

MECHANICAL ENGINEERING

M.Tech. in ME (CAD/CAM)

Semester I			
Sl. No	Course No	Course Title	Credits
1	HS501(Core)	Professional and Communication Skills	1-0-2-2
2	ME581(Core)	Analytical Methods in Engineering	3-0-0-4
3	ME589(Core)	Research Methodology	2-0-0-3
4	ME601(Core)	Computer Aided Geometric Design	3-0-0-4
5	Elective I	-	3-0-0-4
6	ME590L	Geometric Modeling Lab (GML)	0-0-2-2
Semester II			
1	ME611(Core)	NC-CNC Machine Tools and Programming	3-0-0-4
2	Elective II	-	3-0-0-4
3	Elective III	-	3-0-0-4
4	Elective IV	-	3-0-0-4
5	ME591L	Geometric Programming Lab (GPL)	0-0-2-2
Semester III			
1	ME598	Graduate Seminar I	2
2	ME699	M.Tech. Thesis	16
Semester IV			
1	ME599	Graduate Seminar II	2
2	ME699	M.Tech. Thesis	16

Electives

1.	ME612	Rapid Product Development Technologies	3-0-0-4
2.	ME615	Computer Integrated Manufacturing Systems	3-0-0-4
3.	ME535	Finite Element Methods for Mechanical Engineering	3-0-0-4
4.	ME636	Computational Fluid Dynamics	3-0-0-4
5.	ME642	Advanced Manufacturing Processes and Technologies	3-0-0-4
6.	ME651	Industrial Instrumentation & Metrology	3-0-0-4
7.	ME681	Engineering Optimization	3-0-0-4
8.	ME686	MEMS: Microfabrication and Application	3-0-0-4
9.	ME687	Smart Materials and Structures	3-0-0-4
10.	EC661	Fuzzy Logic and Neural Networks	3-0-0-4

Electives in Modular form (Common with CSE)

1.	EM601d	Parallel Processing	1-0-0-1
2.	EM601h	Dependable Computing	1-0-0-1
3.	EM602d	Artificial Intelligence and its Applications	1-0-0-1
4.	EM608a	Modelling and Simulation	1-0-0-1
5.	EM608b	Graphical Models	2-0-0-2
6.	EM609c	Speech and Music Signal Processing	1-0-0-1

CORE COURSES

Course Title	:	ANALYTICAL METHODS IN ENGINEERING		
Course Code	:	ME581	Course Type	: Compulsory
Contact Hours	:	L- 3 T- 1 P- 0	Credit	: 4
Program/Semester	:	M. Tech./ Semester-I		
Pre-requisites	:	None		
Evaluation Scheme	:	Quiz I (10%), Mid-Term (35%), Quiz II (10%), End-Term (45%)		

Course Details:

INTRODUCTION. [1 H]

SOLUTION METHODS FOR ORDINARY DIFFERENTIAL EQUATIONS (ODEs)

First order differential equations, nth order differential equations [5 H]

FIRST-ORDER PARTIAL DIFFERENTIAL EQUATIONS (PDEs)

Classification, Analytical Solutions for Linear and Semi-linear equations [5 H]

SECOND-ORDER PDEs

Classification, Transformations to Canonical forms for Hyperbolic, Elliptic and parabolic Equations [5 H]

CONCEPTS IN APPROXIMATE SOLUTIONS OF DIFFERENTIAL EQUATIONS

Space of Functions: Inner product, Orthogonal functions, Norm, Projection of a Function onto an Orthogonal set, Gram-Schmidt Orthogonalization and Orthonormal set, Parseval's theorem [5 H]

FOURIER SERIES

Series of Trigonometric functions, Convergence of Fourier Series: Piecewise Continuous and Smooth function, Evaluation of Fourier Coefficients: Even and Odd functions, Even and odd extensions of a function, Uniform Convergence of a Fourier Series, Parseval's theorem for Fourier Series, Application of Parseval's theorem to estimate the Mean Square Error [6 H]

ANALYTICAL SERIES SOLUTIONS OF PDEs

Separation of Variables, Extension of Separation of Variables methodology by Method of Superposition, Rectangular coordinate system, Cylindrical coordinate system (Bessel function), Spherical coordinate system (Legendre function), Hyperbolic Equations, Elliptic Equations, Parabolic Equations [5 H]

FOURIER TRANSFORM AND ITS APPLICATIONS

Fourier Series to Fourier Integral, Properties of Fourier Transformation, Problems in Infinite and Semi-infinite Media, Solution of PDEs in Infinite and Semi-infinite Media, Dirac Delta Function [5 H]

LAPLACE TRANSFORM AND ITS APPLICATIONS

Fourier Transform to Laplace Transform, Review of Laplace Transform, Laplace Inverse Transform by Complex Number Residue theory, Solution of PDEs by Laplace Transform [5 H]

Suggested Textbooks:

- I. J B Doshi, "Differential Equations for Scientists and Engineers," Narosa Publishing House, 2010.
- II. Michael D Greenberg (1998), "Advanced Engineering Mathematics (2nd Ed)," Prentice Hall, (Indian Edition).

References:

1. Erwin Kreyszig, "Advanced Engineering Mathematics," Wiley India, 1999.
2. T. Myint-U and L. Debnath, Linear Partial Differential Equations for Scientists and Engineers, Birkh"ausser, Boston, 2007.
3. M K Jain, S R K Iyengar and R K Jain, "Numerical Methods for Scientific and Engineering Computation," New Age International Publisher, 2007

Course Title	:	Research Methodology			
Course Code	:	ME589	Course Type	:	Compulsory
Contact Hours	:	L- 2 T- 0 P- 0	Credit	:	3
Program/Semester	:	M. Tech. / Semester-I			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End-Term (40%), Report & Presentation (20%)			

Course Details:

Overview of Research and its Methodologies: Concepts, needs, process, types and steps in research & scientific method Paradigm **(4H)**

Literature review- concepts & theories, what it is, why needed and how to carry out a literature review **(3H)**

Selecting and defining a research problem: need of problem formulation, criteria for selecting a problem? Identifying variables, evaluating problems, **(3H)**

Basics of technical Communication, Writing a technical report, writing skills for Research (Writing Research Proposals: Why and How to write Good Research Proposals? Writing Research Reports and Thesis: How to write articles, research papers, projects and reports/ thesis? Contents of a thesis), writing abstracts & Conclusions, etc. **(4H)**

Conducting the research: Research activities, Preparations for conducting a research, Research Design, Models of Research, Current trends in Research, Legal & ethical aspects of Research, citation methods & rules, foot note, text note, end note, references, bibliography. IPR and plagiarism issues **(4H)**

Sampling Design, Data Collection, Processing and Analysis of Data, Interpretation of Data **(4H)**

Planning and conducting experiments, Design of Experiments **(3H)**

Role of creativity, Roadblocks and bottleneck during research process. **(3 H)**

Suggested Textbooks:

1. C.R. Kothari, Research Methodology: Methods and Techniques, New Age International Publishers, 3rd Edition, 2015

Reference

- 1 Taylor, Sinha and Ghosal, Research Methodology, PHI
- 2 Paneerselvam R., Research Methodology, PHI, 2nd Edition

Course Title	:	Computer Aided Geometric Design			
Course Code	:	ME601	Course Type	:	Compulsory/Elective
Contact Hours	:	L- 3 T- 1 P- 0	Credit	:	4
Program/Semester	:	M. Tech./ Semester-I			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz (20%), Mid-Term (20%), End-Term (40%), Project (20%)			

Course Details:

Overview of Transformations, Projections, Curves, Surfaces and Solids. **[6H]**
 Mathematical representations: Intrinsic and Parametric representations, Differential Geometry applied to Curve and Surface Design. **[6H]**
 Curves: Non uniform B-Spline (NUB) Curve Models, Rational Curves, Non Uniform Rational B-spline (NURB), Properties of Bezier curves. Manipulation of Curves. **[6H]**
 Surfaces: Sculptured, Coons patches, Rational Parametric, NUB, NURB, Polygonal and Quadric Representation of Surfaces. Blending of Surfaces, Curves on Surfaces, Surface with Irregular Boundaries, Manipulation of Surfaces. **[6H]**
 Design of curves and surfaces. Analytical and Relational Properties of Curves and Surfaces; Curves and Surfaces in Solids; Plane, Curve, Surface Intersections. Evaluation of some methods of Geometric Modeling. **[6H]**
 Mathematical Models of Solids, Constructive Solid Geometry, Boundary Representation, Non-Manifold Geometry, Global Properties of Solid Model. **[6H]**
 Applications in product design, analysis and manufacturing e.g. sheet metal working, tool design, mechanical components, etc. Applications in Assembly, Design of volumes. Intersection of surface and interference of volumes, Shape Grammar. **[6H]**

Suggested Textbooks:

1. Michael E. Mortenson, Geometric Modeling, Industrial Press Inc. Edition: 3rd

References:

1. Ibraheim Zeid, CAD/CAM: Theory and Practice, TMH. Revised First Edition
2. I.D. Faux and M.J. Pratt, Computation Geometry for Design and Manufacture, John Wiley (Ellis Horwood Ltd.).
3. Choi, B.K, Surface Modeling for CAD/CAM, Elsevier.
4. Farin, Gerald, Curves and Surfaces for Computer Aided Geometric Design – A Practical Guide, Academic Press Inc.
5. Kunwoo Lee, Principles of CAD/CAM/CAE systems, Addison Wesley.
6. Yamaguchi, Curves and Surfaces in Computer Aided Geometric Design, Springer.

Course Title	:	Geometric Modelling Lab			
Course Code	:	ME590	Course Type	:	Lab
Contact Hours	:	L- 0 T- 0 P- 2	Credit	:	2
Program/Semester	:	M. Tech./ Semester-I			
Pre-requisites	:	None			
Evaluation Scheme	:	Lab work (50%), Project (50%)			

Course Details:

- 1. Introduction to Solid Modelling** (Getting familiar with user-interface of CAD environment)
- 2. Solid Modelling from 2D Detailed Drawing** (Commands to be used: Extrude, extrude cut, smart dimensions, circle, line, revolve, plane, etc.)
- 3. Modelling of Sheet Metal Components** (Creating a base flange, Adding a miter flange, Mirroring the part and creating new bends, Adding an edge flange and editing its sketch profile Mirroring a feature, Adding and bending a tab, Adding a cut across a bend, Folding and unfolding bends, creating a closed corner)
- 4. Modelling of Machine Components** (Creating assembly components with dimensional features)
- 5. Assembly of Machine Components** (Creating assemblies and sub-assemblies of components)
- 6. Macros** (Assembly automation of components. Task to do: Creating a macro file, creating a macro button, editing macro file by editing the coordinates in Visual basic code, creating models using macros.)
- 7. Motion Study** (Simulation of mechanism)
- 8. Rendering of Solid Models** (Adding graphical attributes to modelled components)
- 9. Geometric Modelling of day to day use components**
- 10. Point Cloud to Surface Modelling** (Creating 3D model from point cloud data)

Suggested Textbooks:

References:

Course Title	:	NC-CNC Machine Tools and Programming			
Course Code	:	ME611	Course Type	:	Compulsory/Elective
Contact Hours	:	L- 3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech.			
Pre-requisites	:	None			
Evaluation Scheme	:	Mid Sem Exam (25%), End Sem Exam (40%), Quizzes/Programming Assignment (15%) and Programming/Automation Project (20%)			

Course Details:

Automation

Types of automation, Programmed Automation, History of Numerical Control, Components of NC: Punched Tape, MCU, Processing Unit, Axis Designation, NC Motion Control: PTP, Straight cut, Contouring NC Coding System: EIA & ISO format, Application Numerical Control, Advantages, & Disadvantages, Adoptive Control System [5H]

Computer Numerical Control

Block Diagram of CNC operations, Positioning System: Open loop and Closed loop System, Precision in NC Positioning: Control resolution, Accuracy, Repeatability [8H]

Part Programming

Procedures Associated with part programming, Cutting process parameter selection, Process planning issues and path planning, Part programming formats, G & M Codes, Interpolations, Canned Cycles and Subprograms, Tool Compensations [12H]

CNC Hardware Basics

Machines Structure, Guidways: Requirements, types and design features, Actuation systems: Ball Screws, Introduction of Servo and Stepper Motors, Feedback devices: Encoder, Optical grating, Resolvers, Inductosyn [5H]

Modern CNC Systems

Indexable carbide tools, Modular Tooling & Tool Presetting, Machining Centers, Automatic tool changers [2H]

Computer Aided Part Programming

APT Programming, Part Program Generation through ProE/DeICAM, Post Processors [5H]

Computations for part programming

Segmentations of free form curves, Consideration for INTOL and OUTTOL, Part programming for Bezier and B-spline Curves, Generating part program from CAD drawings [5H]

Suggested Textbooks:

1. Rao P N.,||CAD/CAM Principles and Practicel, Tata McGraw-Hill

References:

1. Robert Quesada, T. Jeyapoovan, —Computer Numerical Control : Machining Center and Turning Centers| , Tata McGraw-Hill
2. S K SINHA,||CNC Programming|, Galgotia Pubs.
3. CNC Machine Manuals
4. Chang, Wysk and Wang, Computer Aided Manufacturing, Prentice Hall International. 3rd Edition
5. Kochan D., CAM: Developments in Computer Integrated Manufacturing System, Springer Verlag.

6. Chang, T.C., An Introduction to Automated Process Planning Systems, Prentice Hall International.
7. Kundra, Rao and Tiwari, Numerical Control and CAM, TMH.
8. Koren, Computer Control of Manufacturing Systems, TMH.
9. Kochan D., Integration of CAD/CAM, North Holland.

Course Title	:	Geometric Programming Lab			
Course Code	:	ME591	Course Type	:	Lab
Contact Hours	:	L- 0 T- 0 P- 2	Credit	:	2
Program/Semester	:	M. Tech./ Semester-II			
Pre-requisites	:	None			
Evaluation Scheme	:	Lab work (50%), Project (50%)			
Course Details:					
<ol style="list-style-type: none"> 1. Drawing basic shapes in OPEN GL/MATLAB 2. Implementing transformations 3. Calculating area of polygon, finding intersections of lines 4. Plotting and manipulation of Bezier curves, Curves trimming and sub division 5. Implementation of Boolean operations on 2D Polygons 6. Extracting coordinates of geometric model from...IGES, DXF, STL, STEP..... 7. Finding Intersection of triangle with plane 8. Finding cross section contour of STL file 9. Finding Missing facets in STL file 10. Implementation of De Casteljaou's algorithm for drawing or subdividing Bezier curve 11. Voronoi Diagram and Delaunay triangulation 12. Plotting and manipulation of NURBS, defining conic sections as NURBS, Combining synthetic and analytic curves, 					
Suggested Textbooks:					
References:					

ELECTIVES

Course Title	:	Rapid Product Development Technologies			
Course Code	:	ME612	Course Type	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech.			
Pre-requisites	:	None			
Evaluation Scheme	:	Mid Sem Exam (20%), End Sem Exam (40%), Quizzes/Programming Assignment (20%) and Programming/Automation Project (20%)			

Course Details:

Overview of Rapid Product Development:

Product Developing Cycle, Components of RPD, Classification of manufacturing processes. Preprocessing: Solid Modeling, Data exchange formats, STL file format, RP Preprocessing. **[4 H]**

Rapid Prototyping (RP):

Introduction to RP, Need of RP; Basic Principles of RP, Steps in RP, Process chain in RP in integrated CAD-CAM environment, Advantages of RP, Classifications of different RP techniques, Selection of RP processes, Issues in RP, Emerging trends. **[8 H]**

RP Techniques:

Solid RP, liquid RP techniques and Powder RP Techniques - Process Technology and Comparative study of Selective laser sintering, Selective powder binding, etc. **[10 H]**

Rapid Tooling (RT):

Introduction to RT, Indirect RT processes – silicon rubber molding, epoxy tooling, spray metal tooling and investment casting. Direct RT processes – laminated tooling, powder metallurgy based technologies, welding based technologies, direct pattern making, emerging trends in RT. **[5 H]**

Reverse Engineering:

Geometric data acquisition, 3D reconstruction. **[5 H]**

Applications and case studies:

Engineering applications, Medical applications **[5 H]**

Special Topic on RP:

Programming in RP, Modelling, Slicing, Internal Hatching, Surface Skin Fills, Support Structure. Overview of the algorithms for RP&T and Reverse Engineering. **[5 H]**

Suggested Textbooks:

1. Chua, C.K., Leong, K.F., Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley and Sons Inc., 2000.

References:

1. Pham, D.T., Demov, S.S., Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer-Verlag London Limited, 2001.
2. Hopkinson, N., Hague, R.J.M. and Dickens, P.M., Rapid Manufacturing and Industrial Revolution for the Digital Age, John Wiley and Sons Ltd, Chichester, 2005.
3. Noorani, R., Rapid Prototyping: Principles and Applications, John Wiley & Sons, Inc., New Jersey, 2006.

4. Zeid, I., Mastering CAD/CAM, Tata McGraw Hill, 2006
5. Gebhardt, A., Rapid Prototyping, Hanser Gardner Publications, Inc., Cincinnati, 2003.
6. Gibson, I., Software Solutions for Rapid Prototyping, Professional Engineering Publication Ltd., 2002.
7. Patri, K. V., and Weiyin, Ma, Rapid Prototyping - Laser-based and Other Technologies, Kluwer Academic Publishers, U.S.A., 2003.
8. Rapid Prototyping Journal
9. Journal of Virtual and Physical Prototyping
10. Selected papers from International Journal of Machine Tools and Manufacture, International Journal of Advanced Manufacturing Technology, Computer Aided Design, Computer Aided Design and applications, etc.
11. Mortenson, M.E., Geometric Modelling, John Wiley and Sons, Inc., 1997
12. Saxena, A., Sahay, B., Computer Aided Engineering Design, Anamaya Publishers, New Dehi, 2005
13. Rogers, D.F and Adams, J.A., Mathematical Elements for Computer Graphics, Tata McGraw Hill, 2002.
14. Zeid, I., CAD/CAM: Theory and Practice, Revised First Edition, Tata McGraw Hill, 2007.
15. Faux, I. D. and Pratt, M. J., Computation Geometry for Design and Manufacture, John Wiley (Ellis Horwood Ltd.), 1983.
16. Venuvinod, P.K. and Ma, W., Rapid prototyping: Laser based and other technologies, Kluwer Academic Publishers,2004.
17. Gibson, I., Advanced Manufacturing Technology For Medical Application, John Wiley & Sons,Singapore,2005.
18. Kamrani, A.K. and Nasr, E.A., Rapid Prototyping Theory And Practice , Springer,USA ,2006.
19. Hilton, P.D. and Jacobs, P.F., Rapid Tolling: Technologies and Industrial Applications, Dekker,New York ,2005.
20. Bidanda, B. and Bartolo, P., Virtual Prototyping & Bio Manufacturing In Medical Applications, Springer, USA ,2008.

Course Title	:	Computer Integrated Manufacturing Systems			
Course Code	:	ME615	Course Type	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech.			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz (20%), Mid-Term (30%), End-Term (50%)			
Course Details:					
<p>Introduction: Production Systems; Automation in Production Systems; Manual Labor in Production Systems; Automation Principles and Strategies [3 H] Manufacturing Operations: Manufacturing Industries and Products; Manufacturing Operations; Production Facilities; Product/Production Relationships; Lean Production [3 H] Manufacturing Models and Metrics: Mathematical Models of Production Performance; Manufacturing Costs [3 H] Material Transport Systems: Introduction to Material Handling Equipment; Material Transport Equipment; Analysis of Material Transport Systems [3 H] Storage Systems: Storage System Performance and Location Strategies; Conventional Storage Methods and Equipment; Automated Storage Systems; Engineering Analysis of Storage Systems. [3 H] Introduction to Manufacturing Systems: Components of a Manufacturing System; Classification of Manufacturing Systems; Overview of the Classification Scheme [3 H] Single-Station Manufacturing Cells: Single Station Manned Workstations; Single Station Automated Cells; Applications of Single Station Cells; Analysis of Single Station Cells [3 H] Manual Assembly Lines: Fundamentals of Manual Assembly Lines; Analysis of Single Model Assembly Lines; Line Balancing Algorithms; Mixed Model Assembly Lines; [3 H] Workstation Considerations; Other Considerations in Assembly Line Design; Alternative Assembly Systems [3 H] Automated Production Lines: Fundamentals of Automated Production Lines; Applications of Automated Production Lines; Analysis of Transfer Lines. [2 H] Automated Assembly Systems: Fundamentals of Automated Assembly Systems; Quantitative Analysis of Assembly Systems. [2 H] Cellular Manufacturing: Part Families; Parts Classification and Coding; Production Flow Analysis; Cellular Manufacturing; Applications of Group Technology; Quantitative Analysis in Cellular Manufacturing. [3 H] Flexible Manufacturing Systems: What is a Flexible Manufacturing Systems; FMS Components; FMS Applications and Benefits; FMS Planning and Implementation Issues; Quantitative Analysis of Flexible Manufacturing Systems. [3 H] Quality Programs for Manufacturing: Quality in Design and Manufacturing; Traditional and Modern Quality Control; Process Variability and Process Capability; Statistical Process Control; Six Sigma; The Six Sigma DMAIC Procedure; Taguchi Methods in Quality Engineering; ISO 9000. [3 H] Inspection Principles and Practices: Inspection Fundamentals; Sampling vs. 100% Inspection; Automated Inspection; When and Where to Inspect; Quantitative Analysis of Inspection [2 H]</p>					
Suggested Textbooks:					
1. Computer Integrated Manufacturing by James A. Rehg (Author), Henry W. Kraebber (Author)					
References:					

Course Title	:	Computational Fluid Dynamics			
Course Code	:	ME636	Course Type	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech.			
Pre-requisites	:	None			
Evaluation Scheme	:	Assignment (10%), Quizzes (20%), Project (20%), Mid-sem (15%) and End-sem (35%)			

Course Details:

1. Review of equations governing fluid flow and heat transfer, common boundary conditions. [3 H]
2. Review of Matrix inversion techniques. [3 H]
3. Finite-difference method, discretisation and numerical solutions. [4 H]
4. 1-D steady-state conduction problem, tridiagonal matrix solution. [3 H]
5. 2-D steady-state conduction problem, Line-by-line method. [3 H]
6. Time-stepping, explicit and implicit schemes. [3 H]
7. 2-D unsteady conduction problems, explicit scheme. [4 H]
8. Implicit scheme, Gauss-Seidel algorithm, ADI. [3 H]
9. Wave-equation discretisation, Upwind and other convective schemes. [2 H]
10. Dispersion and dissipation errors, stability and consistency. [3 H]
11. Vorticity-streamfunction formulations [3 H]
12. Navier-Stokes Equations- SMAC schemes. [3 H]
13. Finite Volume Method [3 H]
14. Operator-Splitting Algorithm [3 H]

Suggested Textbooks:

1. Computational Fluid Flow and Heat Transfer, Eds K. Muralidhar and T. Sundararajan, Narosa, India.

References:

1. Computer Simulation of Flow and Heat Transfer, P.S. Ghoshdastidar, Tata McGraw Hill.
2. Computational Fluid Flow and Heat Transfer, Tannehill, Anderson & Pletcher, Taylor & Francis Series
3. Computational Methods for Fluid Dynamics, Ferziger & Peric, Springer

Course Title	:	Engineering Optimization			
Course Code	:	ME681	Course Type	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech.			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz (20%), Mid-Term (30%), End-Term (50%)			

Course Details:

Classical Optimization method

Single variable optimization; Multi variable optimization with no constraints (semidefinite case, saddle point), with equality constraints (solution by direct substitution, method of constrained variation, method of Lagrange multipliers), with inequality constraints (Kuhn-Tucker conditions, constraint qualification); Convex programming problem, NLP: One dimensional minimization methods **[8 H]**

Elimination methods: Interval halving method; Fibonacci method; Golden section method **[5 H]**

Interpolation method: Direct root methods (Newton method, quasi-Newton method, secant method), NLP: Unconstrained optimization techniques **[4 H]**

Direct search methods: Random search; Grid search; Univariate; Pattern directions; Hooke and Jeeves' method; Powell (conjugate directions, algorithms); Rosenbrocks; Simplex (Reflection, Expansion, Contraction) **[5 H]**

Indirect search methods: Gradient of a function; Steepest descent (Cauchy); Conjugate gradient (Fletcher-Reeves); Newton's; Marquardt; Quasi-Newton (Variable metric); Davidon-Fletcher-Powell; Broydon-Fletcher-Goldforb-Shanno; NLP: Constrained optimization techniques **[5 H]**

Direct methods: Random search method; Sequential linear programming; Feasible directions (basic approach); Feasible directions (Zoutendijk's method); Rosen's gradient projection; Generalized reduced gradient; Sequential quadratic programming **[4 H]**

Indirect methods: Transformation techniques; Penalty function method (basic approach); Interior penalty function method; Convex programming; Exterior penalty function; Interior penalty function method (Extrapolation technique); Penalty function method (Mixed equality and inequality constraints); Penalty function method (Parametric constraints); Augmented Lagrange multiplier method; Checking convergence; Integer programming (IP) **[6 H]**

Integer linear programming: Graphical representation; Gomory's cutting plane; Bala's algorithm for 0-1 programming **[2 H]**

Integer nonlinear programming: Integer polynomial programming; Branch and bound method; Sequential linear discrete programming; Generalized penalty function method **[3 H]**

Suggested Textbooks:

1. Engineering Optimization: Theory and Practice by SS Rao

References:

Course Title	:	MEMS: Microfabrication and Application			
Course Code	:	ME686	Course Type	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech.			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz (10%), Mid-Term (30%), End-Term (40%), Project (20%)			

Course Details:

Introduction: The History of MEMS Development; The Intrinsic Characteristics of MEMS; Devices: Sensors and Actuators; Scaling Laws. **[2H]**

Materials for MEMS: Silicon-Compatible Material System; Other Materials and Substrates; Important Material Properties and Physical Effects. **[5H]**

Processes for Micromachining: Basic Processing Tools; Advanced Process Tools; Nonlithographic Microfabrication Technologies; Combining the Tools—Examples of Commercial Processes. **[15H]**

Review of Essential Electrical and Mechanical Concepts: Conductivity of Semiconductors; Crystal Planes and Orientations; Stress and Strain; Flexural Beam Bending Analysis Under Simple Loading Conditions; Torsional Deflections; Intrinsic Stress; Dynamic System, Resonant Frequency, and Quality Factor; Active Tuning of Spring Constant and Resonant Frequency. **[8H]**

MEM Structures and Systems in Industrial and Automotive Applications: General Design Methodology; Techniques for Sensing and Actuation; Passive Micromachined Mechanical Structures; Sensors and Analysis Systems; Actuators and Actuated Microsystems **[6H]**

MEM Structures and Systems in Photonic Applications: Imaging and Displays; Fiber-Optic Communication Devices; **[2H]**

MEMS Applications in Life Sciences: Microfluidics for Biological Applications; DNA Analysis; Microelectrode Arrays. **[2H]**

Suggested Textbooks:

1. N. Maluf, K. Williams, “An Introduction to Microelectromechanical Systems Engineering”, 2e, Artech House, Massachusetts, 2004.
2. C. Liu “*Foundations of MEMS*”, 2e, Pearson Education, New Jersey, 2012.

References:

1. T.R. Hsu “*MEMS And Microsystems: Design And Manufacture*”, McGraw Hill Education, New Delhi 2002.
2. N. P. Mahalik, “*MEMS*”, McGraw Hill Education, New Delhi 2007.

Course Title	:	Smart Materials and Structures			
Course Code	:	ME687	Course Type	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech.			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz (20%), Mid-Term (20%), End-Term (40%), Project (20%)			

Course Details:

Introduction to smart materials and their applications; Piezoelectric, magnetostrictive, and electrostrictive materials. Shape memory alloys, electrorheological and magnetorheological fluids. [10 H]

Piezoelectric Material Systems: Fundamentals of Piezoelectricity, Piezoelectric Actuators and Sensors: Principle, working and modeling; Piezoelectric Beams and Plates: Modeling and analysis. [8 H]

Shape Memory Alloys: Fundamentals of SMA Behavior; Constitutive Modeling, Actuation Models of Shape Memory Alloys [8 H]

Electroactive Polymer Materials: Classification of Electroactive Polymers; Actuator and Sensor Equations of Ionomeric Polymer Transducers. [8 H]

Applications of Smart Materials such as Energy Harvesting, MEMS and NEMS, Active vibration Control. [8H]

Suggested Textbooks:

1. Vijay K. Varadan, K. J. Vinoy, S. Gopalakrishnan, Smart Material Systems and MEMS: Design and Development Methodologies, Wiley, 2006

References:

- I. Donald J. Leo, Engineering analysis of smart material systems, John Wiley Sons, Inc., 2007.
- II. A V Srinivasan and D Michael McFarland, —Smart Structures – Analysis and Design, Cambridge University Press, 2001.
- III. Inderjit Chopra and Jayant Sirohi, Smart Structures Theory, Cambridge University Press, 2014.

Course Title	:	Fuzzy Logic & Neural Networks			
Course Code	:	EC661	Course Type	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech.			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10-15%), Mid-Term (20-40%), Quiz II (10-15%), End-Term (40-60%), Assignment (0-20%)			

Course Details:

Classical sets – Fuzzy sets – Membership functions – Fuzzy relations – Knowledge base – Fuzzification– Fuzzy rules – Decision-making logic – Defuzzification. Mamdani and Takagi-Sugeno architectures of Fuzzy inference system. Fuzzy Logic Controllers. [18H]

Introduction to Neural Networks – Artificial neuron – Neuron modelling, Multi-layer feed forward network – Learning Techniques and algorithms - Error back-propagation, generalized delta rule. Radialbasis function networks. [18H]

Adaptive Neuro-Fuzzy Inference System (ANFIS). [4H]

Engineering applications of Fuzzy Logic system. [2H]

References:

1. T. J. Ross, 'Fuzzy Logic with Engineering Applications', Tata McGraw Hill, 1997.
2. J. M. Zurada, 'Introduction to Artificial Neural Systems', Jaico Publishing home, 2002.
3. Simon Haykin, 'Neural Networks', Pearson Education, 2003
4. John Yen & Reza Langari, 'Fuzzy Logic – Intelligence Control & Information', Pearson Education, New Delhi, 2003.
5. J.S.R. Jang, C.T. Sun, and E. Mizutani, "Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence", Prentice Hall, 1996.

Course Title	:	Industrial Instrumentation & Metrology			
Course Code	:	ME651	Course Type	:	Elective
Contact Hours	:	L-3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech. / Semester-I/II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (5%), Mid-Term (35%), Quiz II (10%), End-Term (50%),			
Course Details:					
<p>Theory and Experimentation in Engineering: Problem solving approaches, Types of engineering experiments, computer simulation and physical experimentation; Generalized measuring system, types of inputs, analog and digital signals, standards, calibration and uncertainty (4H) Measurement System: Performance characteristics, static performance characteristics-static calibration-linearity, static sensitivity, repeatability, hysteresis threshold-resolution, readability and span (3H) Analysis of Experimental Data : Causes and types of experimental error, un-certainty analysis, statistical analysis of data, probability distributions and curve fitting; Dynamic performance characteristics; Input types; Instrument types- zero order instrument, first order instrument, second order instrument (3H) Measurement of pressure; Flow measurement and flow visualization; measurement of temperature; optical methods of measurements; Data Acquisition and Processing (15H) Types and configurations of DAS, signal conditioning, A/D, D/A conversion; Design, Planning, Execution and Analysis of experimental projects (8H) Measurement of Acceleration, Vibration And Density Accelerometers - LVDT, Piezoelectric, Strain gauge and Variable reluctance type accelerometers - Mechanical type vibration instruments - Seismic instruments as accelerometer – Vibration sensor - Calibration of vibration pickups - Units of density and specific gravity – Baume scale and API scale - Pressure type densitometers - Float type densitometers – Ultrasonic densitometer - gas densitometer. (8H) Metrology: Measurement of length, measurement of angle, Measurement of geometric forms, straightness, flatness, roundness etc. Mechanical and optical methods. Measurement of screw threads and gears. Measurement of surface roughness and texture. Introduction to CMM. In-process gages. Inspection and quality monitoring. (4H)</p>					
Suggested Textbooks:					
<ol style="list-style-type: none"> 1. Mechanical Measurements by S.P. Venkateshan ,IIT, Madras, Ane Books Pvt. Ltd, 4821, Parwana Bhawan, 1st Floor, 24 Ansari Road, Darya Ganj, New Delhi - 110 002. 2. Engineering Metrology by R.K. Jain, Khanna Publishers, New Delhi, 1997 					
Reference					
<ol style="list-style-type: none"> 1. E.O. Doebelin, Measurement systems- Applications and Design, 4th Ed., Tata McGraw-Hill, 1990. 2. T.G. Beckwith, R.D. Marangoni and J.H. Lienhard, Mechanical Measurements, 5th Ed., Addison Wesley, 1993. 3. Holman, Experimental Methods for Engineers, 6e, McGraw-Hill, 1994. 					

M.Tech. in ME (Design)

Semester I			
Sl. No	Course No	Course Title	Credits
1	HS501(Core)	Professional and Communication Skills	1-0-2-2
2	ME581(Core)	Analytical Methods in Engineering	3-0-0-4
3	ME621(Core)	Advanced Mechanics of Solids	3-0-0-4
4	ME631(Core)	Mechanical Vibrations and Condition Monitoring	3-0-0-4
5	Elective I		3-0-0-4/2-0-0-3
6	ME592L	Design Lab I	0-0-3-2
Semester II			
1	ME535(Core)	Finite Element Methods for Mechanical Engineering	3-0-0-4
2	Elective II		3-0-0-4
3	Elective III		3-0-0-4
4	Elective IV		3-0-0-4
5	ME593L	Design Lab II	0-0-3-2
Semester III			
1.	ME598	Graduate Seminar I	2
2.	ME699	M.Tech Thesis	16
Semester IV			
1.	ME599	Graduate Seminar II	2
2.	ME699	M.Tech Thesis	16

Electives

1	ME589	Research Methodology	2-0-0-3
	ME601	Computer aided Geometric Design	3-0-0-4
2	ME612	Rapid Product Development Technologies	3-0-0-4
3	ME622	Fracture and Fatigue	3-0-0-4
4	ME623	Mechanics of Composite Laminates	3-0-0-4
5	ME624	Reliability of Mechanical Systems	3-0-0-4
6	ME632	Fault Diagnosis and Prognosis of Engineering Systems	3-0-0-4
7	ME636	Computational Fluid Dynamics	3-0-0-4
8	ME675	Thermal Aspects in Manufacturing	3-0-0-4
9	ME681	Engineering Optimization	3-0-0-4
10	ME685	Robotics and Intelligent Systems	3-0-0-4
11	ME686	Micro Electromechanical Systems (MEMS)	3-0-0-4
12	ME687	Smart Materials and Structures	3-0-0-4
13	EC661	Fuzzy logic and Neural Networks	3-0-0-4
14	MT603	Sensor and Actuators	3-0-0-4

Electives in Modular form (Common with CSE)

1.	EM601d	Parallel Processing	1-0-0-1
2.	EM601h	Dependable Computing	1-0-01
3.	EM602d	Artificial Intelligence and its Applications	1-0-0-1
4.	EM608a	Modelling and Simulation	1-0-0-1
5.	EM608b	Graphical Models	2-0-0-2
6.	EM609c	Speech and Music Signal Processing	1-0-0-1

CORE COURSES

Course Title	:	ADVANCED MECHANICS OF SOLIDS			
Course Code	:	ME621	Course Type	:	Compulsory/ Elective
Contact Hours	:	L- 3 T- 1 P- 0	Credit	:	4
Program/Semester	:	M. Tech. / Semester-I			
Pre-requisites	:	ME202			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End-Term (40%) Project (20%)			

Course Details:

Analysis of Stresses and Strains in rectangular and polar coordinates: Cauchy's formula, Principal stresses and principal strains, 3D Mohr's Circle, Octahedral Stresses, Hydrostatic and deviatoric stress, Differential equations of equilibrium, Plane stress and plane strain, compatibility conditions. Introduction to curvilinear coordinates. **[8 H]**

Generalized Hooke's law and theories of failure. Energy Methods. **[5 H]**

Bending of symmetric and unsymmetric straight beams, effect of shear stresses, Curved beams, Shear center and shear flow, shear stresses in thin walled sections, thick curved bars. **[8 H]**

Torsion of prismatic solid sections, thin walled sections, circular, rectangular and elliptical bars, membrane analogy. **[8 H]**

Thick and thin walled cylinders, Composite tubes, Rotating disks and cylinders. **[6 H]**

Euler's buckling load, Beam Column equations. **[4 H]**

Strain measurement techniques using strain gages, characteristics, instrumentations, principles of photo-elasticity. **[3 H]**

Suggested Textbooks:

- I. L. S. Srinath, Advanced Mechanics of Solids, 2nd Edition, TMH Publishing Co. Ltd., New Delhi, 2003
- II. Beer, Johnson, et al, Mechanics of Material, 7th Edition, Tata McGraw Hill Publishing Co., 2016

References:

1. R. G. Budynas, Advanced Strength and Applied Stress Analysis, 2nd Edition, McGraw Hill Publishing Co, 1999.
2. A. P. Boresi, R. J. Schmidt, Advanced Mechanics of Materials, 5th Edition, John Willey and Sons Inc, 1993.
3. S. P. Timoshenko, J. N. Goodier, Theory of Elasticity, 3rd Edition, McGraw Hill Publishing Co. 1970.
4. P. Raymond, Solid Mechanics for Engineering, 1st Edition, John Willey & Sons, 2001.
5. J. W. Dally and W. F. Riley, Experimental Stress Analysis, 3rd Edition, McGraw Hill Publishing Co., New York, 1991

Course Title	:	MECHANICAL VIBRATIONS AND CONDITION MONITORING			
Course Code	:	ME631	Course Type	:	Compulsory
Contact Hours	:	L- 3 T- 0 P- 2	Credit	:	5
Program/Semester	:	M. Tech. / Semester-I			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (15%), Quiz II (10%), Lab (15 %), End-Term (35%) Project (15%)			

Course Details:

Review of Free and forced vibrations of single degree of freedom system. Vibration isolation and transmissibility, Vibration measuring instruments. **[6 H]**

Multi Degrees of freedom systems, Introduction, Influence co-efficient, Maxwell reciprocal theorem, Automobile vehicle suspension, coupling, Vibration absorbers, Various numerical methods for solution of multi degree of freedom systems. **[10 H]**

Whirling of shafts with and without air damping. Discussion of speeds above and below critical speeds. **[4 H]**

Vibration of Continuous Systems: Introduction, vibration of string, longitudinal vibration of rods, torsional vibration of rods, Euler's equation for beams, simple problems. **[6 H]**

Non-linear vibration, Phase Plane, Conservative systems, Stability of equilibrium. The Duffing Oscillator. **[6 H]**

Introduction to condition monitoring of machinery, Condition monitoring methods, Types and Benefits of Vibration Analysis. Vibration Signals from Rotating and Reciprocating Machines. Signal Classification, Stationary and Cyclostationary signals. **[10 H]**

Experiment:

1. Whirling of shaft
2. Simulation of multi-degree of freedom system on MATLAB
3. Simulation of continuous system on MATLAB
4. Study of Force Vibration due to rotary unbalance
5. Study of Force Vibration due to base excitation
6. Vibration measurement on shaker and comparison of input and output
7. Study and measurement of engine vibration
8. Study and measurement of vibration on bearing test rig.
9. Study and measurement of vibration on gear test rig.
10. Simulation of nonlinear vibration of pendulum

Suggested Textbooks:

1. Rao, S. S., Mechanical Vibrations, Fourth Edition, Addison Wesley, 2004.
2. Inman, Mechanical Vibrations, Second Edition, Pearson, 2015

References:

1. Randall. R.B., Vibration-Based Condition Monitoring: Industrial, Aerospace and Automotive Applications, Wiley, United Kingdom, 2011.

2. Caollacott, R. A.; Chapman, Mechanical Fault Diagnosis and Condition Monitoring, Chapman and hall, 1977.
3. Rao, J. S., Advanced Theory of Vibration, Wiley Eastern Ltd. New Delhi, 1992.

Course Title	:	DESIGN LAB I			
Course Code	:	ME592	Course Type	:	Lab
Contact Hours	:	L- 0 T- 0 P- 2	Credit	:	2
Program/Semester	:	M. Tech. / Semester-I			
Pre-requisites	:	None			
Evaluation Scheme	:	LAB (100%)			
Course Details:					
I. Exercise on programming in Matlab/ Scilab – 2 Turns II. Exercise on Modeling in Solidworks – 2 turns III. Bending and Torsion analysis using Strain Gauge – 2 turns IV. Determining first three modes of the cantilever beam theoretically and experimentally – 2 turns V. Modelling of real system in CATIA and harmonic and transient analysis (3 turns) VI. Design Project					
Suggested Textbooks:					
References:					

Course Title	:	FINITE ELEMENTS METHODS FOR MECHANICAL ENGINEERING			
Course Code	:	ME535	Course Type	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech. / Semester-II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (20%), Quiz II (10%), End-Term (40%) Project (20%)			

Course Details:

Introduction to FEM

Need of finite element method, process of finite element method, field and boundary conditions, steps involved in fem, weighted residual methods, virtual work as the 'weak form' of equilibrium equations for analysis of solids or fluids, variational principles, establishment of natural variational principles for linear, self-adjoint differential equations, maximum, minimum, or a saddle point, constrained variation principles, lagrange multipliers and adjoin functions. [12 H]

Plane Strain and Stress

Introduction, two – dimensional elements, completeness of polynomials, rectangular elements – lagrange family, rectangular elements – ‘serendipity’ family, triangular element family- CST and LST Elements. [6 H]

Errors and Accuracy

Error, mistakes and accuracy. Convergence criteria, discretization error and convergence rate, non-conforming elements and the patch test. [3 H]

Plate Bending and Shell Elements

Kirchhoff and Mindlin Elements. Full integration, reduced integration, selective reduced integration, Membrane and shear Locking. 8-noded and 9-noded elements, Heterosis Element [8 H]

Three – Dimensional Stress Analysis

Introduction, modeling of solids, tetrahedral and hexahedron elements. Axisymmetric Elements. [5 H]

Dynamic Considerations

Formulation; element mass matrices; Eigen values and eigenvectors evaluation generalized Jacobi method; tridiagonalization; implicit symmetric QR step with Wilkinson; shift for diagonalization; Guyan reduction. [6 H]

Introduction to non-linear finite element. [2 H]

Suggested Textbooks:

1. J N Reddy, An introduction to the Finite Element Method, McGraw-Hill, New York, 1993.
2. R D Cook, D S Malkus and M E Plesha, Concepts and Applications of Finite Element Analysis, 3 ed., John Wiley, New York, 1989.

References:

1. K J Bathe, Finite Element Procedures in Engineering Analysis, Prentice-Hall, Englewood Cliffs, NJ, 1982.
2. T J T Hughes, The Finite Element Method, Prentice-Hall, Englewood Cliffs, NJ, 1986.
3. O C Zienkiewicz and R L Taylor, The Finite Element Method, 3d ed. McGraw-Hill, 1989

Course Title	:	DESIGN LAB II			
Course Code	:	ME593	Course Type	:	Lab
Contact Hours	:	L- 0 T- 0 P- 2	Credit	:	2
Program/Semester	:	M. Tech. / Semester-II			
Pre-requisites	:	None			
Evaluation Scheme	:	LAB (100%)			
Course Details:					
I. Exercise on mechanism design and analysis in ADAMS – 2 Turns II. Exercise on Dynamic analysis of Car in ADAMS – 2 Turns III. Exercise on Modeling & analysis in hyperworks – 2 Turns IV. Exercise on analysis (static, modal, harmonic, transient, non-linear and impact analysis) using finite element software such as Ansys, Hyperworks, Nastran or ABAQUS) – 4 Turns V. Design Project					
Suggested Textbooks:					
References:					

ELECTIVES

Course Title	:	Fracture and Fatigue			
Course Code	:	ME622	Course Type	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech.			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz (20%), Mid-Term (30%), End-Term (50%)			
Course Details:					
Fracture:					
History and overview of Fracture Mechanics; Structural failure and design philosophies; Ductile and brittle fracture of materials; The fracture mechanics approach to design; Griffith's theory of brittle failures; Irwin's stress intensity factors. [8 H]					
LEFM; Stress concentration, Energy balance criteria, stress intensity factor, crack tip plastic zone, crack resistance, K_{Ic} , the critical value, Relation of G&K, K_{Ic} measurement. EPFM: Fracture beyond yield, CTOD, experimental determination of CTOD, use J integrals and measurement of J_{Ic} and JR. Fracture Toughness measurement: Standards and its application in design. [12 H]					
Fatigue crack propagation: Fatigue crack growth theories, crack closure, Microscopic theories of fatigue crack growth; Application of theories of fracture mechanics in design and materials development. [12 H]					
Fatigue Introduction / Characteristics of Fatigue Fracture / Evaluation of Fatigue Resistance / Fatigue-Crack Growth Rates / Design against Failure / Cyclic Stress-Strain Behavior / Creep-Fatigue Interactions / Polymeric Fatigue / Fatigue of Composites / Summary [10 H]					
Suggested Textbooks:					
1. Fracture Mechanics: Fundamentals and Applications, Third Edition					
References:					
1. Mechanical Behavior of Materials. Second Edition. Thomas H. Courtney					
2. Mechanical Behavior of Materials: Engineering Methods for Deformation, Fracture, and Fatigue by Norman E. Dowling					

Course Title	:	Mechanics of Composite Laminates			
Course Code	:	ME623	Course Type	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech.			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz (20%), Mid-Term (25%), End-Term (40%), Project (15%)			

Course Details:

Introduction

Basic concepts and mechanical behaviour of laminated fiber-reinforced composite materials, applications to engineering structures, different types of fibers and matrices. **[8 H]**

Micromechanics

Prediction of elastic constants and strengths, mechanics of load transfer from matrix to fiber. **[8 H]**

Macromechanics

Theory of elasticity for anisotropic materials, constitutive law for laminae, transformation of stresses, strains and material properties. Constitutive law for laminates and significance of [A], [B] and [D] stiffness matrices, stress and strain analyses of laminates, failure criteria, hygrothermal stresses, bending of plane anisotropic beams, classical and first order theories of laminated composite plates, analysis of Sandwich Plates, buckling analysis of laminate composite plates, first order shear deformation theory, inter-laminar stresses and delamination. **[20 H]**

Several Aspects of Design

Composite tailoring and design issues, statics and elastic stability of initially curved and twisted composite beams, plates and sandwich structures. **[5 H]**

Suggested Textbooks:

1. R M Jones (1999), —Mechanics of Composite Materials (2nd Ed),|| Taylor and Francis, India.

References:

1. B D Agarwal, L J Broutman and K Chandrashekhara (2006), —Analysis and Performance of Fiber Composites (3rd Ed),|| John Wiley and Sons, Inc., New Delhi, India.
2. Autar K Kaw (2006), —Mechanics of Composite Materials (2nd Ed),|| Taylor and Francis, USA.
3. Reddy, J.N., Mechanics of Laminated Composite Plates and Shells – Theory and Analysis, CRC Press, 2nd Edition, 2004.

Course Title	:	RELIABILITY OF MECHANICAL SYSTEMS			
Course Code	:	ME624	Course Type	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech. / Semester-II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (35%), Quiz II (10%), End-Term (45%)			
Course Details:					
<p>Fundamentals of probability theory, Fundamentals of design of machine elements, Probabilistic models of load (stress) and resistance (strength) variables, Stress-strength interference models. (7 H)</p> <p>Reliability; basic concepts, Uncertainty in engineering systems; Uncertainty Propagation, Modeling, Multiple random variables. (7 H)</p> <p>Product failure theories, Failure models, Limit state function, Probability distribution, PDF & CDF, Evaluation of joint probability distribution, Markov Process, Stochastic Finite Element Analysis, Randomness in response variables. (10 H)</p> <p>First and higher order methods for reliability assessment, Deterministic & probabilistic approach, Risk based design, Central limit theorem, Fault tree approach (8 H)</p> <p>System reliability, Fault Tree Analysis, Monte-Carlo and other simulation techniques (5H)</p> <p>Regression analysis, Software based reliability analysis, Sensitivity analysis and reliability based design optimization, international standards, Applications & case studies. (5 H)</p>					
Suggested Textbooks:					
<ol style="list-style-type: none"> 1. H-S. Ang and W.H. Tang, Probabilistic Concepts in Engineering Planning and Design, Vol. 1: Basic Principles, J. Wiley, 1975 2. Myers, RH, Montgomery, DC and Anderson-Cook, CM (2009). "Response Surface Methodology: Process and Product Optimization Using Designed Experiments", John Wiley & Sons, Inc. 					
Reference					
<ol style="list-style-type: none"> 1. T. Bedford & R. Cooke, Probabilistic Risk Analysis, Foundations and Methods, Cambridge University Press, 2001. 2. Morgan, M. G. and Henriou, M., Uncertainty, Cambridge University Press, 1990 3. J. Evans, D. Olson, Introduction to Simulation and Risk Analysis, Prentice Hall, 1998 					

Course Title	:	FAULT DIAGNOSIS AND PROGNOSIS FOR ENGINEERING SYSTEMS			
Course Code	:	ME632	Course Type	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech. / Semester-II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (10%), Mid-Term (35%), Quiz II (10%), End-Term (45%)			

Course Details:

Introduction

Historical perspective, Diagnosis system requirements designing in Fault Diagnostic and Prognostic Systems, Diagnosis and Prognosis Functional Layers. **(8 H)**

System Approach to Condition Based Maintenance / Prognostics Health Management

Introduction trade studies CBM Test-Plan Design Performance Assessment, CBM/PHM. Impact on maintenance and Operations Sensors, Sensors Placement. **(8 H)**

Signal Processing and Database Management Systems

Signal processing in CBM/PHM, signal preprocessing, Vibration monitoring and Data Analysis, Real Time image features extraction and defect/fault classification. The Virtual sensor Fusion or Integration Technologies, Usage-Pattern Tracking. **(8 H)**

Fault Diagnosis and Prognosis

The Diagnosis framework, historical data diagnosis methods, data-driven Fault classification and decision making, Dynamic Systems Modeling, Physical Model-Based Methods. Model based reasoning, Case based reasoning (CBR). Other methods for fault diagnosis. A Diagnostic framework for Electrical/Electronic systems, Vibration based fault detection and diagnosis for Bearings. Model based prognosis techniques, probability based prognosis techniques, data driven prediction techniques. **(10 H)**

Fault Diagnosis and Prognosis Performance Metrics

Introduction CBM/PHM requirements definition features evaluation metrics, Fault Diagnosis performance metrics. Prognosis performance metrics, Diagnosis and Prognosis effectiveness metrics, Complexity/Cost benefits analysis of CBM/PHM systems. **(8 H)**

Suggested Textbooks

1. George Vachtsevanos, Frank I. Lewis, Michael Roemer, Andrew Hess, Biqing Wu, Intelligent Fault Diagnosis and Prognosis for Engineering Systems, John Wiley and Sons Ltd.

Reference

1. Bo-Suk Yang, Introduction of Intelligent Fault Diagnosis and Prognosis, Nova Science Pub.Inc.
2. Mobley, R. Keith, An Introduction to Predictive maintenance, Butterworth-Heinemann.

Course Title	:	Robotics and Intelligent Systems			
Course Code	:	ME682	Course Type	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech.			
Pre-requisites	:	Basic course on Robotics			
Evaluation Scheme	:	Quiz (20%), Mid-Term (20%), End-Term (40%), Project (20%)			

Course Details:

Introduction: Components and mechanisms of a robotic system, Robot Manipulators, Mobile Robots, Aerial Robots, Applications. **[2H]**

Review of robot manipulators: Importance and evolution of robotic manipulators, robot classifications, applications, robot specifications, Forward kinematics, Inverse kinematics, Velocity Kinematics, Manipulator Jacobian, Manipulator Dynamics: Newton-Euler formulation, Euler-Lagrange formulation. **[6H]**

Path and Trajectory Planning: Joint-space schemes, Cartesian-space schemes, configuration space, path planning using potential fields, Avoiding local minima, Probabilistic roadmap methods; Trajectory planning: PTP method, using Via points. **[6H]**

Linear Control of Manipulators: Feedback Control: Proportional, Derivative and Integral Control, PID control, regulation problem, tracking problem, model based control, trajectory-following control. **[8H]**

Nonlinear Control of Manipulators: Feed forward control, Feedback Linearization, PD control with gravity compensation, Computed torque control, Adaptive Control, Robust Control, Sliding Mode Control, Lyapunov stability analysis, Cartesian based control schemes. **[6H]**

Redundant Manipulators: Singularity and Workspace analysis, redundancy resolution, obstacle avoidance and singularity avoidance. **[4H]**

Artificial Intelligence: An overview of the field of Artificial intelligence. Neural Networks: Fundamentals, Back propagation model, Other models, control Applications. Genetic Algorithms and Evolutionary computing : Optimization Examples. Fuzzy Systems : Fundamentals; Fuzzy Control; Hybrid Systems. Rough Sets : Basics; Knowledge Extraction from data; Control Applications. Chaos; Applications. **[10H]**

Suggested Textbooks:

1. R.K. Mittal and I.J. Nagrath, Robotics and Control, McGraw Hill, 2016

References:

- I. B.Siciliano, L. Sciavicco, L. Villani, G.Oriolo, Robotics- Modelling, Planning and Control, Springer, 2009.
- II. Reza N. Jazar, Theory of Applied Robotics- Kinematics, Dynamics, and Control , Springer, 2007.
- III. M.W.Spong, S.Hutchinson and M. Vidyasagar, Robot Modelling and Control,2006.
- IV. B. Siciliano, O. Khatib (Eds), Springer Handbook of Robotics, Springer, 2008.
- V. Mark W Spong, M Vidyasagar, Robot Dynamics And Control, John Wiley and Sons,

2008.

- VI. Richard M. Murray, Zexiang Li, S. S. Sastry, A Mathematical Introduction to Robotic Manipulation, CRC Press, 1994.
- VII. Russell Stuart, Norvig Peter, “Artificial Intelligence Modern Approach”, Pearson Education series in AI, 3rd Edition, 2010.
- VIII. Dan.W. Patterson, “*Introduction to Artificial Intelligence and Expert Systems*”, PHI Learning, 2009
- IX. Gregory Dudek and Michael Jenkin, Computational Principles of Mobile Robotics, Second Edition, 2010, Cambridge University Press. (ISBN 978-0-521-69212-0 paperback or 978-0-521-87157-0 hardback)
- X. S Mahadevan and J Connell, Robot Learning, Kluwer Academic, 1993

Course Title	:	Sensors and Actuators			
Course Code	:	MT503	Course Type	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech./Ist			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz (10%), Mid-Term (20%), End-Term (40%), Lab (20%) Project (10%)			

Course Details:

INTRODUCTION: Definition – Measurement Techniques – Classification of errors – Error analysis, Static and dynamic characteristics of transducers – general requirements for interfacing and actuation – Performance Characteristics of Sensors and Actuators: Input/output characteristics, accuracy, errors, repeatability, sensitivity analysis, hysteresis, nonlinearity, saturation, frequency response, dynamic characteristics, calibration, resolution, excitation, impedance. [2H]

SENSORS: Classification of sensors – calibration techniques – Potentiometer – strain gauges – optical encoders. [2H]

INDUCTANCE AND CAPACITANCE TRANSDUCER: LVDT – RVDT – Synchro – Microsyn – Applications: Pressure, position, angle and acceleration. Capacitance circuitry – Feedback type condenser microphone – frequency modulating oscillator circuit – Dynamic capacitance variation – A.C. Bridge for Amplitude Modulation – Applications: Proximity, microphone, pressure, displacement. [2H]

MAGNETIC SENSORS & ACTUATORS: Motors as actuators (linear, rotational, AC, DC, Servo and step motors), Torque Motion Characteristics, Motor Selection and Applications. Magnetic Sensors –types, principle, requirement and advantages: Magneto resistive – Hall effect - Eddy current. Magnetostrictive sensors and actuators, Magnetometers (fluxgate, search-coil, Squid), Voice coil actuators (speakers and speaker-like actuators), Electrorheological and magnetorheological actuators, Bolometers (microwaves) [2H]

PIEZOELECTRIC SENSORS & ACTUATORS: Piezoelectric Materials and properties – Modes of deformation – Multimorphs – Environmental effects – Applications: Accelerometer, ultrasonic, Piezoelectric actuators, Piezoelectric resonators, Microphones, hydrophones, speakers, buzzers. [2H]

THERMAL SENSORS & ACTUATORS: Thermoelectric effects, temperature measurement, thermocouple, resistance temperature device (RTD), thermistor, infra red sensor, linear actuator, lateral thermal actuator, volumetric actuator, bimorph actuators and switches [2H]

Suggested Textbooks:

1. Clarence W de Silva, MECHATRONICS - An Integrated Approach, CRC Press; and
2. Alan S Morris, Measurement and Instrumentation Principles, Butterworth-Heinemann

References:

1. T.R. Hsu “MEMS And Microsystems: Design And Manufacture”, McGraw Hill Education, New Delhi 2002.
2. N. P. Mahalik, “MEMS”, McGraw Hill Education, New Delhi 2007.

M.Tech. in ME (Manufacturing)

Semester I			
Sl. No	Course No	Course Title	Credits
1.	HS501 (Core)	Professional and Communication Skills	1-0-2-2
2.	ME581 (Core)	Analytical Methods in Engineering	3-0-0-4
3.	ME541 (Core)	Manufacturing Science	3-0-0-4
4.	ME589 (Core)	Research Methodology	2-0-0-3
5.	Elective I	-	3-0-0-4
6.	ME594L	Manufacturing Processes Lab I	0-0-3-2
Semester II			
1.	ME642 (Core)	Advanced Manufacturing Processes and Technologies	3-0-0-4
2.	Elective II	-	3-0-0-4
3.	Elective III	-	3-0-0-4
4.	Elective IV	-	3-0-0-4/2-0-0-3
5.	ME595L	Manufacturing Processes Lab II	0-0-3-2
Semester III			
1.	ME598	Graduate Seminar I	2
2.	ME699	M.Tech. Thesis	16
Semester IV			
1.	ME599	Graduate Seminar II	2
2.	ME699	M.Tech. Thesis	16

Electives:

1	ME601	Computer Aided Geometric Design	3-0-0-4
2	ME611	NC-CNC Machine Tools and Programming	3-0-0-4
3	ME612	Rapid Product Development Technology	3-0-0-4
4	ME615	Computer Integrated Manufacturing Systems	3-0-0-4
5	ME621	Advanced Mechanics of Solids	3-0-0-4
6	ME535	Finite Element Methods for Mechanical Engineering	3-0-0-4
7	ME636	Computational Fluid Dynamics	3-0-0-4
8	ME645	Metal Forming	3-0-0-4
9	ME646	Nanofinishing Science and Technology	2-0-0-3
10	ME651	Industrial Instrumentation & Metrology	3-0-0-4
11	ME681	Engineering Optimization	3-0-0-4
12	ME685	Robotics and Intelligent Systems	3-0-0-4
13	ME686	Micro Electro Mechanical Systems	3-0-0-4
14	ME675	Thermal Aspects in Manufacturing	3-0-0-4

Electives in Modular form (Common with CSE)

1.	EM601d	Parallel Processing	1-0-0-1
2.	EM601h	Dependable Computing	1-0-0-1
3.	EM602d	Artificial Intelligence and its Applications	1-0-0-1
4.	EM608a	Modelling and Simulation	1-0-0-1
5.	EM608b	Graphical Models	2-0-0-2
6.	EM609c	Speech and Music Signal Processing	1-0-0-1

CORE COURSES

Course Title	:	Manufacturing Science			
Course Code	:	ME541	Course Type	:	Core
Contact Hours	:	L- 3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech. / Semester-I			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)			
Course Details:					
<p>Casting: Mechanism of Solidification, Runner and Riser Design and their placement [5H]</p> <p>Modeling and Mechanics of cutting process: Review of cutting mechanism; Thin Zone model, Lee and Shaffer's relationship, Thick zone model: Okushima and Hitomi Analysis. Cutting force model; Oblique Cutting which includes Angle relationships, Forces and Temperature analysis (Finite Difference Method); Wear model; Evaluation of surface quality; Cutting processes for producing various shapes. [5H]</p> <p>Gear machining: Hobbing [5H]</p> <p>Modelling of grinding process: Grinding force model; Temperature analysis; Wheel life model. [5H]</p> <p>Introduction of finishing process: Machining mechanism in finishing: Honing, Lapping, Super finishing, etc. [5H]</p> <p>Welding: Principles of solid and liquid phase welding processes; modes of metal transfer in arc welding; heat flow characteristics; gas metal reaction, cooling of fusion weld. [5H]</p>					
Suggested Textbooks:					
<ol style="list-style-type: none"> 1. Boothroyd, G and Knight, W A., Fundamentals of Machining and Machine Tools, 3rd Third Edition, Saint Luice Pr, 2005. 2. Ghosh, and A.K. Mallik, Manufacturing Science, Affiliated East-West Press Ltd, New Delhi, 1985. 					
References:					
<ol style="list-style-type: none"> 1. Amitabh Bhattacharya, Metal Cutting Theory & Practice 2. Sen & Bhattacharya, Metal Cutting Theory and Cutting Tool Design 3. E J A Armerago, R H Brown, Machining of Metals, Prentice Hall 					

Course Title	:	Manufacturing Processes Lab I			
Course Code	:	ME594	Course Type	:	Lab
Contact Hours	:	L- 0 T- 0 P- 3	Credit	:	2
Program/Semester	:	M. Tech. Ist sem			
Pre-requisites	:	None			
Evaluation Scheme	:	Report (30%) Exam (70%)			

Course Details:

1. To compare the metal cutting forces during orthogonal cutting using experimental and analytical techniques in turning operation.
2. To compare the metal cutting forces during orthogonal cutting using experimental and analytical techniques in milling operation.
3. To compare the metal cutting forces during orthogonal cutting using experimental and analytical techniques in drilling operation.
4. To develop a relationship between various turning operations cutting parameters using Design of Experiments (DoE) for obtaining high surface finish.
5. To find the lap-joint strength of two thin polymer sheets welded using ultrasonic welding.
6. To find the butt-joint strength of two thin aluminium plates welded using friction stir welding.
7. To find the butt-joint strength of two thin aluminium plates welded using TIG welding.
8. Introduction and application of Abrasive Water Jet Machining (AWJM) to cut thick mild steel plate.
9. Tool Condition Monitoring in drilling operation
10. Measurement of tool wear in turning operation

Suggested Textbooks:

References:

Course Title	:	Advanced Manufacturing Processes and Technologies			
Course Code	:	ME642	Course Type	:	Compulsory/Elective
Contact Hours	:	L- 3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech. / Semester II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)			

Course Details:

Unconventional Machining Processes: Electron Beam Machining (EBM), Plasma Arc Machining (PAM) Laser Beam Machining (LBM), Abrasive Jet Machining (AJM), Water Jet Cutting (WJM), Ultrasonic Machining (USM), Electro-Chemical Machining (ECM), Electric Discharge Machining (EDM), Wire EDM. [20H]

Assembly: Jigs and fixtures, principles of location and clamping, synthesis of simple jigs and fixtures. Principles of assembly, engineering theory of dimensional chains, fully interchangeable and selective assembly. [6H]

Metrology: Limits, fits and tolerance; automated inspection and CMM. Selection of Manufacturing processes for a given product. [4H]

High Speed Machining: Introduction and concepts of HSM. Issues related to HSM. Comparison with conventional manufacturing processes. [2H]

Finishing Processes: Introduction to finishing process, grinding, Lapping, Honing, Super Finishing. [4H]

Precision Manufacturing Processes: Introduction to micro fabrication processes and M4 processes: concepts of accuracy, errors, influences of dimensional wear on accuracy. [2H]

Suggested Textbooks:

1. V.K. Jain Advanced Machining processes, Allied Publishers New Delhi 2002.
2. Black S.C. Chiles, V.Lissaman, A.J. Martin, S.J. Principles of Engineering Manufactures Arnold Edn. 1996.

References:

1. G.F. Benedict, Nontraditional Manufacturing processes, Marcel Dekker, Inc. New York 1987.
2. A. Ghosh and A.K. Malik Manufacturing Science Affiliated East West press Ltd. New Delhi 1985.

Course Title	:	Manufacturing Processes Lab II			
Course Code	:	ME595	Course Type	:	Lab
Contact Hours	:	L- 0 T- 0 P-3	Credit	:	2
Program/Semester	:	M. Tech. IInd sem			
Pre-requisites	:	None			
Evaluation Scheme	:	Reports (30%), Exam (70%)			

Course Details:

1. To identify various angles and parameters of various single point cutting tools during taper turning.
2. To identify chips produced in turning of mild steel and aluminium, work piece at different speeds and feeds.
3. To study effect of cutting fluid on machining.
4. To compare the surface finish by varying cutting parameters on surface grinding machine.
5. To study the cylindrical boring and lapping.
6. To identify wheel characteristics and wheel selection for various workpiece materials.
7. Part programming and proving on a NC lathe for: - a. Outside Turning; b. Facing and Step Turning; c. Taper Turning; d. Drilling; e. Outside Threading.
8. Part programming and proving for milling a rectangular slot.
9. To manufacture a small object using hot forging technique. (Report the observations during the cold forging of given metal pieces).
10. Machining Work: At least two Mechanical assemblies using three or more parts involving machining on lathe, drill, shaper & milling machines.

Suggested Textbooks:

1.

References:

1.

ELECTIVES

Course Title	:	Metal Forming			
Course Code	:	ME645	Course Type	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech.			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)			
Course Details:					
<p>Forming: Review of stress and strain behavior of materials; plastic stress-strain relations (isotropic and anisotropic), plastic and tangent modulus, yield criteria, flow rule, plastic potential, strain hardening; plastic instability; empirical stress-strain equations; effect of pressure, strain-rate and temperature; stress equilibrium and virtual work; deformation and recrystallization; cold and hot working; heat effect during forming. [10H]</p> <p>Plasticity: Yield criteria, isotropic and anisotropic hardening, rules of plastic flow, Levy-Mises and Prandtl-Reuss equations, Isotropic and anisotropic yield theories: von Mises', Tresca, Hill's 1948 and 1979 yield criteria. [8H]</p> <p>Analysis: Mechanics of deformation in forming processes, determination of loads, pressures, torques and powers required in metal forming processes; analysis of stress tensor, eigen values, deviatoric and hydrostatic stress, components, octahedral stresses, analysis of strain and strain-rates; spring back; theory and applications of slab method, limit analysis – upper and lower bound technique, slip-line field method. [10H]</p> <p>Forming Processes: Drawing and sheet metal work, Stamping, FLD concept, FLC prediction, Forging, Extrusion; Rolling; Bending, Deep drawing, Wire and Tube drawing; High Velocity Forming. [12H]</p> <p>Factors affecting deformation mechanisms in different metal forming processes. [2H]</p>					
Suggested Textbooks:					
<ol style="list-style-type: none"> 1. Metal Forming: Processes and Analysis, B. Avitzur, Tata McGraw-Hill Publishing Co. Ltd., 1977 2. Theory of Plasticity, J. Chakrabarty, McGraw Hill, 1998. 					
References:					
<ol style="list-style-type: none"> 1. Metal forming Mechanics and Metallurgy, W. F. Hosford, R. M. Caddell, Prentice-Hall, 2007 2. Plasticity theory and its application in metal forming, V. Gopinathan, Wiley Eastern limited 2005 					

Course Title	:	Nanofinishing Science and Technology			
Course Code	:	ME646	Course Type	:	Elective
Contact Hours	:	L- 2 T- 0 P- 0	Credit	:	3
Program/Semester	:	M. Tech.			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz (10%), Mid-Term (20%), End-Term (40%), Project (10%)			

Course Details:

Traditional nanofinishing methods:

Honing and its process principle, Honing methods, Honing tools, Process parameters, Applications, Lapping process, lapping methods, Lapping tools, Process parameters, Applications, Some Problems **(5H)**.

Advance nanofinishing methods:

Abrasive flow finishing process, Mechanism, Types, Elastic emission machining, mechanism of material removal, Forces analysis, Effect of tool roughness, Factor effecting shear stress, Elasto-abrasive finishing, Elasto-abrasive configuration and characteristics, Types of elasto-abrasive balls, Types of elasto-abrasive processes, Focused ion beam finishing, Process detail, Sample preparation **(9H)**

Magnetic field assisted nanofinishing methods:

Magnetic abrasive finishing process, Working principle, Advantages, Magnetorheological finishing, process parameters, Applications **(5H)**.

Hybrid nanofinishing methods:

Electrochemical grinding, Electrochemical honing, Chemo magnetorheological finishing, Electrochemical magnetic abrasive finishing, Electro-discharge diamond grinding **(9H)**

Suggested Textbooks:

Nanofinishing Science and Technology: Basic and Advanced Finishing

References:

Micromanufacturing and Nanotechnology

Course Title	:	Thermal Aspects in Manufacturing			
Course Code	:	ME675	Course Type	:	Elective
Contact Hours	:	L- 3 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech.			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz (10%), Mid-Term (20%), End-Term (40%), Project (10%)			

Course Details:

Machining:

Regions of heat generation; Types of heat sources, Heat in the Primary Shear Zone, Heat in the Secondary Zone, Heat at the Tool/work Interface, Heat flow at the tool clearance face, Cutting fluid's effect on heat transfer, Heat effect on cutting forces, Heat effect on the tool life, Average shear plane temperature; Average chip-tool interface temperature; Method of tool temperature measurement, Temperature distribution in tool, Heat generation during high speed machining, Finite element analysis for thermal distribution **(15H)**.

Forming:

Formability, Frictional heating, Effect of heating on flow properties, Measurement of friction coefficient, Super plasticity, Elongation, Strain rate, Thermal distortion, Yield strength, Grain refinement, Effect of lubrication **(8H)**.

Micro machining: Micro-ECDM tool wear due to thermal effect, Heat generation during laser cutting, Effect of temperature on channel roughness, Heat transfer correlations in single and multi-phase flow **(5H)**.

Suggested Textbooks:

References:

<http://www.mfg.mtu.edu/marc/primers/heat/heat.html>
Heat generation and temperature prediction in metal cutting: A review and implications for high speed machining, 2006
Next Generation Microchannel Heat Exchangers
http://nptel.ac.in/courses/112106153/Module%2010/Lecture%204/Module_10_Lecture_4_ThermalEffects-friction.pdf

Course Title	:	Industrial Instrumentation & Metrology			
Course Code	:	ME651	Course Type	:	Elective
Contact Hours	:	3L-0 T- 0 P- 0	Credit	:	4
Program/Semester	:	M. Tech. / Semester-I/II			
Pre-requisites	:	None			
Evaluation Scheme	:	Quiz I (5%), Mid-Term (35%), Quiz II (10%), End-Term (50%),			
Course Details:					
<p>Theory and Experimentation in Engineering: Problem solving approaches, Types of engineering experiments, computer simulation and physical experimentation; Generalized measuring system, types of inputs, analog and digital signals, standards, calibration and uncertainty (4H) Measurement System: Performance characteristics, static performance characteristics-static calibration-linearity, static sensitivity, repeatability, hysteresis threshold-resolution, readability and span (3H) Analysis of Experimental Data : Causes and types of experimental error, un-certainty analysis, statistical analysis of data, probability distributions and curve fitting; Dynamic performance characteristics; Input types; Instrument types- zero order instrument, first order instrument, second order instrument (3H) Measurement of pressure; Flow measurement and flow visualization; measurement of temperature; optical methods of measurements; Data Acquisition and Processing (15H) Types and configurations of DAS, signal conditioning, A/D, D/A conversion; Design, Planning, Execution and Analysis of experimental projects (8H) Measurement of Acceleration, Vibration And Density Accelerometers - LVDT, Piezoelectric, Strain gauge and Variable reluctance type accelerometers - Mechanical type vibration instruments - Seismic instruments as accelerometer – Vibration sensor - Calibration of vibration pickups - Units of density and specific gravity – Baume scale and API scale - Pressure type densitometers - Float type densitometers – Ultrasonic densitometer - gas densitometer. (8H) Metrology: Measurement of length, measurement of angle, Measurement of geometric forms, straightness, flatness, roundness etc. Mechanical and optical methods. Measurement of screw threads and gears. Measurement of surface roughness and texture. Introduction to CMM. In-process gages. Inspection and quality monitoring. (4H)</p>					
Suggested Textbooks:					
3. Mechanical Measurements by S.P. Venkateshan ,IIT, Madras, Ane Books Pvt. Ltd, 4821, Parwana Bhawan, 1st Floor, 24 Ansari Road, Darya Ganj, New Delhi - 110 002. 4. Engineering Metrology by R.K. Jain, Khanna Publishers, New Delhi, 1997					
Reference					
4. E.O. Doebelin, Measurement systems- Applications and Design, 4th Ed., Tata McGraw-Hill, 1990. 5. T.G. Beckwith, R.D. Marangoni and J.H. Lienhard, Mechanical Measurements, 5th Ed., Addison Wesley, 1993. 6. Holman, Experimental Methods for Engineers, 6e, McGraw-Hill, 1994.					