CURRICULUM AND SYLLABI

M.Tech.

in

MANUFACTURING TECHNOLOGY

(With effect from Academic Year 2018-2019)

DEPARTMENT OF MECHANICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY CALICUT
CALICUT - 673601

Vision of the Institute
International standing of the highest calibre

Vision of the Department
To impart nationally and internationally recognized education in Mechanical Engineering, leading to well-qualified engineers who are innovative contributors to the profession and successful in advanced studies and research.

Mission of the Institute
To develop high quality technical education and personnel with a sound footing on basic engineering principles, technical and managerial skills, innovative research capabilities, and exemplary professional conduct to lead and to use technology for the progress of mankind, adapting themselves to changing technological environment with the highest ethical values as the inner strength.

Mission of the Department
To offer high quality graduate and post graduate programs in the fields of Mechanical Engineering and to prepare students for professional career and higher studiespromoting excellence in teaching, research, entrepreneurship, collaborative activities with ethical values, making positive contributions to the society.

M. Tech. In Manufacturing Technology

Programme Educational Objectives

PEO 1: To train students with in-depth and advanced knowledge to become highly-skilled professionals in the areas of manufacturing and allied fields capable of analysing and solving complex engineering problems.

PEO 2: To enable graduates to carry out innovative and independent research work in academia/industry to enhance the manufacturing knowledge base and to disseminate the knowledge.

PEO 3: To prepare the students to exhibit a high level of professionalism, integrity, social responsibility and life-long independent learning ability.

Programme Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: Students should be able to demonstrate a degree of mastery over the area as per the Manufacturing Technology program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PO4: An ability to use modern computer/ software tools to model and analyse manufacturing engineering problems.

PO5: An ability to work effectively in interdisciplinary teams to develop useful products for mankind.

PO6: An ability to engage in life-long independent learning with high level of enthusiasm and commitment

Curriculum for M. Tech. in Manufacturing Technology (2018 Admissions onwards)

First Semester					
Code	**Title of Course**	**L**	**T**	**P/S**	**C**
MA6001D	Mathematical Methods for Engineers	3	0	-	3
ME6301D	Advanced Machining Science	3	0	-	3
ME6302D	Advanced Metrology & Computer Aided Inspection	3	0	-	3
	Elective- 1	3	0	-	3
	Elective- 2	3	0	-	3
ME6391D	Manufacturing Technology Laboratory	--		3	2
	Total	**15**	**0**	**3**	**17**

Second Semester					
Code	**Title of Course**	**L**	**T**	**P/S**	**C**
ME6311D	Modern Machining Processes	3	0	-	3
ME6312D	Machine Tool Design & Computer Numerical Control	3	0	-	3
ME6313D	Industrial Automation & Robotics	3	0	-	3
	Elective- 3	3	0	-	3
	Elective- 4	3	0	-	3
ME6392D	CAD/CAM/CAE Laboratory	0	--	3	2
ME6393D	Seminar/ Mini Project	0	0	2	1
	Total	**15**	**0**	**5**	**18**

Third Semester					
Code	**Title of Course**	**L**	**T**	**P**	**C**
ME7394D	Project work (Part-I)	0	0	20	12
	Total	**0**	**0**	**20**	**12**

Fourth Semester					
Code	**Title of Course**	**L**	**T**	**P**	**C**
ME7395D	Project work (Part-II)	0	0	20	13
	Total	**0**	**0**	**20**	**13**

L: Lecture, T: Tutorial: P, Practical, S: Seminar, C: Credit

Total Credits: 60

Notes

1. A minimum of 60 credits (Maximum credits permitted 62) have to be earned for the award of M. Tech. degree in this programme.
2. Students may audit the course on '*Communicative English*' in the first or second semester of the programme and this course shall not be indicated in the grade card.
3. For electives, students may choose any PG level course offered in the Institute with the approval from the Programme Coordinator.
4. It is desirable for students to undergo *Two Months* Industrial Training/Internship during summer vacation.
5. Students are permitted to audit course/s in the Third and Fourth Semesters of the programme. Only a maximum of two audited courses for which a minimum pass (P) grade secured shall be recorded in the grade card.

Credit distribution	
Curricular composition	**Credits**
Theory courses	30
Laboratory courses	4
Seminar	1
Project works	25
Total credits	**60**

List of Electives

Stream-specific elective courses			
Sl. No.	**Code**	**Title of Course**	**C**
1	ME6321D	Mechatronics Systems	3
2	ME6322D	Six Sigma	3
3	ME6323D	Additive Manufacturing	3
4	ME6324D	Industrial Machine Vision	3
5	ME6325D	Micro Machining	3
6	ME6326D	Tool Engineering & Design	3
7	ME6327D	Design of Experiments	3
8	ME6328D	Advanced Hydraulic and Pneumatic Control Systems	3
9	ME6329D	Vibration and Noise in Machine Tools and Machinery	3
10	ME6330D	Quality Engineering & Management	3
11	ME6331D	Design for Manufacture & Assembly	3
12	ME6332D	Advanced Joining Technologies	3

Other suggested electives			
Sl. No.	**Code**	**Title of Course**	**C**
1	ME6612D	Finite Element Methods and Applications	3
2	ME6623D	Industrial Tribology	3
3	ME6601D	Advanced Mechanics of Solids	3
4	ME6628D	Theory of Plasticity: Fundamentals and Computational Methods	3
5	ME6631D	Fracture Mechanics and Fatigue	3
6	ME6630D	Experimental Stress Analysis	3
7	ME6636D	Computer Graphics	3
8	ME6626D	Product Design	3
9	ME6624D	Design of Electro-Mechanical Systems	3
10	ME6501D	Mechanical Behaviour of Materials	3
11	ME6511D	Composite Materials: Mechanics, Manufacturing and Design	3
12	ME6513D	Metal Casting and Joining	3
13	ME6512D	Ceramic Science and Technology	3
14	ME6525D	Characterisation of Materials	3
15	ME6129D	Facilities Layout Planning	3
16	ME6136D	Reliability Engineering and Management	3
17	ME6112D	Manufacturing Planning and Control	3
18	ME6113D	Accounting and Finance for Management	3
19	ME6149D	Financial Management	3
20	ME6130D	Group Technology and Flexible Manufacturing Systems	3
21	ME6135D	System Modelling and Simulation	3

Syllabi for M. Tech. in Manufacturing Technology
(2018 Admissions onwards)

MA6001D MATHEMATICAL METHODS FOR ENGINEERS

Pre-requisites: Nil

Total hours: 39

L	T	P	C
3	0	0	3

Module 1: (10 hours)
Linear Algebra: vector spaces, subspaces, basis, dimension, inner product spaces, Gram-Schmidth process, linear transformations, range and kernel, isomorphism, matrix of transformations and change of basis.

Module 2: (9 hours)
Series Solutions of ODE and Sturm-Liouville Theory: power series solutions about ordinary point, Legendre equation and Legendre polynomials, solutions about singular points; the method of Frobenius, Bessel equation and Bessel functions; Sturm-Liouville problem and generalized Fourier series.

Module 3: (10 hours)
Partial Differential Equations: first order PDEs, linear equations, Lagrange method, Cauchy method, Charpits method, Jacobi method; second order PDEs: classification, method of separation of variables, formulation and solution of wave equation, heat equation and Laplace equation.

Module 4: (10 hours)
Tensor Calculus: spaces of *n*-dimensions, coordinate transformations, covariant, contravariant and mixed tensors, fundamental operation with tensors, quotient law, the line element and metric tensor, conjugate tensor, Christoffel's symbols, covariant derivative.

References:
1. D. C. Lay, *Linear Algebra and its Applications*. Addison Wesley,2003.
2. F. G. Florey, *Elementary Linear Algebra with Application*. Prentice Englewood, 1979.
3. W. W. Bell, *Special Functions for Scientists and Engineers*. Dover Publications,2004.
4. I.Sneddon, *Elements of Partial Differential Equations*. McGraw Hill International, 1985.
5. B. Spain, *Tensor Calculus*, Oliver and Boyd,1965.
6. K. S.Rao, *Introduction to Partial Differential Equations*, 3rd ed. Prentice-Hall, 2010.
7. S. L.Ross, *Differential Equations*, 3rd ed. John Wiley & Sons, 2004.
8. L.A.Pipes and L.R. Harwill, *Applied Mathematics for Engineers and Physicists*. McGraw Hill, 1971.
9. M.A. Akivis and V.V. Goldberg, *An Introduction to Linear Algebra and Tensors*. Dover Publications,1997.
10. P. K.Nayak, Text book of Tensor Calculus and Differential Geometry. PHI Learning, 2012.

ME6301 ADVANCED MACHINING SCIENCE

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (18 hours)

Mechanics of metal cutting; tool geometry-effect of rake, lead and clearance angles; shear angle and its relevance, strain and strain rate in orthogonal cutting, stress distribution along rake face, theories of Merchant, Lee and Shaffer, Oxley, etc. Inserts-chip groove geometries; nomenclature, selection and applications in turning, milling, drilling, design concepts, new tool geometries, selection of operating conditions, carbide grade design, carbide coatings, ceramic, super hard grade design, effect of cutting variables on forces, tool failure analysis, theories of tool wear, measurement of tool wear, tool life and economics of machining, CNC machining.

Module 2: (9 hours)

Thermal aspects in machining; heat and temperature distribution, modeling of chip formation in metal cutting, modeling of machining characteristics in turning, milling, drilling, grinding, etc., measurement of cutting forces and cutting temperatures, surface analysis, methods of improving surface characteristics, Minimum Quantity Lubrication. Grinding; wheel conditioning - Electrolytic in-Process Dressing.

Module 3: (12 hours)

Micro machining; Tool based micromachining methods, cutting edge radius effect, minimum uncut chip thickness, micro turning, micro milling, unconventional micromachining methods – micro EDM, micro WEDM. Ultra-precision machining; mechanism of material removal, methods and applications. High speed machining (HSM)- mechanics, applications. nano surface generation, brittle versus ductile regime machining - ductile cutting of silicon wafers, nanometric cutting, chip formation, recent developments. Rapid Prototyping: principle of rapid prototyping, various RP technologies, selection of a suitable RP process for a given application, emerging trends, reverse engineering: data extraction, data processing. Applications and case studies, Introduction to file formats, Processing STL files.

References:

1. Winston A. Knight, and Geoffrey Boothroyd, *Fundamentals of Metal Machining & Machine Tools*, 3rd ed., CRC Press, 2005.
2. J. A. McGeough, *Advanced Methods of Machining*, Chapman and Hall, 2011.
3. Amitabha Battacharyya, *Metal Cutting*, Theory and Practice, New Central Book Agency, 2012.
4. A. Ghosh, and A. K. Mallik, *Manufacturing Science*, Affiliated East West Press Ltd, 2014.
5. Serope Kalpakjian, and Steven R. Schmid, *Manufacturing Engineering and Technology*, 7th ed., Pearson Education, 2013.
6. M.C. Shaw, *Metal cutting Principles*, 2nd ed., Oxford Clarendon Press, 2012
7. P. L. B. Oxley, *The Mechanics of Machining*, John Wiley & Sons, 1989
8. Gary F. Benedict, *Nontraditional Manufacturing Processes*, CRC Press, 1987.
9. V. C. Vekatesh, and H. Chandrasekharan, *Experimental Techniques in Metal cutting*, Prentice hall of India, 1987
10. C. K. Chua, K.F. Leong and C. S. Lim, *Rapid Prototyping: Principles and Applications*, 3rd ed., World Scientific, 2008
11. N. Hopkinson, R.J.M, Hauge, and P M, Dickens, *Rapid Manufacturing – An Industrial revolution for the digital age*, Wiley, 2006.

ME6302D ADVANCED METROLOGY AND COMPUTER AIDED INSPECTION

Prerequisite: Nil

L	T	P	C
3	0	0	3

Module 1: (13 hours)
Measurement Fundamentals, Measurement Uncertainty according to GUM, Type A Evaluation; Repeated measurements, Regression, Type B Evaluation, Calculation of combined standard uncertainty using Law of Propagation, Numerical Approach, Handling Correlated components, Expanded Uncertainty, Uncertainty and Resolution, Uncertainty and Conformity.
Geometric Dimensioning and Tolerancing: Necessity, Symbols, Calculation of straightness, roundness, Bonus Tolerances.

Module 2: (13 hours)
Coordinate Measuring Machines: Basics, Constructional features, Measurement process, Measurement strategy, Sampling strategy, Measurement Uncertainty
Surface Texture measurement: Definitions, Stylus instruments, Filters and cut-off, computation of parameters like Ra, Rq, Rt, Rp, Rz, Rsm, etc., Bearing Area curve, autocorrelation function, Areal parameters

Module 3: (13 hours)
Machine Vision: Introduction, Image acquisition, File formats and compression, Imaging geometry, Pixel relationships, Preprocessing, Segmentation, Description, Recognition, Interpretation, Case studies.
Scanning microscopes: Principles, Applications.

References:

1. L. Kirkup, and R. B. Frenkel, *An Introduction to Uncertainty in Measurement Using the GUM*, Cambridge University Press, 2006.
2. D. Whitehouse*, Surfaces and Their Measurement*, Hermes Penton Science, London, 2002.
3. J. Hocken, *Coordinate Measuring Machines and Systems,* 2nd ed., CRC Press, Boca Raton, 2012.
4. C. Demant, B. Streicher-Abel, and P. Waszkewitz, *Industrial Image Processing*, Springer-Verlag, Berlin, 1999.

ME6391D MANUFATURING TECHNOLOGY LABORATORY

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total hours: 39

Exercises on cylindrical and centreless grinding, measurements in Universal Measuring Microscope, Profile Projector, metallographic studies using metallurgical microscope, measurement of tool angles and studies of tool wear in inserts using Tool Maker's Microscope, experimental evaluation of cutting forces using dynamometers, studies and experiments on Micromachining centre, programming and measurements with CNC Coordinate Measuring Machine, surface texture analysis, experiments on non-destructive evaluation using ultrasonic testers, exercises on virtual instrumentation.

Exercises on CNC manual program and machine the component using CNC machining centre. Conduct studies on Nanoindenter, SEM, AFM, 3D optical profiler, RP machines, high speed camera and thermal imager. Studies and experiments on WEDM and EDM. Analysis of surface defects during machining.

List of Experiments

1. Centerless grinding and surface roughness measurement using Surftest
2. Study and programming on CNC vertical machining centre and CNC turning centre
3. Grinding of cutting tool angles and measurements using TMM
4. Non -destructive testing using ultrasonic tester
5. Tool wear study and determination of tool life
6. Cutting force measurement in turning using strain gauge
7. Study of tool insert and wear analysis
8. Metallurgical evaluation of specimen using metallurgical microscope
9. Study on micromachining centre and rapid prototyping machine
10. Grinding of surfaces by cylindrical grinding machine and measure using surface roughness instruments
11. Cutting force measurements using KISTLER dynamometer
12. Study and programming on CNC CMM
13. Exercises on CNC WEDM, CNC EDM
14. Study on Optical 3D profilometer, High speed camera, Thermal imager, Nanoindenter, SEM and AFM

References:

1. Geoffrey Boothroyd, and Winston A. Knight, *Fundamentals of Metal Machining and Machine Tools*, 3rd ed. CRC press, 2005.
2. V. C. Venkatesh and H. Chandrasekaran, *Experimental Techniques in Metal Cutting*, Prentice-Hall of India, 1987.
3. Milton C. Shaw, *Metal Cutting Principles*, 2nd ed. Oxford University Press, 2004.
4. B. L. Juneja, G. S. Sekhon, and Nitin Seth, *Fundamentals of Metal Cutting and Machine Tools*, 2nd ed. New Age International, 2003.
5. A. B. Chattopadhyay, *Machining and Machine Tools*, 2nd ed. Wiley India, 2017.
6. P. N. Rao, *CAD/CAM: Principles and Applications*, 3rd ed. Tata McGraw Hill, 2010.

ME6311D MODERN MACHINING PROCESSES

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total Hours: 39

Module 1: (11 hours)
Introduction to advanced machining processes – classification of advanced machining process. Mechanical processes: Abrasive jet machining, Ultrasonic machining and welding, Water jet machining, Abrasive water jet machining, Abrasive flow machining, Magnetic abrasive machining, advanced Micro and Nano processes with smart fluids.

Module 2: (14 hours.)
Chemical and Electro chemical processes: Chemical machining, photo chemical processes. Electrochemical machining, Modifications on basic ECM process: Electro chemical grinding, Electro chemical deburring, Electro polishing, Electro stream drilling, Shaped tube electrolytic machining.

Module 3: (14 hours)
Electro thermal processes: Electro discharge machining, Wire EDM, Electro discharge grinding, Electro discharge sawing, Electro discharge diamond grinding. Plasma Arc Machining, Electron beam machining, Laser beam machining. Ion beam machining. Comparative evaluation of different advanced machining processes

References:
1. P. C. Pandy, and Shan, *Modern machining processes,* 2nd ed., Tata McGraw Hill, 1987.
1. P. K. Mishra, *Non-conventional machining*, 2nd ed., Narosa Publishing House, 1997.
2. Hassan El- Hofy, *Fundamentals of machining processes*, 1st ed., CRC, 2007.
3. V. K. Jain, *Advanced Machining Process*, 2nd ed., Allied Publishing Pvt. Ltd. 2007.
4. T. Jagadeesha, *Unconventional machining processes*, 1st ed., IK publication. 2008
5. Debarr, and Oliver, *Electrochemical machining*, American Elsevier Publishing Co., 1978.
6. Krasyuk, *Electro-spark machining of metal*, 1st ed., Consultants Bureau, 1982.

ME6312D MACHINE TOOL DESIGN AND COMPUTER NUMERICAL CONTROL

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total Hours: 39

Module 1: (14 hours)
Design principles of metal cutting machine tools – classification, kinematics, layouts, machining time calculations. Stepped and step-less regulation of speed and feed, Design of speed box and feed box. Design of machine tool structures, power screws, spindles, bed, head stock, guide-ways. Lubrication systems in machine tools.

Module 2: (14 hours)
Machine Tool dynamics: free and forced vibrations, Vibration and noise isolation in machine tools, Vibration measurement in machine tools. stability analysis, regenerative chatter. Hydraulic drives, Pneumatic drives and Electrical drives for machine tools. Comparison and selection of drives.

Module 3: (11 hours)
Types of CNC machine tools, machining centers, 5 axis machining, Design of CNC machine tools, Mechatronic elements, sensors and transducers, tool changers, testing of machine tools, positioning accuracy and repeatability. Measurements, Laser interferometry, machine tool error analysis, sources of error, error compensation strategies, real time error compensation techniques, CNC programming, industrial design, aesthetics and ergonomics

.

References:

1. N. K. Mehta, *Machine Tool Design and Numerical Control*, 3rd ed., Tata McGraw Hill, 2012.
2. J. N. Acherkan, *Machine Tool Design*, 1st ed., Vols. 1 to 4, MIR Publishers, 1982.
3. J. F. Blackburn, G. Reetholf, and J. L. Shearer, *Fluid Power Control*, 1st ed., 1981.
4. G. Boothroyd, *Fundamentals of Metal Machining and Machine Tools*, 3rd ed., McGraw Hill, 2004.
5. T. Jagadeesha, *Fluid Power Control*, 1st ed., John Wiley publications, 2013.
6. G. Shleisinger, *Testing of Machine tools*, 1st ed., Pergamon press, 1982.
7. Leonard Meirovitch, *Elements of Vibration Analysis*, 1st ed., McGraw Hill, 1986.
8. P. Radhakrishnan, *CAD/CAM/CIM*, 2nd ed., New Age International Publishing, 2000.

ME6313D INDUSTRIAL AUTOMATION AND ROBOTICS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

1: (10 hours)
Introduction to automation: definition, types, merits and Criticism, architecture of industrial automation systems, manufacturing plants and operations: automation strategies, basic elements of automated system, advanced automation functions, Levels of automation.

Module 2: (12 hours)
Industrial control Systems: process and discrete manufacturing industries, continuous and Discrete Control systems: an overview of Computer process control, fundamentals of automated assembly system, actuators and sensors: fluid power and electrical actuators, piezoelectric actuator; sensors for position, motion, force, strain and temperature.

Module 3: (17 hours)
Introduction to robotics: robotics system, classification of robots, robot Characteristics, kinematics for manipulator: frames and transformations, forward and inverse kinematics, DH representation,derivation of forward and Inverse kinematic equations for various types of robots, applications of robots.
Introduction to manipulator jacobian: singularity, jacobian in force domain, velocity propagation from link to link, static forces in manipulators, introduction to dynamic analysis: Lagrangian formulation, trajectory planning: joint space and cartesian space.

References:

1. John J. Craig, *Introduction to Robotics, Mechanics and Control*, 3rd ed., Addison – Wesley, 2018.
2. Saeed B. Niku, *Introduction to Robotics*, *Analysis, Systems and applications*, Prentice Hall India, 2002.
3. Mikell P. Groover, *Automation, Production Systems and Computer Integrated Manufacturing*, Prentice Hall, India, 2004.
4. Mark W. Spong, and M. Vidyasagar, *Robot Dynamics and Control*, John Wiley & Sons, 1989.
5. K. S. Fu, R. C. Gonzales, C. S. G. Lee, *Robotics Control, Sensing, Vision and Intelligence*, McGraw Hill 1987.
6. R. P. Paul, *Robot Manipulators Mathematics Programming, Control, The Computer Control of Robotic Manipulators*, The MIT Press, 1979.
7. Robert J. Schilling, *Fundamentals of Robotics, Analysis and Control*, Prentice Hall of India 1996.
8. R. K. Mittal and I. J. Nagarath, *Robotics and Control*, Tata McGraw-Hill, 2003.
9. M. Groover, and E. Zimmers, *CAD/CAM-Computer Aided Design and Manufacturing*, Prentice Hall of India, 2000.
10. F. G. Shinskey, *Process Control Systems – Application, Design and Tuning*, 4th ed., McGraw-Hill, 1996.

ME6392D CAD / CAM LABORATORY

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total Hours: 39

Computer Aided Design: demonstration of part modeling, assembly and mechanism modeling.
Finite Element Analysis: static structural analysis, coupled thermal stress analysis, exercise on geometry import and meshing, modal analysis, nonlinear analysis: geometric, material and boundary nonlinearities, transient structural analysis.
Computer Aided Manufacturing & Automation: Manual and CNC Programming, Generation of CNC codes from CAD geometries, Introduction to robot accuracy and repeatability measurements, Introduction to components and tools for automation.

List of Exercises

Computer Aided Design:

1. Exercises on part Modelling (Using different software)
2. Exercises on assembly Modelling

Finite Element Analysis:

3. Static structural analysis. (Using different software)
4. Coupled thermal stress analysis.
5. Modal analysis to obtain natural frequencies.
6. Elasto-plastic analysis..
7. Transient structural analysis.

Computer Aided Manufacturing & Automation:

8. Generation of CNC codes from a CAD models
9. Demonstration/use of various CNC Machines
10. Design and testing of pneumatics based automation circuits
11. Robot programming and repeatability & accuracy measurements
12 Demonstration of Pneumatics/hydraulic components and circuits

References:

1. D. F. Rogers and J. A. Adams, *Mathematical Elements of Computer Graphics*, 15th Reprint. McGraw Hill International, 2008.
2. I. Zeid, *CAD/CAM: Theory and Practice*, 2nd ed. Tata McGraw Hill, 2009.
3. N. D. Bhatt and V. M. Panchal, *Machine Drawing,* 53rd ed. Charotar Publishing House, 2014.
4. E. P. Popov, *Engineering Mechanics of Solids*, 2nd ed. Prentice Hall of India, 2000.
5. M. K. Thompson and J. M. Thompson, *ANSYS Mechanical APDL for Finite Element Analysis*. Butterworth-Heinemann, 2017.
6. O. C. Zienkiewicz, R. L. Taylor, and J. Z. Zhu, *The Finite Element Method: Its Basis and Fundamentals*, 7th ed. Butterworth-Heinemann, 2013.
7. ANSYS Mechanical APDL Documentation.
8. Y. Koren, *Computer Control of Manufacturing Systems*, Tata McGraw Hill, 2009.
9. M. P. Groover, *Automation, Production Systems, and Computer Integrated Manufacturing*, 4th ed., Pearson Education, 2015.
10. J. J. Craig, *Introduction to Robotics, Mechanics and Control*, 3rd ed., Addison – Wesley, 1999.
11. T. Jagadeesha, *Fluid Power Control*, 2nd ed., John Wiley Publication, 2013
12. A. Esposito, *Fluid Power with Applications*, 7th ed., Pearson Education, 2003.

ME6393D SEMINAR / MINI PROJECT

Pre-requisite: Nil

L	T	P	C
0	0	2	1

Total hours: 26

Students are free to select either Seminar or Mini Project after consulting with Programme Coordinator/Course Faculty.

SEMINAR

Each student shall prepare a seminar paper on any topic of interest related to the core/elective courses undergone in the first semester of the M. Tech. programme. He/she shall get the paper approved by the Programme Coordinator/Faculty Members in the concerned area of specialization and shall present it in the class in the presence of the Faculty in-charge of seminar class. Every student shall participate in the seminar. Grade will be awarded on the basis of the student's paper, presentation and his/her participation in the seminar.

Course Outcomes for ME6393D Mini Project:

CO1: Select a research problem pertaining to the area of specialization of the M. Tech. programme.
CO2: Choose an appropriate research methodology for solving the problem identified.
CO3: Apply the methods/tools learned to solve the problem.
CO4: Construct a report by employing the rhetoric techniques of academic writing, including invention, research, critical analysis, evaluation and revision

MINI PROJECT

Students can select a research problem pertaining to the area of specialization of the M. Tech. programme by consulting a faculty in the department. The student has to identify an appropriate methodology and solve the problem. The student shall submit a report. The mini project will be evaluated by the faculty in-charge of the mini project.

.

ME7394D PROJECT WORK (Part - I)

L	T	P	C
0	0	20	12

Students are encouraged to identify the area of the project work and conduct the literature review during the second semester itself. The project work starts in the third semester. The topic shall be research and development oriented. The project work can be carried out at the institute or in an industry/research organization. Students desirous of carrying out project work in an industry or in other organizations have to fulfill the requirements as specified in the “Ordinances and Regulations for M. Tech.” The student is expected to complete the research problem definition, formulation and preliminary work (pilot study) in the third semester. There shall be evaluations of the project work during and at the end of the third semester by a committee constituted by the department.

ME7395D PROJECT WORK (Part - II)

L	T	P	C
0	0	20	13

The project work started in the third semester will be extended to the end of the fourth semester. There shall be evaluations of the project work by a committee constituted by the department during the fourth semester. The student shall submit the thesis based on the recommendation of the departmental evaluation committee. There shall be viva-voce examination conducted by an evaluation committee with an external examiner.

Stream-specific elective courses

ME6321D MECHATRONICS SYSTEMS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Total Hours: 39

Module 1: (12 hours)
Introduction to mechatronics: key elements in mechatronics, design process, types of design: traditional and mechatronics designs; advanced approaches in mechatronics; real time interfacing; elements of data acquisition system; case studies of mechatronics systems, identification of key elements of various mechatronics systems, examples.

Module 2: (12 hours)
Introduction to signals, system and controls; system representation, linearisation, time delays, measures of system performance; closed loop controller: PID controller, digital controllers, controller tuning, adaptive control; introduction to microprocessors, micro-controllers and programmable logic controllers components, PLC programming, examples.

Module 3: **(15 hours)**
Actuator and Sensors: fluid power and electrical actuators, piezoelectric actuator; sensors for position, motion, force and temperature, flow sensors-range sensors, ultrasonic sensors, fibre optic sensors, magnetostrictive transducer, selection of sensors; case studies on selection of actuators and sensors for mechatronics systems.
Advanced applications in mechatronics: sensors for condition monitoring, mechatronics control in automated manufacturing; artificial intelligence in mechatronics: fuzzy logic application in mechatronics, microsensors in mechatronics; case studies and design of mechatronics systems

References:

1. Devadas Shetty, Richard A Kolk, *Mechatronics System Design*, 6th ed., Thomson Learning, 2015
2. W. BOLTON, *Mechatronics*, 4th ed., Pearson education Asia 2004.
3. Dan Necsulescu, *Mechatronics,* Parson Education Asia 2002.
4. HMT Ltd*, Mechatronics*, 1st ed., Tata McGraw Hill, 2000
5. B.P. Singh, *Microprocessors and Microcontrollers*, 1st ed., Galgotia Pub, 1997
6. Frank D.Petruzella, *Programmable Logic Controllers*,4th ed., Tata McGraw Hill, 2010
7. Krishna Kant, *Computer Based Industrial Control*, 2nd ed., PHI, 1999

ME6322D SIX SIGMA

L	T	P	C
3	0	0	3

Prerequisite: Nil

Module 1: (11 hours)
Six Sigma Basics: Overview & Implementation, the DMAIC process.
Simple graphical tools: 7 QC Tools, Box Plot, Dot Plot, Stem & Leaf Plot.
Basic Statistics: Histograms to Distributions, Normal Distribution, Central Limit Theorem, Law of large numbers, t, chi-squared and F distributions.
Normal Probability Plotting on ordinary graph paper, Interpretation
Testing a new process for improvement - Variability known from past, Variability estimated from the experiment
Comparing two processes - Randomised samples, Paired samples, Comparing more than two methods simultaneously- ANOVA
Six Sigma Analyse: Experimental strategies - Deficiencies of one factor at a time experiments, Problems in analysis of past data, Necessity for randomization

Module 2: (16 hours)
Basics of Experimental Design - Terminology, Two level factorials, Estimation of effects and interactions, Yates algorithm, Unreplicated experiments - judging significance, Testing for significance in replicated experiments
Developing mathematical model equations, calculating residuals, checking whether experiment has been conducted satisfactorily
Handling non-normal response - Transformations.
Choosing the number of experiments, Testing whether linear model is satisfactory - Curvature, Handling uncontrollable factors – Blocking, Dealing with difficult to randomise factors – split plot experiments
Dealing with large number of factors, Fractional Factorial experiments, Design Resolution.
Use of DoE software

Module 3: (12 hours)
Six Sigma Metrics: DPU, DPO, DPMO, Sigma levels, Yield, First Time Yield, Overall Yield, Throughput Yield, Rolled Throughput Yield, Normalized Yield
Process Capability Indices: Cp, Cpk, Cpm, Cpkm. Dealing with non-normality through transformations, Importance of stability for capability, Effect of sample size - Confidence Intervals
Measurement System Analysis: Repeatability and Reproducibility

Every student should carry out an individual project and present the results.

References:

1. F. Breyfogle, *Implementing Six Sigma: Smarter Solutions Using Statistical Methods*, 2nd ed., John Wiley & Sons, New York, 2003.
2. M. Harry and R. Schroeder, *Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations*, Doubleday, New York, 2000.
3. J. Lawson, and J. Erjavec, *Modern Statistics for Engineering and Quality Improvement*, Thomson Duxbury, 2000.
4. D. C. Montgomery, *Introduction to Statistical Quality Control*, 6th ed., John Wiley & Sons, Inc., New York, 2009.

ME6323D ADDITIVE MANUFACTURING

L	T	P	C
3	0	0	3

Prerequisites: Nil

Total: 39 hours

Module 1: (14 hours)

Product Developing Cycle, Additive Manufacturing, Definition of Rapid Product Development, Virtual prototypical and rapid manufacturing technologies, Physical Prototyping & rapid manufacturing technologies, Synergic integration technologies**.** Principle of Rapid Prototyping, Various RP technologies, Selection of a suitable RP process for a given application, Status of outstanding issue in RP- accuracy, speed, materials (strength, homogeneity and isotropy), Emerging Trends, Rapid Tooling: Introduction to Rapid Tooling, Indirect Rapid Tooling, Silicon rubber tooling, Aluminium filled epoxy tooling, Spray metal tooling, Direct Rapid Tooling

Module 2: (13 hours)
Classification: Liquid based system, Stereolithography Apparatus (SLA), details of SL process, products, Advantages, Limitations, Applications and Uses. Solid based system – Fused Deposition Modeling, principle, process, products, advantages, applications and uses – Laminated Object Manufacturing, Selective Laser Sintering – principles of SLS process, principle of sinter bonding process, Laser sintering materials, products, advantages, limitations, applications and uses. Three Dimensional Printing – process, major applications, research and development. Direct shell production casting – key strengths, process, applications and uses, case studies, research and development. Laser Sintering System, e-manufacturing using Laser sintering, customized plastic parts, customized metal parts, e-manufacturing – Laser Engineered Net Shaping (LENS)

Module 3: (12hours)
Data Extraction, Data Processing, Applications and Case Studies: Engineering Applications, Medical Applications, Processing of Polyhedral Data: Polyhedral BRep modeling, Introduction to STL format, Defects and repair of STL files, Overview of the algorithms required for RP&T and Reverse Engineering, Laboratory and demonstration sessions

References:

1. Rafiq I. Noorani, *Rapid Prototyping - Principles and Applications*, Wiley & Sons, 2005.
2. C. K. Chua, K. F. Leong and C. S. Lim, *Rapid Prototyping: Principles and Applications*, 3rd ed., World Scientific, 2010.
3. N. Hopkinson, R. J. M. Hauge, and P. M. Dickens*, Rapid Manufacturing – An Industrial revolution for the digital age*, Wiley, 2006.
4. Ian Gibson, *Advanced Manufacturing Technology for Medical applications: Reverse Engineering, Software conversion and Rapid Prototyping*, Wiley, 2006.
5. Paul F. Jacobs, *Rapid Prototyping and Manufacturing: Fundamentals of Stereolithography*, McGraw Hill, 1993.
6. D. T. Pham, and S. S. Dimov, *Rapid Manufacturing*, Springer Verlog, 2001.

ME6324D INDUSTRIAL MACHINE VISION

L	T	P	C
3	0	0	3

Prerequisite: Nil

Total hours: 39

Module I: (11 hours)

Introduction: Types of inspection tasks, Structure of image processing systems, examples
Image Preprocessing: Gray Scale transformations, Image arithmetic, Linear Filters, Other Filters
Positioning: Positioning of individual object, Orientation of individual object, Robot positioning
Segmentation: Regions of interest, Thresholding, Contour Tracing, Edge based methods, Template matching

Module 2: (15 hours)

Mark Identification: Bar code identification, Character identification, Identifying pin marked digits on metal, Print quality inspection
Classification: As function approximation, Instance based classifiers, Function based classifiers, Neural network classifiers
Dimension checking: Simple Gauging, Shape checking on punched parts, injection molded parts, High accuracy gauging of threads, Calibration.

Module 3: (13 hours)

Image acquisition and illumination: Solid state sensors, Standard video cameras, other cameras, Transmission to computer, Optics, Lighting
Presence Verification: Simple presence verification, simple gauging for assembly verification, presence verification using classifiers
Object Features: Basic Features, Shape Descriptors, Gray Level Features

References:

1. Demant, *Industrial Image Processing – Visual Quality Control in Manufacturing*, 2nd ed., Springer, 2013.
2. Gonzalez, *Digital Image Processing Using MATLAB*, 2nd ed., Pearson Education, 2010.
3. Gonzalez, and Woods, *Digital Image Processing*, 3rd ed., Pearson Education, 2008.
4. Batchelor, and Whelan, *Intelligent Vision Systems for Industry*, Springer Verlag, 1997.

ME6325D MICRO MACHINING

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (14 hours)
Introduction to Micro-manufacturing and Scaling Laws – Types of Scaling laws - Scaling in Geometry, Scaling in Mechanics, Scaling in Adhesive Forces, Scaling in Electrostatic Forces, Scaling in Electromagnetic Forces, Scaling in Fluid Mechanics, Scaling in Heat Transfer; Salient Features of Micro-Machining - Workpiece microstructure effect, Tool design effect - Crystallographic Orientation Effect, Edge Radius Effect Minimum Chip thickness. Overview about micro fabrication methods - Chemical vapor deposition (CVD) - basic principles of CVD LPCVD, PECVD; Physical vapor deposition (PVD) methods – thermal evaporation and sputtering; Lithography - optical and electron beam lithography; Dry and wet etching

Module 2: (15 hours)
Conventional micromachining processes - micro turning, micro drilling, micro milling, micro grinding – Cutting force, Surface roughness, Chip formation, burr formation, diamond turned machining; Advanced micromachining processes - micro Electro-discharge machining – Principle, system development, heat affected zone, applications; Electro-chemical micromachining – Principle, types, applications; Laser machining processes – Types of LASER for micromachining, LASER micro machining system; Ultrasonic micro machining; abrasive water jet micromachining - Nano finishing – magneto-rheological and allied finishing processes – Micro-machine Tool systems.

Module 3: (10 hours)
Inspection and metrology; Various inspection and metrology based on optical, mechanical, charged beam and electrical; 3D Optical profilometer – white light interferometry, focus variation methods, Nano intender, SEM, TEM, AFM; Force, vibration and acoustic emission measurements.

References:

1. J. A. McGeough, *Micromachining of Engineering Materials*, 1st ed., CRC Press, 2001.
2. Marc J. Madou, *Fundamentals of Microfabrication*, 2nd ed., CRC Press, Taylor and Francis Group, 2002.
3. Stephen A. Cambell, *The Science and Engineering of Microelectronic Fabrication*, 2nd ed., Oxford University Press, 2001.
4. V. K. Jain, *Micromanufacturing*, 1st ed., CRC press, 2012.
5. N. P. Mahalik, *Micromanufacturing & Nanotechnology*, Springer, 2010.
6. Mark J. Jackson, *Microfacbrication & Nanomanufacturing*, 1st ed., CRC Press, 2005.
7. Manas Das, V. K. Jain and P. S. Ghoshdastidar, *Nanofinishing Process using Magnetorheological Polishing Medium*, Lambert Academic Publishing, 2012.
8. Richard Leach, *Characterisation of Areal Surface Texture*, 1st ed., Springer-Verlag Berlin Heidelberg, 2013.
9. Richard Leach, *Optical Measurement of Surface Topography*, 1st ed., Springer-Verlag Berlin Heidelberg, 2011.

ME6326D TOOL ENGINEERING AND DESIGN

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total Hours: 39

Module 1: (13 hours)

Design of cutting tools: tool materials; tool geometry; single point cutting tools; tipped tools; milling cutters; drills; form tools; broaches; gear cutting tools; grinding wheels; cutting force analysis in turning & milling; design of tool holders for single point tools; boring bars; selection of tools for machining applications; tooling for CNC machines.

Module 2: (13 hours)

Press tools: power presses; die cutting operations; centre of pressure; scrap strip lay out for blanking; press tonnage calculations; progressive dies; compound dies; die design for simple components; drawing dies; blank development; estimation of drawing force; blank holders; blank holding pressure; design of drawing dies for simple components; bending; bending dies.

Module 3: (13 hours)

Principles of location and clamping; jigs; types of jigs; design of jigs for machining simple components; fixtures; standard work holding devices; clamping methods and elements; quick-acting clamps; design of milling fixtures for simple components; turning, grinding and welding fixtures; computer aided fixture design; fabrication of jigs and fixtures.

References:

1. C. Donaldson, G. LeCain and V. Goold, *Tool design*, 4th ed., New Delhi, Tata McGraw Hill, 2012.
2. A. Bhattacharyya, *Metal Cutting: Theory and Practice*, Kolkata, New Central Book Agency, 1984.
3. HMT*: Production Technology*. New Delhi, Tata McGraw Hill publications, 2001.
4. F. W. Wilson, *Hand Book of Fixture Design*, McGraw Hill publications, 1962.
5. E. G. Hoffman, *Jigs and fixture design*, 5th ed., Delmar Cengage Learning, 2008.
6. Vukota Boljanovic and J. R. Paquin, *Die Design Fundamentals* 3rd ed., Industrial Press, 2006.
7. M. H. A. Kempster, *Introduction to jig and tool design,* 3rd ed., New Delhi, Viva Books Pvt Ltd, 1998.
8. P. H. Joshi, *Jigs and Fixtures,* 3rd ed. Tata McGraw Hill, 2010.
9. Y. Rong and Y. Zhu, *Computer-Aided Fixture Design*, CRC Press, 1999.

10. Y. Rong and S. Huang, *Advanced Computer-Aided Fixture Design*, Academic Press, 2005

ME6327D DESIGN OF EXPERIMENTS

L	T	P	C
3	0	0	3

Pre requisite: Nil

Total hours: 39

Module 1: (13 hours)

Graphical Data analysis tools - Stem and leaf plot, Dot plot, Box plot
Distribution of sample data - Normal distribution, t distribution
Normal Probability Plotting on ordinary graph paper, Interpretation
Testing a new method for improvement - Variability known from past, Variability estimated from the experiment
Comparing two methods - Randomised samples, Paired samples
Comparing more than two methods simultaneously- ANOVA

Module 2: (13 hours)

Experimental strategies - Deficiencies of one factor at a time experiments, Problems in analysis of past data, Necessity for randomization
Basics of Experimental Design - Terminology, Two level factorials, Estimation of effects and interactions, Yates algorithm, Unreplicated experiments - judging significance, Testing for significance in replicated experiments.
Developing mathematical model equations, calculating residuals, checking whether experiment has been conducted satisfactorily.

Module 3: (13 hours)

Handling non-normal response - Transformations.
Choosing the number of experiments, Testing whether linear model is satisfactory, How to handle uncontrollable factors, How to deal with difficult to randomise factors.
Dealing with large number of factors, Fractional Factorial experiments and Plackett Burman Designs, How to minimise possible confusion, Design Resolution, Sequential experimentation strategies, Folding over.
Determining optimum conditions experimentally - Central Composite Designs, D-Optimal Designs, Response Surface methods, Mixture experiments.
Experiments to determine variability and minimise it.
Training in Design Expert, software for DoE. Individual Design Project, presentation and discussion.
Applications / Case Studies in Research, Quality Improvement, Product Development.

References:

1. M. J. Anderson, and P. J. Whitcomb, *Doe Simplified: Practical Tools for Effective Experimentation*, 3rd ed., Productivity Press, USA, 2015
2. J. Lawson, and J. Erjavec, *Modern Statistics for Engineering and Quality Improvemen*t, Thomson Duxbury, Indian EPZ edition, 2000.
3. G. E. P. Box, W. G. Hunter, and S. J. Hunter, *Statistics for Experimenters*”, 2nd ed., John Wiley & Sons Inc., 2005.

ME6328D ADVANCED HYDRAULIC AND PNEUMATIC CONTROL SYSTEMS

Pre-requisites: Nil

Total Hours: 39

L	T	P	C
3	0	0	3

Module 1: (13 Hours)
Introduction to hydraulics and pneumatics: their advantages and limitations, ISO symbols and standards in hydraulics, recent developments, applications; basic types and constructions of hydraulic pumps and motors: performance curves and parameters; hydraulic actuators; hydraulic control elements; direction, pressure and flow control valves: valve configurations, general valve analysis, series and parallel pressure compensation; flow control valves; electro-hydraulic servo valves-specifications; selection and use of servo valves.

Module 2: (13 Hours)
Electro hydraulic servomechanisms: electro hydraulic position control servos and velocity control servos; basic configurations of hydraulic power supplies; bypass regulated and stroke regulated hydraulic power supplies; design and analysis of typical hydraulic circuits: use of displacement-time and travels-step diagrams; synchronization circuits and accumulator sizing; meter-in, meter - out and bleed-off circuits; fail safe and counter balancing circuits; Case study of hydraulic circuits for machine tool design; study of hydraulic fluid sim software.

Module 3: (13 Hours)
Components of pneumatic systems: direction, flow and pressure control valves in pneumatic systems; development of single and multiple actuator circuits; ISO symbols and standards in pneumatics, safety circuits; valves for logic functions: time delay valve, exhaust and supply air throttling; examples of typical circuits using displacement-time and travel-step diagrams; cascade method; Karnaugh-Veitech mapping method; will-dependent control; travel-dependent control and time dependent control; combined control; program logic control (PLC); electro-pneumatic control and air hydraulic control; applications in assembly, feeding, metalworking, materials handling equipment; Case study of pneumatic machine tool design and industrial automation; study of solid modelling and animation by CATIA software for machine tool design.

References:

1. A. Esposito, *Fluid Power with applications*, 7th ed., Pearson, 2008.
2. J. L. Johnson, *Introduction to Fluid Power*, 1st ed., Delmar Cengage Learning, 2001.
3. P. Joji, *Pneumatic Controls*, 1st ed., Wiley India, 2008.
4. A. C. Morse, *Electro hydraulic Servomechanism*, 1st ed., McGraw-Hill (New York), 1963.
5. J. J. Pippenger and R. M. Koff, *Fluid Power Control systems*, McGraw-Hill (New York), 1959.
6. E.C. Fitch, *Fluid Power Control Systems*, McGraw-Hill (New York), 1966.
7. E. M. Khaimovich, *Hydraulic Control of Machine Tools,* 1st ed., Pergamon, 1965.
8. J. Watton, *Fluid Power Systems: Modeling, Simulation and Microcomputer Control*, Prentice Hall, 1989.
9. Jagadeesha T, Fluid power control, John Wiley publications, 2013
10. H. E. Merritt, *Hydraulic control systems*, 1st ed. Wiley, 1991.
11. J. P. Hasebrink and R. Kobler, *Fundamentals of Pnuematics/Electropeumatics*, FESTO, 1975.
12. W. Deppert and K. Stoll, *Pneumatic Control-An introduction to the principles*, Vogel-Verlag, 1975.
13. B. W. Andersen, *The analysis and Design of Pneumatic Systems*, Krieger Pub. Co., 2001.
14. J. F. Blackburn, G. Reethof, and J.L. Shearer, *Fluid Power Control*, MIT Press, 1966

ME6329D VIBRATION AND NOISE IN MACHINE TOOLS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total Hours: 39

Module 1: (14 hours)
Single degree systems : elements of vibratory systems, equivalent mass, spring and dampers, free vibration without damping, Lagrange's equations of motion, analysis of linear system vibration using Lagrange's equations, free vibration with damping, viscous and coulomb damping, Logarithmic decrement, forced vibration, analytical and graphical solutions, magnification and quality factors, force and motion transmissibility, rotating and reciprocating unbalance, critical speeds.

Module 2: (12 hours)
Two degrees of freedom, formulations, matrix methods, lagrange's equation, principal and generalized coordinates, orthogonally, semi definite systems, three rotor systems, Multi degree freedom systems, equations of motion, eigenvalue problem, Modal Analysis, general response of discrete linear systems, continuous systems, boundary value problems, free vibration eigen value problem, axial vibration of rods, bending vibration of bars, Vibration measurement and control, velocity, acceleration measurement, noise control, propagation of sound, energy density, acoustic intensity, source control, path control, anechoic chambers design, noise absorbers

Module 3: (13 hours)
Vibration control, excitation reduction at source, rigid and flexible rotors, factors affecting vibration level, detuning and decoupling, dynamic properties and selection of materials, hysteretic materials, non linear materials, visco-elastic polymers, complex stiffness representations, dynamic vibration absorbers, passive types, vibration isolation of sdof with coulomb damping, three element isolators, two stage isolators, vibration isolation of multi degree systems, isolation of transient vibrations. Metal cutting force analysis, theory of chatter, modeling of machine tools, vibration analysis in typical machine tools, vibration in coupled machine tools effect of flexible mounting on vibration. Random vibration, stationary and ergodic random process, autocorrelation, power spectral density function, response of linear systems to stationary random process, response of single degree freedom system to random excitation, cross correlation function, response of multi degree freedom system to random excitation, random excitation to continuous system

References:

1. S. S. Rao, *Mechanical vibrations*, 4th ed., Pearson Education, 2004.
2. William Thomson, *Theory of vibrations with applications*, 5th ed., Pearson Education, 2008.
3. A.G. Ambekar, *Mechanical vibrations and noise engineering*, 2nd ed., Prentice Hall of India, 2006.
4. Yusuf Altintas, *Manufacturing Automation: Metal Cutting Mechanics, Machine Tool Vibrations and CNC Design*, Cambridge University Press, 2000.
5. Graham Kelly, *Theory and Problems of Mechanical Vibrations*, 4th ed., McGraw-Hill, 1996.
6. Rao V. Dukkipati, *Advanced Mechanical Vibrations*, 2nd ed., Narosa publishers, 2006.
7. Roger A. Anderson, *Fundamentals of vibrations*, Amerida publishers (U.K.), 1967.
8. Benson H. Tongue, *Principles of vibration*, 3rd ed., Oxford University, 2001.
9. Colin Hansen and Scott D. Snyder, *Active Control of Noise and Vibration*, E & FN Spon (U.K),1997.
10. J. S. Rao and K. Gupta, *Introductory Course on Theory and Practice of Mechanical Vibrations*, 4th ed., Wiley Eastern (U.K), 1987.
11. Leonard Meirovitch, *Fundamentals of Vibrations*, 1st ed., McGraw-Hill, 2001.
12. J. P. Den Hartog, *Mechanical Vibrations*, 2nd ed., Dover publications, New York, 1985.
13. Leo L. Beranek, *Noise reduction*, 1st ed., McGraw-Hill, 1960.
14. Herbert Goldstein, *Classical Mechanics*, 3rd ed., Addison-Wesley, 1970.
15. Ashok Kumar Mallik, *Principles of Vibration control*, 1st ed., Affiliated East-west press, 1990.
16. Christopher C. Fuller, *Active control of vibration*, Academic Press, London, 1997.

ME6330D QUALITY ENGINEERING AND MANAGEMENT

L	T	P	C
3	0	0	3

Prerequisite: Nil

Total Hours: 39

Module 1: (12 hours)
Introduction: Definitions, Dimensions of Quality, Total Quality Management.
Leadership: Deming's principles, Vision, Mission and Quality Policy
Customer: Identification, Customer Satisfaction, Customer Complaints
Employee Involvement - Team Development, Suggestion Schemes, Supplier Partnership
Continuous Process Improvement - PDSA Cycle, Seven Step Process, Kaizen, Six Sigma

Module 2: (11 hours)
Quality Measurement- Quality Costs, Quality awards; Quality Function Deployment; Quality Systems - ISO9000 - Requirements, Documentation, Certification, Failure Mode and Effects Analysis, Total Preventive Maintenance, Taguchi methods - Loss function, Parameter Design and Tolerance Design concepts
Acceptance sampling - Introduction, OC Curves, Single sampling, Rectifying Inspection, Double and sequential sampling.

Module 3: (16 hours)
Introduction to the concept of Control, Deming’s funnel experiment, Control charts for attributes - number nonconforming, fraction nonconforming, number of conconformities, fraction of nonconformities, Control chart for variables - Average Range chart, Average Standard deviation chart.
Advanced Control charts – for individuals, Cusum and EWMA
Reliability - Introduction, Exponential model, System Reliability - Series, Parallel, Standby; Design for Reliability, Reliability Testing

References:

1. Mitra *Fundamentals of Quality Control and Improvement,* 3rd ed., Pearson Education, 2008.
2. D. H. Besterfield, C. Besterfield-Michna, G. H. Besterfield and M. Besterfield-Sacre, *Total Quality Management,* 3rd ed., Pearson Education Inc., 2003.
3. L. C. Alwan, *Statistical Process Analysis*, 2nd ed., Irwin McGraw-Hill, 2000.
4. D. C. Montgomery, *Introduction to Statistical Quality Control,* 6th ed., John Wiley & Sons, Inc. 2009

ME6331D DESIGN FOR MANUFACTURE AND ASSEMBLY

L	T	P	C
3	0	0	3

Pre-requisites: Nil

Total hours: 39

Module 1: (16 hours)

Introduction : Philosophy of DFM, implementing DFM, benefits; concurrent engineering : design for quality, design for life cycle, design for cost, enabling technology, concurrent engineering and the organization, improving the development process; management frameworks : architecture, management's concerns with manufacturability, team building and training; justification of DFM, viewpoints for DFM
quality tools in DFM: problem solving tools, quality function deployment, benchmarking, supplier involvement,

Module 2: (12 hours)

Taguchi approach; computer aided technology: CAD/CAM/CAE, rapid prototyping, group technology, CIM; creative thinking in DFM, tools; general product design : impact of design concept and early project decisions, evaluating manufacturability of conceptual designs, producibility, geometric tolerancing
Design for Assembly : Principles, improving serviceability, recyclability; Design for Machining : Principles, Non:Traditional Machining; Design for forming : Principles, fine blanking, roll forming, precision forming, metal spinning, tube fabrication

Module 3: (11 hours)

Design for Forging, Casting; Design for Coating : Painting, powder coating, metal spraying; Design for Heat Treatment; Design for Fastening & Joining : Design guidelines for fasteners, adhesive assembly, welded assemblies; Design for Materials: Plastics, Composites, Ceramics, Powder Metallurgy

References:

1. K. Chitale, and R. C. Gupta, *Product Design and Manufacturing*, 6th ed., Prentice Hall of India Pvt Ltd., 2014
2. G. E. Dieter, *Engineering Design - A Materials and Processing approach*, 5th ed., Mc Graw Hill education, 2012
3. R. Bakerjian, *Design for Manufacturability*, *Tool and Manufacturing Engineers Handbook*, 4th ed., Society of Manufacturing Engineers, Michigan, 1992.

ME6332D ADVANCED JOINING TECHNOLOGIES

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total Hours: 39

Module 1: (13 hours)

Classification of welding processes: Gas welding, Arc welding; arc physics, power source characteristics; Manual metal arc welding: Concepts, types of electrodes and their applications; Gas tungsten arc welding: Concepts, processes and applications ; gas metal arc welding: Concepts, processes and applications ,types of metal transfer, CO2 welding, pulsed and synergic. MIG welding; FCAW, Submerged arc welding, advantages and limitations, electro slag and electro gas welding; Plasma welding: Concepts, processes and applications; Resistance welding: Concepts, types and applications; Flash butt welding, Stud welding and under water welding.

Module 2: (13 hours)

Friction welding: Concepts, types and applications; Friction stir welding: Metal flow phenomena, tools, process variables and application. Explosive, diffusion and ultrasonic welding: principles of operation, process characteristics and applications. EBW: Concepts types and applications. LBW: Physics of lasers, types of lasers, operation of laser welding setup, advantages and limitations, applications. Soldering: Techniques of soldering, solders, phase diagram, composition, applications; Brazing: Wetting and spreading characteristics, surface tension and contact angle concepts, brazing fillers, role of flux and characteristics, atmospheres for brazing; adhesive bonding; Cladding.

Module 3: (13 hours)

Heat flow, temperature distribution, cooling rates, influence of heat input; joint geometry, plate thickness, preheat, significance of thermal severity number. Epitaxial growth, weld metal solidification ,columnar structures and growth morphology, effect of welding parameters; absorption of gases, gas/metal and slag/metal reactions. Phase transformations, weld CCT diagrams, carbon equivalent-preheating and post heating. Weldability of steels: low alloy steels, stainless steels use of Schaffler and Delong diagrams; welding of cast irons. Welding of Cu, Al, Ti and Ni alloys: processes, difficulties, microstructures, defects and remedial measures. Process induced defects: significance, remedial measures**,** hot cracking, cold cracking, lamellar tearing, reheat cracking. Weldability tests, effect of metallurgical parameters. Computational Study through software packages.

References:

1. R. S. Parmer, *Welding Engineering and Technology*, Khanna Publishers, 1997.
2. B. Cary Howard, *Modern Welding Technology*, Prentice Hall, 1998.
3. G.E. Linnert, *Welding Metallurgy*, 4th ed., Vol. I and II, AWS, 1994.
4. H. Granjon, *Fundamentals of Welding Metallurgy*, Jaico Publishing House, 1994.
5. Kenneth Easterling, *Introduction to Physical Metallurgy of Welding*, 2nd ed., Butterworth Heinmann Ltd., 1992.
6. D. Saferian, *The Metallurgy of Welding*, Chapman and Hall, 1985.
7. M. D. Jackson, *Welding Methods and Metallurgy*, Grffin, London, 1967.
8. R. S. Mishra and M. W. Mahoney, *Friction Stir Welding and Processing*, ASM, 2007.
9. M. Schwartz, *Materials and Applications - Metal Joining Manual*, McGraw-Hill, 1979.
10. Sindo Kou, *Welding Metallurgy*, Wiley, 2002.
11. S. V. Nadkarni, *Modern Arc Welding Technology*, Oxford IBH Publishers, 1996.
12. Christopher Davis, *Laser Welding - A Practical Guide*, Jaico Publishing House, 1994.