Curriculum for Dual Degree Programme
B. Tech. (Mechanical Engineering) - M. Tech. (Manufacturing Engineering) – 4th and 5th year

SEMESTER - VII					
Sl. No.	**Course No.**	**Subject Name**	**L-T-P**	**Credit**	**Contact Hour**
1	ME6L301	Machining Science	3-1-0	4	4
2	ME6L302	Advanced Manufacturing Processes-I	3-1-0	4	4
3	ME4LXXX / ME6LXXX	Elective - 2	3-0-3	5	6
4		Breadth - 2	3-0-0	3	3
5	ME4T001	Industrial Training Defense	0-0-0	2	3
6	ME4D001	Project – Part 1	0-0-0	4	0
7	ME6P351	Advanced Manufacturing Laboratory-I	0-0-3	2	3
		Total L-T-P and Credit		**24**	**23**
SEMESTER - VIII					
Sl. No.	**Course No.**	**Course Name**	**L-T-P**	**C**	**Contact Hour**
1	ME6L303	Advanced Manufacturing Processes-II	3-1-0	4	4
2	ME6LXXX	Elective - 3	3-0/1-0	3/4	3/4
3		Breadth - 3	3-0-0	3	3
4		Breadth - 4	3-0-0	3	3
5	ME4D002	Project – Part 2	0-0-0	6	0
6	ME6P352	Advanced Manufacturing Laboratory-II	0-0-3	2	3
		Total L-T-P and Credit		**21/22**	**16/17**
SEMESTER - IX					
Sl. No.	**Course No.**	**Subject Name**	**L-T-P**	**Credit**	**Contact Hour**
1	ME6LXXX	Elective –4	3-0/1-0	3/4	3/4
2	ME6S301	Seminar	0-0-0	2	0
3	ME6D301	Thesis– Part 1	0-0-0	12	0
		Total		**17/18**	**3/4**
SEMESTER – X					
1	ME6LXXX	Elective – 5	3-0/1-0	3/4	3/4
2	ME6D302	Thesis– Part 2	0-0-0	13	0
		Total		**16**	**3**
		G. Total		**222/226**	**201/207**

List of Electives

Elective – 2 (Semester VII)				
Subject Name	**Course No.**	**L-T-P**	**Credit**	**Contact Hour**
Computer Aided Design and Manufacturing	ME4L002	3-0-3	5	6
Design and Experimental Analysis of welded Joints	ME6L311	3-0-3	5	6
Metal Forming Theory and Practice	ME6L312	3-0-3	5	6

Elective – 3 & 5 (Semester VIII & X)				
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
Surface Engineering	ME6L317	3-0-0	3	3
Numerical Methods for Manufacturing	ME6L318	3-1-0	4	4
Supply Chain Management	ME6L319	3-0-0	3	3
Digital Manufacturing	ME6L320	3-1-0	4	4
Additive Manufacturiing	ME6L331	3-0-0	3	3
Factory Automation	ME6L332	3-0-0	3	3
Soft Computing and Application	ME6L060	3-1-0	4	4

Elective – 4 (Semester IX)				
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
Lasers in Manufacturing	ME6L327	3-1-0	4	4
Precision and Micro Manufacturing	ME6L329	3-1-0	4	4
Robotics and Automation	ME6L013	3-0-0	3	3

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: 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

Syllabi of Elective Courses

SEMESTER – VII (Electives-II)

Subject Code: ME4L002	Subject Name: Computer Aided Design & Manufacturing	L-T-P: 3-0-3	Credit: 5
Pre-Requisite(s): Engineering Drawing & Graphics			

Overview of CAD, Software and hardware requirements of CAD, CAD applications, solid modeling, wire frame modeling, B-rep, CSG approaches, Transformations and projections, Mathematical representation of curves and surfaces, Cubic, Bezier and B-spline curves and properties; Introduction to NC, components, advantages and limitations of NC, CNC, DNC, part programming, adaptive control, group technology, computer aided process planning, FMS and CIM.

Laboratory

Generation of various 3D models through protrusion, revolve and shell sweep and their assembly modelling using any of the CAD modelling software. Determination of deflection and stresses in 2D and 3D trusses and beams. Determination of principal and von-mises stresses in plane stress, plane strain and axi-symmetric components. Determination of stresses in 3D and shell structures. Estimation of natural frequencies and mode shapes in beams using analysis package. Generation of part programs on CNC turning and milling machines to produce free form and sculptured surfaces using CAM package.

Recommended Books:

Zimmers & Groover P., CAD/CAM, PE/PHI Publishers, 1984.
Zeid I., CAD / CAM Theory and Practice,Tata McGraw – Hill, 1991.
Rao P.N., CAD/CAM principles and applications, Tata McGraw – Hill, 2004.
Groover, Automation , Production systems & Computer integrated Manufacturing, Pearson Education, 1987.
Amirouche F., Principles of Computer Aided Design and Manufacturing, Pearson Education, 2004.
Seames W.S., Computer Numerical Control Concepts and programming, Thomson Learning, 1990.

Subject Code: ME6L311	Subject Name: Design and Experimental Analysis of Welded Joints	L-T-P: 3-0-3	Credit: 5
Pre-Requisite(s): Casting, Welding & Forming			

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 welds in 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. Introduction to Fatigue, mechanism of 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. 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.

Laboratory

Testing of weld tensile strength, bend strength, impact strength, magnetic particle testing, X-ray testing, residual stress determination, weld micro hardness, weld distortion study of butt joint, weld bead geometry study

Recommended Books:

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

Subject Code: ME6L312	Subject Name: Metal forming theory and practice	L-T-P: 3-0-3	Credit: 5
Pre-Requisite(s): Casting, Welding & Forming			

Introduction: stress/strain, strain-rate characteristics of materials, yield criteria of metals, classification of metal working processes, formability and theory of sheet metal working, friction and lubrication in metal working operation, theories of friction and lubrication; assessment of friction at interface. Process analysis: various methods of analyzing the metal working processes (slipline field theory; upper bound solution; stab methods). Mechanics of forming processes: rolling- determination of rolling pressure, roll separating force, driving torque and power, and power loss in bearings; forging determination of forces in strip forging and disc forging; drawing- determination of force and power, determination of maximum allowable reduction; deep drawing force analysis, analysis of tube drawing process with fixed and moving mandrel, tandem tube drawing; bending- determination of work load and spring back; extrusion- determination of work load from stress analysis and energy consideration, power loss, hydrostatic extrusion; punching and blanking- mode of metal deformation and failure, two-dimensional deformation model and fracture analysis, determination of working force. Hydrostatic extrusion: comparison with conventional extrusion; pressure required to extrude, variables affecting the process. High speed forming: classification, comparison of low and high speed forming operation problems in high speed forming operation, introduction to high forming process such as explosive forming, electrical and mechanical high speed forming techniques.

Laboratory

Metal froming of sheet by hydraulic press, die design for drawing a cup, tube spinning, coining and blanking operation by hydraulic press, rolling of strips of ferrous and non-ferrous materials, forward and backward extrusion example study, sheet forming by line heating.

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.

Elective – III & V (Semester VIII & X)

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

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

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 Automatiion	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: 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)

Elective – IV (Semester IX)

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): Machining Science			

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: 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: 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: 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.