MECHANICAL ENGINEERING

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.	ME621	Advanced Mechanics of Solid	3-1-0-4
4.	ME535	Finite Element Methods for Mechanical Engineering	3-0-0-4
5.	ME636	Computational Fluid Dynamics	3-0-0-4
6.	ME642	Advanced Manufacturing Processes and Technologies	3-0-0-4
7.	ME651	Industrial Instrumentation & Metrology	3-0-0-4
8.	ME681	Engineering Optimization	3-0-0-4
9.	ME686	MEMS: Microfabrication and Application	3-0-0-4
10.	ME687	Smart Materials and Structures	3-0-0-4
11.	EC661	Fuzzy Logic and Neural Networks	3-0-0-4
12.	ME631	Mechanical Vibration and Condition Monitoring	3-0-2-5
13.	MT603	Sensors and Actuators	3-0-0-4
14.	ME675	Thermal Aspects in Manufacturing	3-0-0-4
15.	ME623	Mechanics of Composite Laminates	3-0-0-4
16.	ME685	Robotics and Intelligent Systems	3-0-0-4
17.	EC407b	Internet of Things	3-0-0-4
18.	EC549b	MEMS/NEMS and Sensors	3-0-0-4
19.	ME645	Metal Forming	3-0-0-4
20.	ME646	Nano Finishing Science and Technology	3-0-0-4

21.	ME637	Fundamentals and Applications of Microfluidics	3-0-0-4
22.	ME605	Design for Manufacturing and Assembly	3-0-0-4
23.	ME613	Product Life Cycle Management	3-0-0-4
24.	ME619	Supply Chain Management	3-0-0-4
25.	ME620	Business Analytics	3-0-0-4
26.	ME614	Scheduling	3-0-0-4
27.	ME626	Design of Experiment	3-0-0-4
28.	ME532	Processing of Composites	3-0-0-4
29.	ME625	Contact Mechanics	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

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	ME589 (Core)	Research Methodology	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 I		3-0-0-4
3	Elective II		3-0-0-4
4	Elective III		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.	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.	ME688	Biomaterials Science and Engineering	3-0-0-4
14.	EC661	Fuzzy logic and Neural Networks	3-0-0-4
15.	MT603	Sensor and Actuators	3-0-0-4
16.	EC407b	Internet of Things	3-0-0-4
17.	ME637	Fundamentals and Applications of Microfluidics	3-0-0-4
18.	ME605	Design for Manufacturing and Assembly	3-0-0-4
19.	ME602	Computational Geometry for Design and Manufacturing	3-0-0-4
20.	ME611	Design of Experiment	3-0-0-4
21.	ME532	Processing of Composites	3-0-0-4
22.	ME625	Contact Mechanics	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

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
	ME688	Biomaterials Science and Engineering	3-0-0-4
14	ME675	Thermal Aspects in Manufacturing	3-0-0-4
15.	ME631	Mechanical Vibration and Condition Monitoring	3-0-2-5
16.	MT603	Sensors and Actuators	3-0-0-4
17.	ME623	Mechanics of Composite Laminates	3-0-0-4
18.	EC407b	Internet of Things	3-0-0-4
19.	EC549b	MEMS/NEMS and Sensors	3-0-0-4
20.	ME637	Microfluidics	3-0-0-4
23.	ME605	Design for Manufacturing and Assembly	3-0-0-4
25.	ME607	Manufacturing System Analysis	3-0-0-4
26.	ME619	Supply Chain Management	3-0-0-4

27.	ME620	Business Analytics	3-0-0-4
29.	ME614	Scheduling	3-0-0-4
33.	ME611	Design of Experiment	3-0-0-4
34.	ME627	Machine Tool Design	3-0-0-4
35.	ME532	Processing of Composites	3-0-0-4
36.	ME643	Surface Engineering	3-0-0-4
37.	ME625	Contact Mechanics	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

MTech in CAD/CAM

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 (20%), Quiz II (10%), End-Term (40%), Project /Assignment (20%)**			

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:

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

References:

1. Erwin Kreyszig, “Advanced Engineering Mathematics,” Wiley India, 9th Ed, 1999.
2. T. Myint-U and L. Debnath, “Linear Partial Differential Equations for Scientists and Engineers, Birkh¨auser”, 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, 9th Ed, 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%) Project (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, 1st edition, 2006

2 Paneerselvam R., Research Methodology, PHI, 2nd Edition, 2013

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 I (10%), Mid-Term (20%), Quiz II (10%), 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, 2006

References:

1. IbraheimZeid, CAD/CAM: Theory and Practice, TMH. Second Edition, 2009
2. I.D. Faux and M.J. Pratt, Computation Geometry for Design and Manufacture, John Wiley (Ellis Horwood Ltd.), 1980
3. Choi, B.K, Surface Modeling for CAD/CAM, Elsevier, 1991
4. Farin, Gerald, Curves and Surfaces for Computer Aided Geometric Design – A Practical Guide, Academic Press Inc., 3rd edition, 1993
5. Kunwoo Lee, Principles of CAD/CAM/CAE systems, Addison Wesley. 1st edition, 1999
6. Yamaguchi, Curves and Surfaces in Computer Aided Geometric Design, Springer, 2013

Course Title	**:**	**NC-CNC Machine Tools and Programming**			
Course Code	**:**	**ME611**	**Course Type**	**:**	**Compulsory/Elective**
Contact Hours	**:**	**L- 3 T- 0 P- 2**	**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, ApplicationNumerical 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/DelCAM, 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 Practice‖, Tata McGraw-Hil, 2016

References:

1. Robert Quesada, T. Jeyapoovan, ―Computer Numerical Control : Machining Center and Turning Centers‖ , Tata McGraw-Hill, 2012
2. S K SINHA, CNC Programming‖, Galgotia Pubs., 2013
3. Chang, Wysk and Wang, Computer Aided Manufacturing, Prentice Hall International. 3rd Edition, 2012
4. Kochan D., CAM: Developments in Computer Integrated Manufacturing System, Springer Verlag., 2015
5. Chang, T.C., An Introduction to Automated Process Planning Systems, Prentice Hall International., 2014
6. Kundra, Rao and Tiwari, Numerical Control and CAM, TMH., 2016
7. Koren, Computer Control of Manufacturing Systems, TMH., 2016
8. Kochan D., Integration of CAD/CAM, North Holland., 2016

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:

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]**

Suggested Textbooks:

1. James A. Rehg, Henry W. Kraebber, Computer Integrated Manufacturing, Pearson Prentice Hall, 2004

References:

1. A. Alavudeen, N. Venkateshwaran, Computer Integrated Manufacturing, PHI Learning Pvt. Ltd., 2008.
2. Alan Weatherall, Computer Integrated Manufacturing: From Fundamentals to Implementation, Butterworth-Heinemann, 2013.

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	**:**	**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	**:**	**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. K. Muralidhar and T. Sundararajan, Computational Fluid Flow and Heat Transfer, Eds, Narosa, India. 2009.

References:

1. P.S. Ghoshdastidar, Computer Simulation of Flow and Heat Transfer, Tata McGraw Hill, 1998.
2. Tannehill, Anderson &Pletcher, Computational Fluid Flow and Heat Transfer, Taylor & Francis Series, 2nd Ed. 1798.
3. Ferziger&Peric, Computational Methods for Fluid Dynamics, Springer, 2002.

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	**:**	**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:

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)

Suggested Textbooks:

1. Mechanical Measurements by S.P. Venketeshan ,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

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.

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, John Wiley & Sons, Inc. 4th Edition, 2009

References:

1. Mohan C. Joshi, Kannan M. Moudgalya, Optimization: Theory and Practice, Alpha Science International Limited, 2004.
2. A. Ravindran, G. V. Reklaitis, K. M. Ragsdell, Engineering optimization: methods and applications, Wiley India Edition, 2nd Edition, 2006

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 Jersy, 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:

1. Donald J. Leo, Engineering analysis of smart material systems, John Wiley Sons, Inc., 2007.
2. A V Srinivasan and D Michael McFarland, ―Smart Structures – Analysis and Design,‖ Cambridge University Press, 2001.
3. Inderjit Chopra and Jayant Sirohi, Smart Structures Theory, Cambridge University Press, 2014.

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; 2004
2. Alan S Morris, Measurement and Instrumentation Principles, Butterworth-Heinemann, 2001.

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	**:**	**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:

1. http://www.mfg.mtu.edu/marc/primers/heat/heat.html
2. Heat generation and temperature prediction in metal cutting: A review and implications for high speed machining, 2006
3. Next Generation Microchannel Heat Exchangers

(http://nptel.ac.in/courses/112106153/Module%2010/Lecture%204/Module_10_Lecture_4_Thermaleffects-friction.pdf)

MTech in Design

CORE COURSES

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, 3rd, New York, 1993.

2 R D Cook, D S Malkus and M E Plesha, Concepts and Applications of Finite Element Analysis, John Wiley, New York, 3 ed., 1989.

References:

1. K J Bathe, Finite Element Procedures in Engineering Analysis, Prentice-Hall, Englewood Cliffs, NJ, Ester Economy Edition, 1982.
2. T J T Hughes, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, 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	**:**	**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 (20%), Quiz II (10%), End-Term (40%), Project /Assignment (20%)**			

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:

3 J B Doshi, "Differential Equations for Scientists and Engineers," Narosa Publishing House, 2010.

4 Michael D Greenberg (1998), "Advanced Engineering Mathematics (2nd Ed)," Prentice Hall, (Indian Edition).

References:

4. Erwin Kreyszig, "Advanced Engineering Mathematics," Wiley India, 9th Ed, 1999.
5. T. Myint-U and L. Debnath, "Linear Partial Differential Equations for Scientists and Engineers, Birkh¨auser", Boston, 2007.
6. M K Jain, S R K Iyengar and R K Jain, "Numerical Methods for Scientific and Engineering Computation," New Age International Publisher, 9th Ed, 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%), Project /Assignment (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, 1st edition, 1st edition, 2006
2 Paneerselvam R., Research Methodology, PHI, 2nd Edition, 2013

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 /Assignment (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:

1 L. S. Srinath, Advanced Mechanics of Solids, 2nd Edition, TMH Publishing Co. Ltd., New Delhi, 2003
2 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 (20%), Quiz II (10%), End-Term (40%), Project /Assignment (20%)**			

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- 0T- 0 P- 2**	**Credit**	**:**	**2**
Program/Semester	**:**	**M. Tech. / Semester-I**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Regular LAB Performance (60%)+ End semester (40%)**			

Course Details:

I. Exercise on programming in Matlab/ Scilab – **2 Turns**
II. Exercise on Modelling 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	**:**	**DESIGN LAB II**			
Course Code	**:**	**ME593**	**Course Type**	**:**	**Lab**
Contact Hours	**:**	**L- 0T- 0 P- 2**	**Credit**	**:**	**2**
Program/Semester	**:**	**M. Tech. / Semester-II**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Regular LAB Performance (60%)+ End semester (40%)**			

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	**:**	**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 I (10%), Mid-Term (20%), Quiz II (10%), End-Term (40%), Project /Assignment (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, 2006

References:

1. IbraheimZeid, CAD/CAM: Theory and Practice, TMH. Revised First Edition, 1991
2. I.D. Faux and M.J. Pratt, Computation Geometry for Design and Manufacture, John Wiley (Ellis Horwood Ltd.). 1979.
3. Choi, B.K, Surface Modeling for CAD/CAM, Elsevier. 1991
4. Farin, Gerald, Curves and Surfaces for Computer Aided Geometric Design – A Practical Guide, Academic Press Inc. 1992.
5. Kunwoo Lee, Principles of CAD/CAM/CAE systems, Addison Wesley. 1999.
6. Yamaguchi, Curves and Surfaces in Computer Aided Geometric Design, Springer. 2013

Course Title	**:**	**Fault Diagnosis and Prognosis of 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 (20%), Quiz II (10%), End-Term (40%), Project /Assignment (20%)**			

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 l. Lewis, Michael Roemer, Andrew Hess, Biqing Wu, Intelligent Fault Diagnosis and Prognosis for Engineering Systems, John Wiley and Sons Ltd. 2006

Reference

1. Bo-Suk Yang, Introduction of Intelligent Fault Diagnosis and Prognosis, Nova Science Pub.Inc., 2011
2. Mobley, R. Keith, An Introduction to Predictive maintenance, Butterworth-Heinemann. Elsevier, 2002.

Course Title	**:**	**Fundamentals and Applications of Microfluidics**			
Course Code	**:**	**ME637**	**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%), Mid-Term (20%), Quiz II (10%), End-Term (40%), Project /Assignment (20%)**			

Course Details:

1. Introduction
Definition of microfluidics; The birth of microfluidics; Relationships among MEMS, Nanotechnology, and Microfluidics; Some applications of microfluidics – lab-on-a-chip devices, chemical engineering; Microfluidics in nature. **[4H]**

2. Basic Equations of Fluid Mechanics at Micrometric Scale
Ranges of forces of microscopic origin; Microscopic scales intervening in liquids and gases; Continuum assumption; Equations governing fluid flow under continuum assumption; Non-Newtonian fluid flow; Basics of heat transfer; Significance of non-dimensional numbers – Reynolds number, Knudsen number; Molecular approaches; Electrokinetics. **[8H]**

3. Microchannel Flow Theory
Scaling laws; Surface tension; Capillarity; Wall-slip effects; Temperature jump; Microfluidics of drops and bubbles; Diffusion, mixing and separation in microsystems; Electrokinetic phenomena; Magnetohydrodynamics. **[8H]**

4. Fabrication Techniques for Microfluidics
Current status; Basic microtechniques; Functional materials; Silicon based micromachining techniques; Polymer based micromachining techniques; Photolithography; Assembling and packaging of microfluidic devices; biocompatibility. **[7H]**

5. Experimental Flow Characterization
Micro-PIV (μPIV) – overview and examples; Pressure measurements; Flow rate measurements; Temperature measurements; Velocity measurements; Turbulence control. **[5H]**

6. Applications of Microfluidics
Micropumps and microchannel flows; Laboratory-on-a-chip-devices; Microair vehicles; Microvalves; Microflow needles; Micromixers; Microdispensers. **[8H]**

Suggested Textbooks:

1. Nam-Trung Nguyen and Steven T. Wereley. Fundamentals and Applications of Microfluidics, 2nd edition, Artech House. 2006.
2. Patrick Tabeling. Introduction to Microfluidics, Oxford University Press. 2010.

References:

1. Clement Kleinstreuer, Microfluidics and Nanofluidics: Theory and Selected Applications, Wiley. Microfluidics, Wiley., 2013.

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	**:**	**Quiz I (10%), Mid-Term (20%), Quiz II (10%), End-Term (40%), Project /Assignment (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. Mortenson, M.E., Geometric Modelling, John Wiley and Sons, Inc., 1997
9. Saxena, A., Sahay, B., Computer Aided Engineering Design, Anamaya Publishers, New

Dehi, 2005
10. Rogers, D.F and Adams, J.A., Mathematical Elements for Computer Graphics, Tata McGraw Hill, 2002.
11. Zeid, I., CAD/CAM: Theory and Practice, Revised First Edition, Tata McGraw Hill, 2007.
12. Faux, I. D. and Pratt, M. J., Computation Geometry for Design and Manufacture, John Wiley (Ellis Horwood Ltd.), 1983.
13. Venuvinod, P.K. and Ma, W., Rapid prototyping: Laser based and other technologies, Kluwer Academic Publishers,2004.
14. Gibson, I., Advanced Manufacturing Technology For Medical Application, John Wiley &Sons,Singapore,2005.
15. Kamrani, A.K. and Nasr, E.A., Rapid Prototyping Theory And Practice ,Springer,USA ,2006.
16. Hilton, P.D. and Jacobs, P.F., Rapid Tolling: Technologies and Industrial Applications, Dekker,New York ,2005.
17. Bidanda, B. and Bartolo, P., Virtual Prototyping & Bio Manufacturing In Medical Applications, Springer, USA ,2008.

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 I (10%), Mid-Term (20%), Quiz II (10%), End-Term (40%), Project /Assignment (20%)**			

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, KIc, the critical value, Relation of G&K, KIc measurement. EPFM: Fracture beyond yield, CTOD, experimental determination of CTOD, use J integrals and measurement of JIc 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. Ted L. Anderson, T. L. Anderson, Fracture Mechanics: Fundamentals and Applications, CRC PresS, Third Edition, 2005.

References:

1. Thomas H. Courtney, Mechanical Behavior of Materials. McGraw-Hill., Second Edition., 1990.
2. Norman E. Dowling "Mechanical Behavior of Materials: Engineering Methods for Deformation, Fracture, and Fatigue" 4th Ed. 2012.

Course Title	**:**	**Sensors and Actuators**			
Course Code	**:**	**MT503**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L- 2T- 0 P- 2**	**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. **[4 H]**

SENSORS: Classification of sensors – calibration techniques – Potentiometer – strain gauges – optical encoders. **[3 H]**

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. **[6 H]**

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) **[6 H]**

PIEZOELECTRIC SENSORS & ACTUATORS: Piezoelectric Materials and properties – Modes of deformation – Multimorphs – Environmental effects – Applications: Accelerometer, ultrasonic, Piezoelectric actuators, Piezoelectric resonators, Microphones, hydrophones, speakers, buzzers. **[5 H]**

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 **[4 H]**

Suggested Textbooks:

3. Clarence W de Silva, MECHATRONICS - An Integrated Approach, CRC Press; 2004
4. Alan S Morris, Measurement and Instrumentation Principles, Butterworth-Heinemann, 2001.

References:

3. T.R. Hsu "*MEMS And Microsystems: Design And Manufacture*, McGraw Hill Education, New Delhi 2002.
4. N. P. Mahalik, "*MEMS*", McGraw Hill Education, New Delhi 2007.

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 I (10%), Mid-Term (20%), Quiz II (10%), End-Term (40%), Project /Assignment (20%)**			

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 Mechanics of Composite Materials, Taylor and Francis, India. (2nd Ed),1999.

References:

1. B D Agarwal, L J Broutman and K Chandrashekhara ―Analysis and Performance of Fiber Composites, John Wiley and Sons, Inc., New Delhi, India, (3rd Ed), 2006.
2. Autar K Kaw, ―Mechanics of Composite Materials, Taylor and Francis, USA, (2nd Ed), 2006.
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 (20%), Quiz II (10%), End-Term (40%), Project /Assignment (20%)**			

Course Details:

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)**

Reliability; basic concepts, Uncertainty in engineering systems; Uncertainty Propagation, Modeling, Multiple random variables. **(7 H)**

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)**

First and higher order methods for reliability assessment, Deterministic & probabilistic approach, Risk based design, Central limit theorem, Fault tree approach (**8 H)**

System reliability, Fault Tree Analysis, Monte-Carlo and other simulation techniques **(5H)**

Regression analysis, Software based reliability analysis, Sensitivity analysis and reliability based design optimization, international standards, Applications & case studies. **(5 H)**

Suggested Textbooks:

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. "Response Surface Methodology: Process and Product Optimization Using Designed Experiments", John Wiley & Sons, Inc. , 2009.
3. Achintya Haldar and Sankaran Mahadevan "Reliability Assessment using Stochastic Finite Element Analysis, John Wiley & Sons, Inc. , 2000.

Reference

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	**:**	**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	**:**	**Quiz I (10%), Mid-Term (20%), Quiz II (10%), End-Term (40%), Project /Assignment (20%)**			

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. K. Muralidhar and T. Sundararajan, Computational Fluid Flow and Heat Transfer, Eds, Narosa, India. 2009.

References:

1. P.S. Ghoshdastidar, Computer Simulation of Flow and Heat Transfer, Tata McGraw Hill, 1998.
2. Tannehill, Anderson &Pletcher, Computational Fluid Flow and Heat Transfer, Taylor & Francis Series, 2nd Ed. 1798.
3. Ferziger&Peric, Computational Methods for Fluid Dynamics, Springer, 2002.

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 I (10%), Mid-Term (20%), Quiz II (10%), End-Term (40%), Project /Assignment (20%)**			

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:

1. http://www.mfg.mtu.edu/marc/primers/heat/heat.html
2. Heat generation and temperature prediction in metal cutting: A review and implications for high speed machining, 2006
3. Next Generation Microchannel Heat Exchangers

(http://nptel.ac.in/courses/112106153/Module%2010/Lecture%204/Module_10_Lecture_4_Thermaleffects-friction.pdf)

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 I (10%), Mid-Term (20%), Quiz II (10%), End-Term (40%), Project /Assignment (20%)**			

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, John Wiley & Sons, Inc. 4th Edition, 2009

References:

1. Mohan C. Joshi, Kannan M. Moudgalya, Optimization: Theory and Practice, Alpha Science International Limited, 2004.
2. A. Ravindran, G. V. Reklaitis, K. M. Ragsdell, Engineering optimization: methods and applications, Wiley India Edition, 2nd Edition, 2006

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 I (10%), Mid-Term (20%), Quiz II (10%), End-Term (40%), Project /Assignment (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 toque 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 filed 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:

1. B.Siciliano, L. Sciavicco, L. Villani, G.Oriolo, Robotics-Modelling, Planning and Control, Springer, 2009.
2. Reza N. Jazar, Theory of Applied Robotics- Kinematics, Dynamics, and Control , Springer, 2007.
3. M.W.Spong, S.Hutchinson and M. Vidyasagar, Robot Modelling and Control,2006.
4. B. Siciliano, O. Khatib (Eds), Springer Handbook of Robotics, Springer, 2008.
5. Mark W Spong, M Vidyasagar, Robot Dynamics And Control, John Wiley and Sons, 2008.
6. Richard M. Murray, Zexiang Li, S. S. Sastry, A Mathematical Introduction to Robotic Manipulation, CRC Press, 1994.
7. Russell Stuart, Norvig Peter, "Artificial Intelligence Modern Approach", Pearson Education series in AI, 3rd Edition, 2010.
8. Dan.W. Patterson, "*Introduction to Artificial Intelligence and Expert Systems*", PHI Learning, 2009
9. 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)
10. S Mahadevan and J Connell, Robot Learning, Kluwer Academic, 1993

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 I (10%), Mid-Term (20%), Quiz II (10%), End-Term (40%), Project /Assignment (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; NonlithographicMicrofabrication 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 Jersy, 2012.

References:

1. T.R. Hsu "MEMSAnd 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 I (10%), Mid-Term (20%), Quiz II (10%), End-Term (40%), Project /Assignment (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:

1. Donald J. Leo, Engineering analysis of smart material systems, John Wiley Sons, Inc., 2007.
2. A V Srinivasan and D Michael McFarland, ―Smart Structures – Analysis and Design,‖ Cambridge University Press, 2001.
3. Inderjit Chopra and Jayant Sirohi, Smart Structures Theory, Cambridge University Press, 2014.

Course Title	**:**	**Design for Manufacture and Assembly**			
Course Code	**:**	**ME605**	**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%), Mid-Term (20%), Quiz II (10%), End-Term (40%) Project (20%)**			

Course Details:

Introduction of DFMA: History, procedure to apply, DFMA during product design, classification of manufacturing process, introduction of assembly, DFMA advantages and disadvantages(04)**[4H]**

Design for Casting and Moulding: Introduction to sand casting, typical characteristics of a sand cast part, design recommendation, investment casting: introduction, steps in investment casting, design consideration, typical characteristics and applications, die casting: introduction to die casting design consideration, applications, injection moulding: introduction, typical characteristics of injection moulded parts, design recommendations, design for powder metal processing: introduction, design recommendations. (**08H**)

Design for Metal Extrusion: Metal extrusion working process, suitable material for extrusion, design recommendation, impact or cold extrusion: process, designrecommendations for backward extrusion, designrecommendations for forward extrusion, fine blanked parts: fine blanking process detail, material suitable for fine blanked parts, designrecommendations for piece parts, rolled formed section: process, design recommendations rolled section, design for forging: forging processes, forging nomenclature, suitable materials, design recommendations. **(07H)**

Design for Welding: Welding process, classifications, design for welding, design for solder and brazed assembly, suitable materials, detail design recommendations. **(03H)**

Design for Cleaning: Introduction to cleaning process, in-process cleaningoperations, cleaning processes and their applications, design recommendations, design for polishing: introduction to polishing processes, design recommendations forpolishing process, design for plated surface: electroplating process, typical characteristics,design recommendations for plating, vacuum metalized surfaces: process, design recommendations, design for heat treatment: introduction, heat treating process for steel, design recommendations for heat treatment.**(06H)**

Design for Assembly: The assembly process, characteristics and applications, example of common assembly, economic significance of assembly, general taxonomies of assembly operation and systems, assembling a product, design for assembly: introduction,design consideration, design for fasteners: Introduction, design recommendation for fasteners, extraction of assembly feature information from CAD Model, definition of assembly feature attributes, characterization of assembly feature, overview of procedure to extract assembly features from CAD model of assembly. **(06H)**

Suggested Textbooks:

1. O. Molloy, S. Tilley and E.A. Warman, Design for Manufacturing and assembly, First Edition, Chapman &Hall, London, UK. (1998).
2. D. E. Whitney, Mechanical Assemblies: Their Design, Manufacture, and Role inProduct Development, Oxford University Press, New York, (2004).
3. A.K. Chitale and R.C. Gupta, Product design and Manufacturing, Prentice Hallof India, New Delhi. (1999).

References:

Course Title	**:**	**Scheduling**			
Course Code	**:**	**ME614**	**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%), Mid-Term (30%), End-Term (40%), Project (20%)**			

Course Description: This course introduces the principles, techniques and algorithms for solving machine (resource) scheduling problems of the manufacturing and service systems. The topics covered in this course are overview of terminology, characteristics and classification of scheduling and sequencing problems, an overview of computational complexity theory, single machine, parallel machines, flow shop, job shop, and open shop scheduling problems with various scheduling criteria, dispatching rules, branch-and bound, dynamic programming, local search, and metaheuristic approaches

Course Details:

Introduction: Definition of the scheduling problem, notation, three-field representation for scheduling problems, classification of scheduling problems, Equivalency of performance measures, regular and irregular performance measures, complexity theory, classification of solution algorithms, measuring performance of approximation algorithms **[4 H]**

Single machine scheduling problems: Dominant sets, mathematical programming formulations, total flow time minimization, weighted flow time minimization, total lateness minimization, Maximum lateness and maximum tardiness minimization, number of tardy jobs minimization, total weighted completion time minimization with precedence constraints, dynamic programming approach, Neighborhood search techniques, dominance properties in total tardiness minimization, branch and bound algorithm for total tardiness minimization **[5H]**

Parallel machines scheduling problems: Mathematical programming formulations, list scheduling, makespan minimization, makespan minimization with preemption, mean flow time minimization, Mean flow time minimization with machine availability, uniform and unrelated parallel machines **[4H]**

Metaheuristics: Simulated annealing, tabu-search and genetic algorithms **[3H]**

Flow shop scheduling problems: Permutation schedules, mathematical programming formulations, two-machine makespan minimization, three-machine makespan minimization, branch and bound algorithm for makespan minimization, Heuristics for multiple machines makespan minimization, two machine total flow time minimization by branch and bound algorithm, scheduling problems: Flow shops with dominating machines, proportionate flow shops, ordered flow shops **[5 H]**

Job shop scheduling problems: Two-machine makespan minimization, Network representation of the job shop problem, disjunctive programming formulation, priority dispatching rules, heuristic algorithms for makespan minimization **[4H]**

Open shop scheduling problems: Two-machine makespan minimization, multiple machines makespan minimization **[3H]**

Suggested Textbooks:

1. K.R. Baker, D. Trietsch, Principles of Scheduling and Sequencing, Wiley, 2009.
2. T.E. Morton, Heuristic Scheduling Systems: with Applications to Production Systems, Wiley, 1993.
3. M. Pinedo, Scheduling Theory, Algorithms, and Systems, Prentice Hall, 2008.
4. M. Pinedo, and X. Chao, Operations Scheduling with Applications in Manufacturing and Services, McGraw-Hill, 1999.
5. D. Sule, Industrial Scheduling, PWS Publishing, 1997

Course Title	**:**	**Supply Chain Management**			
Course Code	**:**	**ME619**	**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 (30%), Project (40%)**			

Course Details:

Introduction and overview of supply chain management, Inbound and outbound logistics, Supply

chain as a source of competitive advantage. Inbound logistics. Buyer-Vendor co-ordination,

Procurement, Vendor development, reduced sourcing and supplier partnership - benefits, risks and critical success factors, multi-level supply control. Outbound logistics: Customer service, physical distribution planning, channel considerations, inventory strategies and management. **[12H]**

Forecasting Supply Chain network analysis, transportation infrastructure and management, facility location, Materials handling, Strategic considerations for supply chain: industry analysis and value-chain models, the concept of total cost of ownership, supply stream strategies, classification and development guidelines, measuring effectiveness of supply management, logistics engineering. **[10H]**

Order processing and Information System, Online E-commerce platform, Operations Research

Models for operational and strategic issues in supply chain management, Bullwhip Effect and

supply-chain management game. **[8H]**

Application of Supply chain network in practical life scenario and solution approach by traditional method CPLEX and LINGO (Model Formulation and Solution approach). **[4H]**

Suggested Textbooks:

1. William C. Copacino, Supply Chain Management: The basics and beyond, The St. Luci Press,

APICS Series on Resource Management.

2. David Simchi Levi, Philip kaminsky, and Edith Simchi Levi. Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies. Irwin McGrawHill, 2000.

3. Sunil Chopra and Peter Meindl. Supply Chain Management: Strategy, Planning, and Operation, Prentice Hall of India, 2002.

Course Title	**:**	**Business Analytics**			
Course Code	**:**	**ME620**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L- 2 T- 0 P- 1**	**Credit**	**:**	**4**
Program/Semester	**:**	**M. Tech.**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz (10%)-I, Mid-Term (20%), Quiz (10%)-II, End-Term (30%), Lab (20%)**			

Course Details:

Module1: Business Statistics

Basic probability concepts, Conditional probability, Probability distributions, Continuous and discrete distributions, Sequential decision-making Sampling and estimation: Estimation problems, Point and interval estimates Hypothesis testing: Null and alternate hypotheses; Types of errors, Level of significance, Power of a test, ANOVA **[10H]**

Module2: Predictive Analytics

Simple linear regression: Coefficient of determination, Significance tests, Residual analysis, Confidence and Prediction intervals Multiple linear regression: Coefficient of multiple coefficient of determination, Interpretation of regression coefficients, Categorical variables, heteroscedasticity, Multi-collinearity, outliers, Autoregression and Transformation of variables Logistic and Multinomial Regression: Logistic function, Estimation of probability using logistic regression, Deviance, Wald Test, Hosmer Lemshow Test **[10H]**

Module3: Optimization Analytics

Multi-period LP models. Applications of linear programming in product mix, blending, cutting stock, transportation, transshipment, assignment, scheduling, planning and revenue management problems. Network models and project planning. Integer Programming (IP) problems, mixed-integer and zero-one programming. Applications of IP in capital budgeting, location decisions, contracts. **[8H]**

Suggested Textbooks:

1. Business Analytics: By James Evans

Reference book:

1. Fundamentals of Business Analytics : By R.N. Prasad, Seema Acharya

Course Title	**:**	**Surface Engineering**			
Course Code	**:**	**ME643**	**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:

Introduction: Concept and importance, classification of surface modification techniques, advantages and their limitations. **[3H]**

Surface Degradation: Causes, types and consequences of surface degradation, forms of wear – adhesive, abrasive, surface fatigue, corrosive, fretting and erosive wear, classical governing laws related to wear, techniques to evaluate the wear damage. **[9H]**

Materials for Surface Engineering: Materials characteristics, their importance in surface engineering, wear resistant materials, selection of materials for engineering the surfaces for specific applications, new coating concepts including multi-layer structures, functionally gradient materials (FGMs), intermetallic barrier coatings and thermal barrier coating. **[9H]**

Coating based Surface Modification Techniques: Principles and application of weld surfacing: SMAW, SAW, GMAW, thermal spraying – flame spraying, electric arc spraying, plasma spraying, detonation gun spraying and high velocity oxy fuel spraying, electro deposition and electro less coatings. **[9H]**

Irradiation based and Laser Assisted Surface Engineering (LASE) Techniques: laser cladding, alloying, glazing, laser and induction hardening, heat treatment of steel and remelting by laser / TIG. Microwave glazing. **[4H]**

Diffusion based Surface Modification Techniques: Ion implantation, chemical vapour deposition (CVD) and physical vapour deposition (PVD), carburizing, nitriding, plasma nitriding, cyaniding. **[4H]**

Characterisation of Engineered Surfaces: Importance, different characterisation techniques - physical, mechanical and functional characterisations, surface finish, microhardness, strength and tribological characterisations. **[4H]**

Suggested Textbooks:

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

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

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

Course Title	**:**	**Nano Finishing Science and Technology**			
Course Code	**:**	**ME646**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**3**
Program/Semester	**:**	**M. Tech. / Semester-I/II**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

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]**

Topic 3: 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:

1. V.K. Jain, "Nanofinishing Science and Technology: Basic and Advanced Finishing" CRC Press, Taylor & Francis Group Pubs.

Reference

1. N.P. Mahalik, "Micromanufacturing and Nanotechnology" Springer Pubs.
2. Fritz Klocke, "Manufacturing Processes 2: Grinding, Honing, Lapping", Springer Pubs.

Course Title	**:**	**Design of Experiment**			
Course Code	**:**	**ME626**	**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%), Mid-Term (20%), Quiz II (10%), End-Term (40%) Project (20%)**			

Course Details:

1. Introduction

Introduction to experimental design principles, simple comparative experiments, introduction to R language and its applications in DOE problems. **[3H]**

2. Single factor experiments, randomized blocks, Latin square designs and extensions, introduction to R language. **[5H]**

3. Introduction to factorial designs, two levels, 2^k factorial designs, confounding and blocking in factorial designs, applications to manufacturing problems. **[4H]**

4. Fractional factorial designs, two-level, three-level and mixed-level factorials and fractional factorials, applications to quality control problems. **[5H]**

5. Regression models including multiple regression models and its application to transportation scheduling problems. **[4H]**

6. Response surface methodology, parameter optimization, robust parameter design and its application to control of processes with high variability. **[6H]**

7. Random and mixed effects models, nested and split plot and strip plot designs and its application to semiconductor manufacturing problem. **[5H]**

8. Repeated measures design, analysis of covariance and its applications in comparing alternatives. **[5H]**

9. Design of computer experiments and the applications in industrial engineering problems. **[4H]**

Suggested Textbooks:

References:

1. Montgomery, D. C. Design and Analysis of Experiments, John Wiley & Sons. Inc. (2001).
2. Dean, A. M. and Voss, D. T. Design and Analysis of Experiments (Springer text in Statistics), Springer Science + Business Media, Inc. (1999).
3. Box, G. E. P., Hunter, W. G., and Hunter, J. S. Statistics for Experimenters: An Introduction to Design, Data Analysis, and Model Building, John Wiley & Sons. (1978).
4. Diamond, W. J. Practical Experiment Designs for Engineers and Scientists, John Wiley & Sons. Inc. (2001).
5. Jeff Wu, C. E. and Hamada, M. I. Experiments: Planning, Analysis, and Parameter Design Optimization, John Wiley & Sons. Inc. (2000).

Course Title	**:**	**Processing of Composites**			
Course Code	**:**	**ME5XX**	**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%), Mid-Term (20%), Quiz II (10%), End-Term (40%), Project /Assignment (20%)**			

Course Details:

Introduction: Definition, Classification, Advantages/Disadvantages, Properties, Fiber-Reinforced Composites, Elastic Behaviour under Loading, Longitudinal and transverse Tensile Strength, Discontinuous Fiber-Reinforced Composites, Particulate Composites, Applications**[3H]**

Dispersed Phase: Fiber Reinforcements, Natural Fibres, Synthetic Fibres, Surface Modification of Fibres,Fibre Selection Criteria, Particulate Materials, Nano-Reinforcements**[3H]**

Matrix Materials: Polymer Matrix, Thermoset Polymers and Thermoplastics, Metallic Matrix Materials, Intermetallic Compounds, Ceramic Matrix Materials, Glasses and Glass-Ceramics**[5H]**

Polymer Matrix Composites: Processing of PMCs, Spray-Up Process, Resin Transfer Molding (RTM),Vacuum Impregnation, Autoclave, Filament Winding, Pultrusion, Compression Molding, Thermoplastic Composite Processing, Advances in PMCs, Smart Composites, Structure and Properties of PMCs, Environmental Effects on PMCs, Applications **[8H]**

Metal Matrix Composites: Selection of Reinforcements, Processing of MMCs, Liquid-State Processes, Solid-State Processes, Gaseous-State Processes, Deposition Techniques, Secondary Processing, Properties of Metal Matrix Composites, Applications**[5H]**

Ceramic Matrix Composites: FailureBehavior of CMCs, Toughening Mechanisms in CMCs, Processing of CMCs, Ceramic Particle-Based Processes, In Situ Ceramic Composite Processing, Mechanical Properties of CMCs, Applications **[4H]**

Carbon-Carbon Composites: Carbon Fiber Reinforcements, Matrix Systems, Processing of C/C Composites, Microstructure of C/C Composites, Properties of C/C Composites,Applications**[4H]**

Nanocomposites: Polymer NCs, Clay-Polymer NCs, Graphite-Polymer NCs, Nanofiber-Reinforced Composites, Particulate NCs, Metal Matrix NCs, Processing and coating of Metallic NCs, Ceramic NCs, Carbon Nanotube-Ceramic NCs, Properties of Ceramic NCs, Applications **[3H]**

Machining, Joining and Repair of Composites: Machinability Aspects of Polymer Matrix Composites, Machining and Joining of MMCs, Machining Metal Matrix Composites, Machining Ceramic Matrix Composites, Drilling Technology, Abrasive Water Jet Machining of Composites, Laser Machining of Composites, Adhesive joints, Mechanical joints, Non-destructive testing and evaluation (NDTE), Repairing of Composites, Self-healing composites **[5H]**

Suggested Textbooks:

1. Balasubramanian M., Composite Materials and Processing, Boca Raton, 2014
2. Davim JP (Ed.), Machining Composites Materials, Wiley-ISTE, 2009

References:

1. JR Vinson and Sierakowski RL, The Behavior of Structures Composed of Composite Materials, IInd Ed., Kluwer, Dordrecht, 2004.

Course Title	**:**	**Contact Mechanics**			
Course Code	**:**		**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%), Mid-Term (20%), Quiz II (10%), End-Term (40%), Project /Assignment (20%)**			

Course Details:

Introduction, Mechanical contact is the principal method of load transfer between engineering components. Stresses in the contact region are generally very high and failure mechanisms associated with these stresses may limit the performance of the component.The classical Hertzian analysis of elastic contact of two bodies, which forms the basis of the design of such components as ball and roller bearings, wheels on rails, gear teeth in contact etc..**(10 H)**

The development of plastic deformation in heavily-loaded systems, including the possibility of shakedown under repeated loading. (**8 H)**

Situations involving frictional tractions, e.g. the transmission of a tangential force when accelerating a railroad locomotive, micro-slip between components in static contact due to machine vibration (leading to fretting corrosion failure), oblique impact of elastic bodies, etc. **(10 H)**

Mechanics considerations in the analysis of surface fatigue failures, initiation and development of sub-surface defects, effect of loading history, etc. (**8H**)

Influence of surface roughness on contact stress distributions, friction and on the conduction of heat and electricity across an interface. **(8 H)**

Suggested Textbooks:

1. Johnson, KL.Contact mechanics, Cambridge University Press, 1987.

Reference

1. K.L. Johnson, K. Kendall, A.D. Roberts, Surface Energy and the Contact of Elastic Solid, *Proc. R. Soc. London, Ser. A* 1971, *324*, 301-313.

Course Title	**:**	**Biomaterials Science and Engineering**			
Course Code	**:**	**ME688**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L- 3 T- 1 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:

Introduction: Requirements of biomaterials, Classification of biomaterials, Mechanical properties of biomaterials, Effects of processing on properties of biomaterials [5 H]

Biological Materials: Structure of proteins, collagen, elastic proteins, polysaccharides, chitin and chitosan, structure properties relationships [6 H]

Metallic Implant Materials: Some common examples and properties of metals used as implants: stainless steel, titanium and titanium alloy, cobalt chrome alloys. Problem of corrosion, corrosion behavior and the importance of passive films for tissue adhesion, wear, fatigue, stress shielding, stress-corrosion cracking. Host tissue reaction with metals. [6 H]

Polymeric Implant Materials: Some common examples and properties of polymers used as implants: PE, PMMA, Silicon Rubber, Polyester, Acetals, Biodegradable Polymers. (Classification according to thermosets, thermoplastics and elastomers). Viscoelastic behavior: Tg, creep-recovery, stress relaxation, strain-rate sensitivity. Host tissue reaction: importance of molecular structure, hydrophilic and hydrophobic surface properties, migration of additives (processing aids), aging and environmental stress cracking. [6 H]

Ceramics Implant Materials: Definition of bioceramics. Common types of bioceramics (inert and bioactive types) and their properties (importance of wear resistance and low fracture toughness). Host tissue reactions: importance of interfacial tissue reaction (e.g. ceramic/bone tissue reaction). [6 H]

Composite Implant Materials: Mechanics of improvement of properties by incorporating different elements. Composites theory of fiber reinforcement (short and long fibers, fibers pull out). Polymers filled with osteogenic fillers (e.g hydroxyapatite). Textile composites. Host tissue reactions. [6 H]

Testing of Biomaterials: In-vitro testing. Mechanical test: wear, fatigue, tensile, corrosion studies and fracture toughness. Effect of physiological fluid on the properties of biomaterials. In-vivo testing (animals). Ex-vivo testing. Contact allergy to biomaterials. Standards. [5 H]

Suggested Textbooks:

1. Hoffman, Schoen, Lemons, Biomaterials Science-Ratner, Elsevier; 2nd Edition (2004).
2. Temenoff and Mikos , Biomaterials. 2008.
3. Ashby, M. F. and Jones, D. R. H., "Engineering Materials: an Introduction to their Properties and Applications", 1st Edn.,Pergamon Press, 1980.

References:

1. SH Teoh , Engineering Materials for Biomedical Applications, World Scientific, 2004.
2. JB Park and RS Lakes (Eds), Biomaterials - An Introduction, Springer-Verlag, 3rd Edition, 2007.
3. BD Ratner, AS Hoffman, FJ Schoen, JE Lemons (Eds), Biomaterials Science: An Introduction to Materials in Medicine, Academic Press, 2nd Edition, 2004.

M.Tech. in Manufacturing

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:

7. Erwin Kreyszig, "Advanced Engineering Mathematics," Wiley India, 1999.
8. T. Myint-U and L. Debnath, Linear Partial Differential Equations for Scientists and Engineers, Birkh¨auser, Boston, 2007.
9. 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

2. Taylor, Sinha and Ghosal, Research Methodology, PHI, 1st edition, 2006
3. Paneerselvam R., Research Methodology, PHI, 2nd Edition, 2013

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	**:**	**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, 2006.

References:

1. IbraheimZeid, CAD/CAM: Theory and Practice, TMH. Revised First Edition, 1991
2. I.D. Faux and M.J. Pratt, Computation Geometry for Design and Manufacture, John Wiley (Ellis Horwood Ltd.). 1979.
3. Choi, B.K, Surface Modeling for CAD/CAM, Elsevier. 1991
4. Farin, Gerald, Curves and Surfaces for Computer Aided Geometric Design – A Practical Guide, Academic Press Inc. 1992.
5. Kunwoo Lee, Principles of CAD/CAM/CAE systems, Addison Wesley. 1999.
6. Yamaguchi, Curves and Surfaces in Computer Aided Geometric Design, Springer. 2013

ELECTIVES

Course Title	**:**	**NC-CNC Machine Tools and Programming**			
Course Code	**:**	**ME611**	**Course Type**	**:**	**Compulsory/Elective**
Contact Hours	**:**	**L- 3T- 0 P- 2**	**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, ApplicationNumerical 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/DelCAM, 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 Practice‖, Tata McGraw-Hill, 3rd Edition, 2010.

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. 2010.
3. Chang, Wysk and Wang, Computer Aided Manufacturing, Prentice Hall International. 3rd Edition, 2009.
4. Kundra, Rao and Tiwari, Numerical Control and CAM, TMH, 2008.
5. Koren, Computer Control of Manufacturing Systems, TMH.

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:

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]**

Suggested Textbooks:

James A. Rehg, Henry W. Kraebber, Computer Integrated Manufacturing, Pearson Prentice Hall, 2004

References:

1. A. Alavudeen, N. Venkateshwaran, Computer Integrated Manufacturing, PHI Learning Pvt. Ltd., 2008.
2. Alan Weatherall, Computer Integrated Manufacturing: From Fundamentals to Implementation, Butterworth-Heinemann, 2013.

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:

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

References:

3. R. G. Budynas, Advanced Strength and Applied Stress Analysis, 2nd Edition, McGraw Hill Publishing Co, 1999.
4. A. P. Boresi, R. J. Schmidt, Advanced Mechanics of Materials, 5th Edition, John Willey and Sons Inc, 1993.
5. S. P. Timoshenko, J. N. Goodier, Theory of Elasticity, 3rd Edition, McGraw Hill Publishing Co. 1970.
6. P. Raymond, Solid Mechanics for Engineering, 1st Edition, John Willey & Sons, 2001.
7. 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 (20%), Quiz II (10%), End-Term (40%), Project /Assignment (20%)**			

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	**:**	**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. K. Muralidhar and T. Sundararajan, Computational Fluid Flow and Heat Transfer, Eds, Narosa, India. 2009.

References:

1. P.S. Ghoshdastidar, Computer Simulation of Flow and Heat Transfer, Tata McGraw Hill, 1998.
2. Tannehill, Anderson &Pletcher, Computational Fluid Flow and Heat Transfer, Taylor & Francis Series, 2nd Ed. 1798.
3. Ferziger&Peric, Computational Methods for Fluid Dynamics, Springer, 2002.

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:

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]**

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]**

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 filed method. **[10H]**

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]**

Factors affecting deformation mechanisms in different metal forming processes. **[2H]**

Suggested Textbooks:

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:

2. Metal forming Mechanics and Metallurgy, W. F. Hosford, R. M. Caddell, Prentice-Hall, 2007
3. Plasticity theory and its application in metal forming, V. Gopinathan, Wiley Eastern limited 2005

Course Title	**:**	**Industrial Instrumentation & Metrology**			
Course Code	**:**	**ME651**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**3L-0T- 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:

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)

Suggested Textbooks:

1. Mechanical Measurements by S.P. Venketeshan ,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

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.

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:

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

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:

2. Engineering Optimization: Theory and Practice by SS Rao, John Wiley & Sons, Inc. 4th Edition, 2009

References:

1. Mohan C. Joshi, Kannan M. Moudgalya, Optimization: Theory and Practice, Alpha Science International Limited, 2004.
2. A. Ravindran, G. V. Reklaitis, K. M. Ragsdell, Engineering optimization: methods and applications, Wiley India Edition, 2nd Edition, 2006

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 toque 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 filed 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:

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

References:

1. B.Siciliano, L. Sciavicco, L. Villani, G.Oriolo, Robotics- Modelling, Planning and Control, Springer, 2009.
2. Reza N. Jazar, Theory of Applied Robotics- Kinematics, Dynamics, and Control , Springer, 2007.
3. M.W.Spong, S.Hutchinson and M. Vidyasagar, Robot Modelling and Control,2006.
4. B. Siciliano, O. Khatib (Eds), Springer Handbook of Robotics, Springer, 2008.
5. Mark W Spong, M Vidyasagar, Robot Dynamics And Control, John Wiley and Sons, 2008.
6. Richard M. Murray, Zexiang Li, S. S. Sastry, A Mathematical Introduction to Robotic Manipulation, CRC Press, 1994.
7. Russell Stuart, Norvig Peter, "Artificial Intelligence Modern Approach", Pearson Education series in AI, 3rd Edition, 2010.
8. Dan.W. Patterson, "*Introduction to Artificial Intelligence and Expert Systems*", PHI Learning, 2009
9. 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)
10. S Mahadevan and J Connell, Robot Learning, Kluwer Academic, 1993

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 Jersy, 2012.

References:

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

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:

2. R M Jones (1999), ―Mechanics of Composite Materials (2nd Ed),‖ Taylor and Francis, India.

References:

4. 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.
5. Autar K Kaw (2006), ―Mechanics of Composite Materials (2nd Ed),‖ Taylor and Francis, USA.
6. Reddy, J.N., Mechanics of Laminated Composite Plates and Shells – Theory and Analysis, CRC Press, 2nd Edition, 2004.

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	**:**	**Quiz I (10%), Mid-Term (20%), Quiz II (10%), End-Term (40%), Project /Assignment (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. Mortenson, M.E., Geometric Modelling, John Wiley and Sons, Inc., 1997
9. Saxena, A., Sahay, B., Computer Aided Engineering Design, Anamaya Publishers, New Dehi, 2005

10. Rogers, D.F and Adams, J.A., Mathematical Elements for Computer Graphics, Tata McGraw Hill, 2002.
11. Zeid, I., CAD/CAM: Theory and Practice, Revised First Edition, Tata McGraw Hill, 2007.
12. Faux, I. D. and Pratt, M. J., Computation Geometry for Design and Manufacture, John Wiley (Ellis Horwood Ltd.), 1983.
13. Venuvinod, P.K. and Ma, W., Rapid prototyping: Laser based and other technologies, Kluwer Academic Publishers,2004.
14. Gibson, I., Advanced Manufacturing Technology For Medical Application, John Wiley &Sons,Singapore,2005.
15. Kamrani, A.K. and Nasr, E.A., Rapid Prototyping Theory And Practice ,Springer,USA ,2006.
16. Hilton, P.D. and Jacobs, P.F., Rapid Tolling: Technologies and Industrial Applications, Dekker,New York ,2005.
17. Bidanda, B. and Bartolo, P., Virtual Prototyping & Bio Manufacturing In Medical Applications, Springer, USA ,2008.

Course Title	**:**	**Processing of Composites**			
Course Code	**:**	**ME532**	**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%), Mid-Term (30%), End-Term (40%), Project (20%)**			

Course Details:

Introduction: Definition, Classification, Advantages/Disadvantages, Properties, Fiber-Reinforced Composites, Elastic Behaviour under Loading, Longitudinal and transverse Tensile Strength, Discontinuous Fiber-Reinforced Composites, Particulate Composites, Applications**[3H]**

Dispersed Phase: Fiber Reinforcements, Natural Fibres, Synthetic Fibres, Surface Modification of Fibres,Fibre Selection Criteria, Particulate Materials, Nano-Reinforcements**[3H]**

Matrix Materials: Polymer Matrix, Thermoset Polymers and Thermoplastics, Metallic Matrix Materials, Intermetallic Compounds, Ceramic Matrix Materials, Glasses and Glass-Ceramics**[5H]**

Polymer Matrix Composites: Processing of PMCs, Spray-Up Process, Resin Transfer Molding (RTM),Vacuum Impregnation, Autoclave, Filament Winding, Pultrusion, Compression Molding, Thermoplastic Composite Processing, Advances in PMCs, Smart Composites, Structure and Properties of PMCs, Environmental Effects on PMCs, Applications **[8H]**

Metal Matrix Composites: Selection of Reinforcements, Processing of MMCs, Liquid-State Processes, Solid-State Processes, Gaseous-State Processes, Deposition Techniques, Secondary Processing, Properties of Metal Matrix Composites, Applications**[5H]**

Ceramic Matrix Composites: Failure Behavior of CMCs, Toughening Mechanisms in CMCs, Processing of CMCs, Ceramic Particle-Based Processes, In Situ Ceramic Composite Processing, Mechanical Properties of CMCs, Applications **[4H]**

Carbon-Carbon Composites: Carbon Fiber Reinforcements, Matrix Systems, Processing of C/C Composites, Microstructure of C/C Composites, Properties of C/C Composites,Applications**[4H]**

Nanocomposites: Polymer NCs, Clay-Polymer NCs, Graphite-Polymer NCs, Nanofiber-Reinforced Composites, Particulate NCs, Metal Matrix NCs, Processing and coating of Metallic NCs, Ceramic NCs, Carbon Nanotube-Ceramic NCs, Properties of Ceramic NCs, Applications **[3H]**

Machining, Joining and Repair of Composites: Machinability Aspects of Polymer Matrix Composites, Machining and Joining of MMCs, Machining Metal Matrix Composites, Machining Ceramic Matrix Composites, Drilling Technology, Abrasive Water Jet Machining of Composites, Laser Machining of Composites, Adhesive joints, Mechanical joints, Non-destructive testing and evaluation (NDTE), Repairing of Composites, Self-healing composites **[5H]**

Suggested Textbooks:

1. Balasubramanian M., Composite Materials and Processing, Boca Raton, 2014
2. Davim JP (Ed.), Machining Composites Materials, Wiley-ISTE, 2009

References:

1. JR Vinson and Sierakowski RL, The Behavior of Structures Composed of Composite Materials, IInd Ed., Kluwer, Dordrecht, 2004.

Course Title	**:**	**Contact Mechanics**			
Course Code	**:**	**ME534**	**Course Type**	**:**	
Contact Hours	**:**	**L- 3 T- 0 P- 4**	**Credit**	**:**	
Program/Semester	**:**	**M. Tech.**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Introduction,Mechanical contact is the principal method of load transfer between engineering components. Stresses in the contact region are generally very high and failure mechanisms associated with these stresses may limit the performance of the component.The classical Hertzian analysis of elastic contact of two bodies, which forms the basis of the design of such components as ball and roller bearings, wheels on rails, gear teeth in contact etc..**(10 H)**

The development of plastic deformation in heavily-loaded systems, including the possibility of shakedown under repeated loading. (**8 H)**

Situations involving frictional tractions, e.g. the transmission of a tangential force when accelerating a railroad locomotive, micro-slip between components in static contact due to machine vibration (leading to fretting corrosion failure), oblique impact of elastic bodies, etc. **(10 H)**

Mechanics considerations in the analysis of surface fatigue failures, initiation and development of sub-surface defects, effect of loading history, etc. (**8H**)

Influence of surface roughness on contact stress distributions, friction and on the conduction of heat and electricity across an interface. **(8 H)**

Suggested Textbooks:

1. Johnson, KL.Contact mechanics, Cambridge University Press, 1987.

Reference

1. L. Johnson, K. Kendall, A.D. Roberts, Surface Energy and the Contact of Elastic Solid, *Proc. R. Soc. London, Ser. A* 1971, *324*, 301-313.

Course Title	**:**	**Biomaterials Science and Engineering**			
Course Code	**:**	**ME688**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L- 3 T- 1 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:

Introduction: Requirements of biomaterials, Classification of biomaterials, Mechanical properties of biomaterials, Effects of processing on properties of biomaterials [5 H]

Biological Materials: Structure of proteins, collagen, elastic proteins, polysaccharides, chitin and chitosan, structure properties relationships [6 H]

Metallic Implant Materials: Some common examples and properties of metals used as implants: stainless steel, titanium and titanium alloy, cobalt chrome alloys. Problem of corrosion, corrosion behavior and the importance of passive films for tissue adhesion, wear, fatigue, stress shielding, stress-corrosion cracking. Host tissue reaction with metals. [6 H]

Polymeric Implant Materials: Some common examples and properties of polymers used as implants: PE, PMMA, Silicon Rubber, Polyester, Acetals, Biodegradable Polymers. (Classification according to thermosets, thermoplastics and elastomers). Viscoelastic behavior: Tg, creep-recovery, stress relaxation, strain-rate sensitivity. Host tissue reaction: importance of molecular structure, hydrophilic and hydrophobic surface properties, migration of additives (processing aids), aging and environmental stress cracking. [6 H]

Ceramics Implant Materials: Definition of bioceramics. Common types of bioceramics (inert and bioactive types) and their properties (importance of wear resistance and low fracture toughness). Host tissue reactions: importance of interfacial tissue reaction (e.g. ceramic/bone tissue reaction). [6 H]

Composite Implant Materials: Mechanics of improvement of properties by incorporating different elements. Composites theory of fiber reinforcement (short and long fibers, fibers pull out). Polymers filled with osteogenic fillers (e.g hydroxyapatite). Textile composites. Host tissue reactions. [6 H]

Testing of Biomaterials: In-vitro testing. Mechanical test: wear, fatigue, tensile, corrosion studies and fracture toughness. Effect of physiological fluid on the properties of biomaterials. In-vivo testing (animals). Ex-vivo testing. Contact allergy to biomaterials. Standards. [5 H]

Suggested Textbooks:

1. Biomaterials Science-Ratner, Hoffman, Schoen, Lemons (Elsevier; ISBN 0-12 -582461)
2. Biomaterials -Temenoff and Mikos (Pearson Prentice Hall; ISBN 0-13-009710-1)
3. Materials Science and Engineering: An Introduction -Callister (John Wiley and Sons; ISBN 0-471-13576-3)
4. Science and Engineering of Materials -Askland and Phule (Thomson; ISBN 0-534-55396-6)

References:

1. SH Teoh (Ed), Engineering Materials for Biomedical Applications, World Scientific, 2004.
2. JB Park and RS Lakes (Eds), Biomaterials - An Introduction, Springer-Verlag, 3rd Edition, 2007.
3. BD Ratner, AS Hoffman, FJ Schoen, JE Lemons (Eds), Biomaterials Science: An Introduction to Materials in Medicine, Academic Press, 2nd Edition, 2004.

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 I (10%), Mid-Term (20%), Quiz II (10%), End-Term (40%), Project /Assignment (20%)**			

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, KIc, the critical value, Relation of G&K, KIc measurement. EPFM: Fracture beyond yield, CTOD, experimental determination of CTOD, use J integrals and measurement of JIc 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. Ted L. Anderson, T. L. Anderson, Fracture Mechanics: Fundamentals and Applications, CRC PresS, Third Edition, 2005.

References:

1. Thomas H. Courtney, Mechanical Behavior of Materials. McGraw-Hill., Second Edition., 1990.
2. Norman E. Dowling "Mechanical Behavior of Materials: Engineering Methods for Deformation, Fracture, and Fatigue" 4th Ed. 2012.