffusion brazing,Braze welding, Combined forming and diffusion welding,Solid-state deposition welding processes; and

Pressure non-fusion welding processes: Cold welding processes, Pressure gas welding process, Forge welding process, Roll welding, Explosion welding process.

Recommended Books:

Joining of Materials and Structures By Messler Robert W. Jr.,Elsevier Butterworth–Heinemann, 2004.

Principles of welding By Messler Robert W. Jr., WILEY-VCHVerlag GmbH & Co. KGaA, Weinheim, 1999.

Mathematical Simulation and Computer Analysis of Thin Strip Rolling Mill By V P Polukhin, MIR Publishers, 1975.

Friction stir welding From basics to applications Edited by Daniela Lohwasser and Zhan Chen,Woodhead Publishing India Pvt. Ltd, 2010.

Welding and Welding Technology By Little L Richard, McGraw Hill, 1976.

The Solid phase welding of Metals By R F Tylecote, Edward Arnold Pub. Ltd, 1968.

Subject Code: ME6L315	Subject Name: Quality Engineering and Management	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s):			

Course content:

Statistical methods, Statistical interface in quality control, Process Capability;

Economics of Quality Control, Dimensions of Quality;

Statistical Process Control, Control Charts for Variables and Attributes;

Process design and improvement with designed experiments, Acceptance Sampling;

ISO9000, Six sigma, Case studies; and

Reliability engineering, Design of Experiment (DOE).

Recommended Books:

Total Quality Management By D H Besterfiled, Pearson Education, 2014.
Total Quality Management By Feigenbaum A.V.,, McGraw Hill, 1968.
Oakland J.S., *Total Quality Management*, Butterworth – Heinemann Ltd., Oxford, 1993.
Montgomery D.C., *Statistical Quality Control*, Wiley Pulication, 1985.
Amitava Mitra, Fundamental of Quality Control and improvement, Wiley Publications, 1993.

Subject Code: ME6L060	Subject Name: Soft Computing and Applications	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s): None			

Introduction to soft computing: Soft computing vs hard computing, Adaptive systems and update mechanisms, and Need of soft computing to solve engineering and management problems.

Artificial neural networks: ANN, Back propagation, Radial basis function networks, and Functional link artificial neural networks.

Fuzzy logic: Theory and principles of TS and MF systems.

Bio/Nature-inspired techniques based optimization: Genetic algorithm, Differential evolution, Particle swarm optimization, Ant colony optimization, and Bacterial foraging algorithm.

Multi-objective optimization: Non-dominated sorting genetic algorithm – II, Multi-objective particle swarm optimization, and Their applications.

Development of intelligent and hybrid systems.

Applications of ANN, fuzzy logic and bioinspired techniques to real life problems

Recommended Books:

Deb, K., *'Optimization for Engineering Design Algorithms and Examples'*, Prentice Hall of India, 2009.

Haykin, S., *'Neural Networks and Learning Machines'*, Prentice Hall, 2009.

Jang, J. S. R., C. T. Sun and E. Mizutani, *'Neuro, Fuzzy and Soft computing: A Computational Approach to Learning and Machine Intelligence'*, Prentice Hall, 2009.

Jong, K. A. D., *'Evolutionary Computation – A Unified Approach'*, PHI Learning, 2009.

Pao, Y. H., *'Adaptive Pattern Recognition and Neural Networks'*, Addison- Wesley, 1989.

Pratihar, D. K, *Soft Computing Fundamentals and Applications*, Narosa Publications, 2014.

Research publications (will be suggested during the lectures)

** Already approved and running at **institute level**

Subject Code: ME6L317	Subject Name: Surface Engineering	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s):			

Course content:

Concept and Importance, Classification of surface modification techniques, Advantages and their limitations;

Causes, types and consequences of surface degradation, Forms of wear – Adhesive, Abrasive, Surface fatigue, Corrosive, Fretting and erosive wear, Classical governing laws related to wear, Techniques to evaluate the wear damage;

Materials characteristics, their importance in surface engineering, Wear resistant materials, Selection of materials for engineering the surfaces for specific applications;

New coating concepts including multi-layer structures, Functionally gradient materials (FGMs), Intermetallic barrier coatings and Thermal barrier coating;

Principles and application ofweld surfacing: SMAW, SAW, GMAW, Thermal spraying – Flame spraying, Electric arc spraying, Plasma spraying, Detonation gun spraying and High velocity oxy fuel spraying ;

Ion implantation, Chemical Vapour Deposition (CVD) and Physical Vapour Deposition (PVD), Carburizing, Nitriding, Plasma nitriding, Cyaniding;

Laser cladding, Alloying, Glazing, Laser and Induction hardening, Heat treatment of steel and remelting by Laser / TIG;

Microwave glazing;

Importanceof Different characterisation techniques – Physical, Mechanical and Functional characterisations, Surface finish, Microhardness, Strength and Tribological characterizations;

Electro deposition and Electroless coatings; and

Pulsed Laser Deposition.

Recommended Books:

Surface Engineering of Metals: Principles, Equipment, Technologies By T.Burakowski and Wierzchoń T., CRC Press, Boca Raton, Florida, 1999.

Surface Engineering Casebook By J.S. Burnell-Gray and P.K.Datta (eds.), Woodhead Publishing Limited, Cambridge, England, 1996.

Engineering coatings - design and application By S. Grainger and J. Blunt (eds.), Abington Publishing, Cambridge, England, 1998.

Advanced Surface Coatings: a Handbook of Surface Engineering By D. S. Rickerby and A. Matthews (eds), Blackie, London,1991.

Coatings Tribology: Properties, Techniques and Applications in Surface Engineering By K. Holmberg and A. Matthews, Elsevier Science B.V., Amsterdam, 1994.

Subject Code: ME6L318	Subject Name: Finite Element Techniques for Manufaturing	L-T-P: 3-1-0	Credit: 4

Pre-Requisite(s): Finite Element Methods in Engineering

Course content:

Introduction to linear and nonlinear problems;

Geometric non-linearity: Linear buckling or Eigen buckling, pre-stress and stress stiffening, nonlinear buckling and imperfections, incremental equation of equilibrium, nonlinear strain-displacement matrix, tangent-stiffness matrix, Strain measures;

Material nonlinearity: Plasticity systems, yield criteria, flow rules, hardening rules, tangent stiffness, finite strain formulation for metal forming analysis, governing rate equations, governing incremental equations, Elasto-plastic formulation, element expressions;

Contact nonlinearity: Contact applications, contact kinematics, contact algorithms, issues in FE contact analysis and troubleshooting; and

Issues in nonlinear FEA: Solution methods and strategies, convergence and stop criteria, post processing of results, troubleshooting.

Recommended Books:

Concepts and applications of finite element analysis By R. D. Cook, John Wiley & Sons, 2007.
Finite-Element Plasticity and Metalforming Analysis By G. W. Rowe, C. E. N. Sturgess, P. Hartley, Cambridge University Press, 2005.
Advances in Numerical Methods By Nikos Mastorakis, John Sakellaris, Springer, 2008.
Advances in Production Technology By Christian Becher, Springer, 2014.
Finite Element Method in Manufacturing Processes By J. Paulo Davim (Editor), John Wiley & Sons, 2011.
An Introduction to Nonlinear Finite Element Analysis By J. N. Reddy, McGraw Hill Education, Oxford University Press, 2014.

Subject Code: ME6L319	Subject Name: Supply Chain Management	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s):			

Course content:

Introduction and overview of supply chain management, Inbound and outbound logistics, Supply chain as a source of competitive advantage;

Buyer-Vendor co-ordination, Procurement, Vendor development, Distribution planning, Channel considerations;

Inventory strategies and management, Transportation infrastructure and management, Facility location, Materials handling;

Strategic considerations for supply chain: Supply Chain strategies, Measuring effectiveness of supply management, Bullwhip Effect, Information technology tools in supply chains, Supply chain coordination, Agile and lean supply chains; and

Green Supply chain, Reverse Logistics, Third party logistics, Case studies.

Recommended Books:

Designing and managing the supply chain: Simchi-Levi and Ravi Shankar: Tata Mcgraw Hill, 1999.

Logistics and Supply Chain Management, Martin Christopher, Pearson, 1992.

Supply chain management Strategy, planning and operations, Chopra, S., and Meindl, P., Prentice Hall, 2001.

Quantitative Models for Supply Chain Management, Sridhar Tayur, Ram Ganeshan, Michael Magazine (editors), Kluwer Academic Publishers, 1999.

Introduction to Supply Chain Management, R.B. Handfield and E.L. Nochols, Jr.. Prentice Hall, 1999.

Subject Code: ME6L330	Subject Name: Inspection and Testing in Manufacturing	L-T-P: 3-1-0	Credit: 3

Pre-Requisite(s):

Course content:

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 (eddy-current), X-ray, Acoustic and Tomographic techniques; and

Comparison and selection of NDT methods.

Recommended Books:

Nondestructive Testing, Louis Cartz, ASM International

Nondestructive Evaluation and Quality Control, ASM Handbook, Vol. 17.

Non-Destructive Test and Evaluation of Materials By J Prasad, McGraw Hill, 2017

Welding Inspection, American Welding Society,3rd Ed.,2000

The Mechanical Testing of Metals and Alloys By foster, P. Field, Cousens Press , 2007

Metals Handbook: Mechanical testing, American Society for Metals, 1978

ASTM standards for mechanical test, such as: ASTM E8/E8M (Tension test for metals), ASTM D6110-10 (Charpy impact test), ASTM E9-09 (Compression test), ASTM E139-11 (Creep test)

ASTM standards for various non-destructive tests

Subject Code: ME6L331	Subject Name: Additive Manufacturing	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): Advanced Manufacturing Processess - I			

Course content:

Introduction to Additive Manufacturing (AM), Critical applications, Traditional manufacturing v/s AM;

Rapid Prototyping (RP): Basic principles, Steps, Advantages, Different manufacturing processes, Importance of RP in context of batch production;

RP in integrated CAD CAM environment, FMS and CIM and their application, Introduction to Reverse Engineering;

Different AM processes and relevant physics of AM process chain: Direct and Indirect processes Rapid Prototyping;

Classification of different AM techniques based on raw materials, layering technique (2-D or 3-D) and energy sources: Powder based AM processes involving sintering and melting, Stereo-lithography (SL), Extrusion based fused deposition modeling (FDM), Laminated object manufacturing, Solid ground curing, Repetitive masking and deposition, Beam interference solidification;

CAD/CAM Modeling, Slicing procedures, Internal hatching, Support structure;

Advances in metal additive manufacturing, composite manufacturing and micro additive manufacturing;

Micro- and Nano-lithography;

Tessellation (STL format) and tessellation algorithms, Accuracy and Surface quality in Additive Manufacturing, Effect of part deposition orientation; and

Bio-medical applications.

Recommended Books:

Rapid Prototyping: Principles and Applications By C.K. Chua, K.F. Leong, C.S. Lim, John Wiley, 2010.

Additive manufacturing technologies: rapid prototyping to direct digital manufacturing By Ian Gibson, David W. Rosen, Brent Stucker. Springer, 2010Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing By Andreas Gebhardt. Hanser Publishers, 2011

Rapid Prototyping, Tooling and Manufacturing By R. J. M. Hague, P. E. Reeves, Paperback, 2002.

Rapid Prototyping Technology: Selection and Application By Kenneth Cooper, CRC, 2001.

Rapid Prototyping: Theory and Practice By Kamrani A., Nasr E. A., Springer, 2006

Laser assisted fabrication of materials By J.D. Majumdar and I. Manna. Springer Series in Material Science, 2013

Rapid Prototyping: Laser-Based and Other Technologies By Patri K. Venuvinod, Weiyin Ma, Springer, 2004.

Rapid Prototyping By Andreas Gebhardt, Hanser, 1996.

Rapid Prototyping and Engineering Applications: A Toolbox for Prototype ... By Frank W. Liou, CRC Press, 2007.

Subject Code: ME6L332	Subject Name: Factory Automation	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s):			

Course content:

Introduction: Concept and scope of industrial automation, Socio-economic considerations, Types of automation, Automation strategies, Automation Technologies;

Fluid Power Control: Fluid Power Control elements and standard graphical symbols for them, Construction and performance of fluid power generators, Hydraulic & pneumatic cylinders - construction, design and mounting, Hydraulic & pneumatic valves for pressure, flow & direction control, Simple hydraulic and pneumatic circuits;

Pneumatics: Pneumatic Logic Circuits: Boolean Algebra, Truth tables, Un-complementation algorithm and Karnaugh Maps, Design of pneumatic logic circuits for a given time displacement diagram or sequence of operation;

High Volume Production Systems: Transfer devices, Vibratory bowl feeders, Non-vibratory feeders. Part orienting, feed track, Part placing and part escapement systems; Automation strategies, Analysis of flow lines, Automated assembly systems;

Mechatronics: Mechanical system interfacing, Simple mechatronic devices: Stepping motors, DC motors, Analog / digital conversion; and

Programmable automation: CNC, industrial robotics; Flexible manufacturing systems.

Recommended Books:

Fluid Power with Applications by A. Esposito, Prentice Hal of India, New Delhi, 2008.
Pneumatic Systems by S.R. Majumdar, McGraw Hill, 2017
Assembly Automation and Product Design, by Geoffrey Boothroyd, CRC press, 2005
Automation, Production System and Computer Integrated Manufacturing by M. P. Groover, Prentice Hal of India, New Delhi, 2017

Subject Code: ME6L334	Subject Name: Product Design and Manufacturing	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Design methodology and design philosophy- types of designs, design models, concurrent engineering, 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- QFD;
Generation and evaluation of concepts – TRIZ, Decision matrix etc;
Embodiment Design- product architecture, configuration, parametric design, systems approach and other consideration of embodiment design;
Industrial Design – aesthetics and ergonomic aspects of product design. Value Engineering. Failure mode and effects analysis;
Manufacturability assessments of given design, Product Costing and Bill of Materials, Process planning for components and assembly, Product manufacturing and Testing.

Recommended Books:

Kevin Otto and Kristin Wood, " Product design"- Pearson, 2004
David G. Ullman, "The Mechanical Design Process" – McGraw Hill, 2003
George E. Dieter, " Engineering Design" – McGraw Hill, 2000
Karl T. Ulrich and Steven D. Eppinger," Product Design and Development" Tata McGraw Hill, 2007
Paul J G "Form, Function and Design" Dover Publication 1994
Kurt Rowland, "The Development of Shape" Ginn and Company 1994
James F Thorpe, "Mechanical Systems Components" Allyn and Bacon, Boston 1989

Subject Code: ML6L019	Subject Name: Mechanical Behaviour of Materials	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s):			

Course content:

Elasticity basics: Stress and strain tensors, tensor transformations, Mohr's circle representation of stress and strain, Constitutive equations;

Origin of stresses in thin films: Thermo-elastic mismatch between film and substrate, Lattice mismatch in hetero-epitaxial films, Recrystallization, Phase transformation, Incorporation of atoms and chemical reactions;

Application of the above for designing structures with low stresses;

Experimental techniques for measuring stresses/strains in thin films: Substrate curvature; Stoney's equation, Methods for curvature measurement and X-ray diffraction;

Measurement of mechanical properties of thin films - Nanoindentation, Bulge test, 4-point bend test and micro-tensile test; and

Models for high stresses, Strain-hardening rates and Bauschinger effect in thin films, Influence of grain size, Film thickness and interfaces.

Recommended Books:

Mechanical Behavior of Materials By Marc André Meyers, Krishan Kumar Chawla, Cambridge, 2nd Ed., 2009

** Already approved and running in M.Tech. **Materials Science and Engineering**

Subject Code: ML6L012	Subject Name: Biomaterials Processing and Applications	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s):			

Course content:

Surface chemistry and physics of selected metals, polymers, and ceramics, surface characterization methodology, modification of biomaterials' surfaces, biosensors and microarrays, bulk properties of implants, acute and chronic responses to implanted biomaterials, drug delivery and tissue engineering; Property requirement of biomaterials; Concept of biocompatibility; Cell-material interactions and foreign body response; Assessment of biocompatibility of biomaterials, important biometallic alloys; Ti-based, stainless steels, Co-Cr-Mo alloys; Bio-inert, bio-active and bio-resorbable ceramics; Processing and properties of different bio-ceramic materials with emphasize on hydroxyapatite; Synthesis of biocompatible coatings on structural implant materials; Microstructure and properties of glass ceramics; Biodegradable polymers; Design concept of developing new materials for bio-implant applications.

Text / Reference Books:

TeohSwee Hin Engineering Materials For Biomedical Applications (Biomaterials Engineering and Processing Series

** Already approved and running in M.Tech. **Materials Science and Engineering**

Subject Code: ML6L014	Subject Name: Powder Materials and Processing	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s):			

Course content:

Introduction: development of powder metallurgy, scope of powder metallurgy, characterization of metal powders, physical properties-particle size and shape determination, technological properties-apparent density, flow rate etc. and chemical properties, particle interaction and control; Powder manufacturing: powder mixing and blending, dry and colloidal processing, reduction, electrolysis, and atomization processes, shaping techniques such as compacting, injection molding; Compaction and sintering: die compaction and other consolidation techniques, sintering, sintering with liquid phase; Powder metallurgy products: bearing, filters, friction parts, hard metals, refractory metals, contact materials, magnetic materials, structural parts, and dispersion strengthened materials.

Text / Reference Books:

Glaus G. Goetzel, TREATISE ON POWDER METALLURGY in three volumes
Volume 1: Technology of Metal Powders and Their Products
Volume II: Applied and Physical Powder Metallurgy
Volume III: Classified and Annotated Bibliography

** Already approved and running in M.Tech. **Materials Science and Engineering**

Subject Code: ID6L002	Subject Name: Design and Analysis of Experiments	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): Preliminary knowledge of statistics			

Course content:

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, 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.

Text/Reference Books:

Design and Analysis of Experiments, D. C. Montgomery, John Wiley & Sons, Wiley Student Edition, International Student Version, 7th Edition, 2009

Experimental Design: From User Studies to Psychophysics, D. W. Cunningham and C. Wallraven, CRC Press, 2011

Design of Experiments: An Introduction Based on Linear Models, M. Morris, Chapman & Hall/CRC Texts in Statistical Science, First Edition, 2010

Experiments: Planning, Analysis, and Optimization C. F. J. Wu and M. S. Hamada, Wiley Series in Probability and Statistics, Wiley, 2009

Statistics for Experimenters: Design, Innovation, and Discovery, G. E. P. Box, J. S. Hunter, and W. G. Hunter, Wiley, 2nd Edition, 2005

Practical Guide to Designed Experiments: A Unified Approach, P. D. Funkenbusch, CRC Press, 2004

Statistical Design and Analysis of Experiments, with Applications to Engineering and Science, R. L. Mason, R. F. Gunst, and J. L. Hess, Wiley Interscience, Second Edition, 2003

Design and Analysis of Experiments A. M. Dean and D. Voss, Springer Texts in Statistics, Second Edition, 2001

The Theory of the Design of Experiments, D. R. Cox and N. Reid, Chapman and Hall/CRC, 2000

Statistical Design and Analysis of Experiments, P. W. M. John, (Classics in Applied Mathematics No 22), Society for Industrial and Applied Mathematics, 1999

** Already approved and running at **institute level**