M.Tech in Mechanical Engineering (Specialization: Machine Design)

Department of Mechanical Engineering, Tezpur University

1. **Aim of the Programme:**

   The Department of Mechanical Engineering, Tezpur University started in the year 2006 with four-year undergraduate programme. At present, the department also offers Master of Technology (M. Tech) and Doctor of Philosophy (PhD) at the post graduate level. Currently, the M.Tech programme is being offered with two specializations: Applied Mechanics and Thermo-Fluids Engineering. However, in view of the great demand for M.Tech in Mechanical Engineering with specialization in Machine Design, among the student of this region, the department wishes to offer a new specialization at the M.Tech level focus solely on Machine Design. The aim of the new specialization is to develop a broad background in the field of Machine Design during the first two semesters followed by an in-depth study of a problem in the field for the last two semesters.

2. **Eligibility Criteria for MTech in Mechanical Engineering :**

   The minimum eligibility for enrollment in the programme is BE/BTech or equivalent Bachelor Degree in Mechanical, Aerospace Engineering, Automobile Engineering or in any other allied disciplines in Mechanical Engineering with a minimum of 60% marks (or 6 CGPA in 10 point scale) in aggregate, and relaxation may be allowed for those belonging to SC/ST/OBC (non-creamy layer)/Differently-Abled and other categories of candidates as per the Government of India rules. Preference will be given to candidates having valid GATE scores in Mechanical Engineering.

3. **Programme Structure:**
   (i)   The programme contains some core courses and elective courses mainly from Solid Mechanics and Machine Design.
   (ii)   All core and elective courses involve assignments and/or mini project emphasizing on the practical aspects of a course.
   (iii)   Further, the enrolled students will have to study three Choice Based Credit Transfer (CBCT) courses offered by any other department of the university.
   (iv)   A student will choose elective and CBCT courses for him/her in consultation with the programme coordinator.
   (v)   The programme contains a course, named as Term Paper, under which a student will carry out a literature survey under the guidance of a faculty member in any research area of interest and periodically present his/her observation to a board of faculty members.

M.Tech in Mechanical Engineering (Specialization: Machine Design)

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Curriculum

Semester	SN	Code	Title	L	T	P	CH	Cr	Total Credits
I	1	ME-501	Advanced Solid Mechanics	3	1	0	4	4	20
	2	ME-623	Mathematical Methods for Engineers	3	1	0	4	4	
	3	ME-509	Advanced Dynamics and Vibration	3	0	0	3	3	
	4	xx-xxx	Open Elective I					3	
	5	xx-xxx	Elective I					3*	
	6	xx-xxx	Elective II					3*	
II	1	ME-502	Finite Element Methods	3	1	0	4	4	21
	2	ME-510	Engineering Design Laboratory	0	0	3	6	3	
	3	ME-592	Term Paper	0	0	0	0	2	
	4	xx-xxx	Open Elective II					3	
	5	xx-xxx	Elective III					3	
	6	xx-xxx	Elective IV					3*	
	7	xx-xxx	Elective V					3*	
III		ME-613	M.Tech. Thesis (Part-I)					12	24
IV		ME-614	M.Tech. Thesis (Part-II)					12	
		Minimum credit to be completed for award of the degree							**65**

* *Minimum credits are shown against the elective courses. The overall credit, however, may vary with the actual credits of opted elective courses (credits of other courses are fixed as shown).*

Syllabus

ME-501: Advanced Solid Mechanics　　　　　　　　　　**L-T-P-CH-CR: 3-1-0-4-4**

Course objectives:

　i.　Be proficient in alternative measures of stress and strain, formulation and solution of 2D and 3D elasticity problems.
　ii.　Understand advanced beam theory for shear deformation and large deformation, contact mechanics, stress concentration, pressure vessels and compound cylinders.
　iii.　Possess the ability to apply the principles of solid mechanics to model and analyze of practical engineering problems concerned with stress and deformation analysis.
　iv.　Be proficient in the use of commercial software package for modeling and analyzing structural problem.

Analysis of stress: Introduction, Cauchy's formula, principal stresses, stress invariants, three-dimensional Mohr's circle, octahedral stresses, hydrostatic and deviatoric stresses, differential equations of equilibrium in rectangular and polar coordinates, stress boundary conditions, plane stress and plane stress problems;

Analysis of strain: Introduction, definitions of normal and shear strains, principal strains, strain invariants, plane strain in rectangular and polar coordinates, compatibility conditions;

Stress-strain relations for linearly elastic bodies: Generalized Hooke's law, relations between elastic constants;

Axisymmetric problems: Thick and thin walled cylinders, composite tubes, rotating disks;

Energy methods: Introduction, principle of superposition, elastic strain energy and complementary energy, reciprocal relations, Maxwell-Betti theorem, Castigliano's theorem, principle of virtual work, statically indeterminate structures, Kirchoff's theorem;

Bending of beams: Bending of symmetrical and unsymmetrical straight beams, shear stresses in beams, shear center and shear flow, curved beam;

Torsion: Torsion of circular, elliptical and rectangular bars, thin walled sections;

Elastic stability: Euler's buckling load, beam column, eigenvalue problem;

Assignment and mini-project.

Course outcomes:

CO1:　Understand advanced stress-strain correlations.
CO2:　Obtain simple mathematical and physical relationships between mechanics and materials.
CO3:　Critical thinking and critical judgment of assumptions adopted.
CO4:　Establish links between theoretical and practical applications.
CO5:　Identify, formulate, model and analyze the complex engineering structural problem.

Textbooks
1. Srinath L.S. *Advanced Mechanics of Solids* (Tata McGraw-Hill, New Delhi, 2009)

2. Raymond P. *Solid Mechanics in Engineering* (Willey, 2001)

References
1. Sadd M.H. *Elasticity: Theory, Applications, and Numerics* (Academic Press, 2009)
2. Budynas R.G. *Advanced Strength and Applied Stress Analysis* (McGraw Hill, 1999)
3. Boresi A.P. and Schmidt, R.J. *Advanced Mechanics of Materials* (John Willey & Sons, 2003)

ME-623: Mathematical Methods for Engineers   **L-T-P-CH-CR: 3-1-0-4-4**

Course objectives:

There are two main objectives of this course:

   i. to summarize, crystallize, enhance and give a forward orientation to the mathematical methods taught in the undergraduate curriculum.
  ii. to prepare the students for future requirements related to advanced courses and research.

*Linear Algebra***:**
Introduction to Matrices & Linear Transformations;
Vector Spaces: Definition, linear independence of vectors, basis, inner product and inner product space, orthogonality, Gram-Schmidt procedure, subspaces;
Operational Fundamentals: Range and null space (rank & nullity), elementary transformations;
Systems of Linear Equations: Nature of solutions, existence and uniqueness of solution, Gauss elimination and Gauss Jordon methods, Echelon form, pivoting, LU decomposition and Cholesky method, Gauss-Seidel and Jacobi iterative methods, condition number, minimum norm and least square error solutions;
Eigenvalues and eigenvectors of matrices: Properties like multiplicity, eigenspace, spectrum and linear independence of eigenvectors, similarity transformation and Jordon canonical form, eigenvalues/eigenvectors of symmetric matrices: orthogonal diagonalization.
Iterative methods to find eigenvalues/eigenvectors of symmetric matrices: Forward iteration and Mises power method, inverse iteration;
Eigenvalue problems of general matrices & Singular value decomposition;
*Vector Analysis***:**
Curves in space: Parametric representation, tangent vector, arc length, curvature, principal normal vector, osculating plane, bi-normal vector;
Surfaces: Parametric representation, tangent vector and tangent plane;
Scalar & Vector fields: Gradient, directional derivative, potential; divergence, curl, solenoidal and irrotational vector fields; Line integral and path independence; Surface and volume integrals; Gauss (divergence), Stokes and Green's theorems;
*Topics in Numerical Methods***:**
Solution of nonlinear equations and systems, Newton-Raphson method for systems of nonlinear equations;
Interpolation and approximation: Polynomial interpolation - Lagrange and Newton single-polynomial interpolation, limitations of single-polynomial interpolation, Hermite interpolation;
Piecewise polynomial interpolation - piecewise cubic interpolation, spline interpolation;

Numerical integration: Newton-Cotes integration formulae, trapezoidal rule, Simpson's rule; Richardson Extrapolation and Romberg integration; Gaussian quadrature

Ordinary Differential Equations (ODEs):
Fundamental ideas: Autonomous systems, equilibrium points, linear homogeneous systems with constant coefficients;
Numerical solution of ODEs: Euler's method, improved Euler's method, Runge-Kutta methods; Solving systems of ODEs;
Stability of dynamic systems: Phase plane analysis, limit cycles, Lyapunov stability analysis;
Series Solutions and Laplace & Fourier transform methods of solving ODEs;

Partial Differential Equations (PDEs):
Quasi-linear second order PDEs: Hyperbolic, parabolic and elliptic forms, Initial and boundary conditions;
Hyperbolic equations: Method of separation of variables, solution of the wave equation by separation of variables, D'Alembert's solution of the wave equation;
Parabolic equations: Heat conduction in a finite bar, Heat conduction in an infinite wire;
Elliptic equations: Steady-state heat flow in a rectangular plate, steady-state heat flow with internal heat generation;
Numerical solution of partial differential equation.

Course-outcomes:

Students after successful completion of this course on mathematics will be able to:

  CO1:   Demonstrate an understanding of the mathematical concepts
  CO2:   Perform computations in higher mathematics
  CO3:   Develop and maintain problem-solving skills
  CO4:   Use mathematical ideas to model real-world problems
  CO5:   Communicate mathematical ideas with others

Textbooks:
1. Dasgupta B. *Applied Mathematical Methods*, Pearson Education (2006)
2. Kreyzig E. *Advanced Engineering Mathematics*, John Wiley & Sons, (2001)

References:
1. Strang G. *Linear Algebra and its Application*, Cengage Learning (2006)
2. O'Neil P.V. *Advanced Engineering Mathematics*, Cengage Learning (2007)
3. Arfken G. B. *et al*, *Mathematical Methods for Physicists*, Elsevier (2005)

ME-509: Advanced Dynamics and Vibration   **L-T-P-CH-CR: 3-0-0-3-3**

Course objectives:

  i.   To introduce the principles and applications Dynamics and role of vibration in machine system.

ii.   Provide a more rigorous basis for many familiar solutions from basic dynamics and vibration system.
iii.   Utilize different approach to deal vibration problems to develop solutions of practical engineering problems.
iv.   Understand dynamics and vibration of real life system, to solve practical engineering problem.
v.   To understand vibration control, use in different instruments and other device design.

Principles of dynamics: Generalized co-ordinates, degrees of freedom, constraints; equations of motions, Hamilton's principle, Lagrange's equations,
Single, two and multiple degrees of freedom systems,
Free and forced Vibration, transverse and torsional vibrations of two and three rotor systems, critical speeds,
Vibration isolation and measurements, normal mode vibration, coordinate coupling.
Vibration absorbers. Effect of damping; Continuous systems: vibration of strings, beams, bars; Raleigh-Ritz and Galerkin's methods.
Measurement techniques, vibration measuring instruments- design and working principle.

Course outcomes:

CO1:   Solve complex engineering problem in the field of Dynamics and Vibration
CO2:   Understanding the role of dynamics and vibration in engineering problem and to know the physical approach to both.
CO3:   To derive and obtain mathematical and physical relationships in problems related to vibration analysis.
CO4:   Critical thinking and critical judgment of assumptions adopted in practical problem from the field of dynamics and vibration.
CO5:   To model a vibration control system and knowledge about design of realistic system.

CO6:   Establish links between theoretical and practical applications of dynamics and vibration.

Textbooks:

1. Meirovitch L. *Elements of Vibration Analysis* (McGraw Hill, Second edition, 2006)
2. Meirovitch L. *Principles & Techniques of Vibrations* (Prentice Hall, New Jersey, 1997)
3. Thomson W. T. *Theory of Vibration with Applications* (CBS Publ., 5th edition, 1997)

References:

1. Rao J. S. and Gupta K. *Theory and Practice of Mechanical Vibrations* (New Age Publication, 1999)
2. Inman D. J. *Engineering Vibrations* (Prentice Hall, New Jersy, 4th Edition, 2013)
3. Tse F. S., Morse I. E. and Hinkle R. T. *Mechanical Vibrations* (CBS Publ., 2nd edition, 2004)

ME-502: Finite Element Methods **L-T-P-CH-CR: 3-1-0-4-4**

Course objectives:

i.   To introduce the basic principles and need of finite element method (FEM).
ii. To introduce the mathematical concepts of the FEM for obtaining an approximate solution of partial differential equations.
iii. To understand different steps and approaches to solve a problem using FEM.
iv. To find the solution in many points as many as we want of an object by discretizing the object.
v.   To develop proficiency in solving realistic engineering problem using commercial finite element software package.
vi. To encourage student for higher education by acquiring in-dept knowledge of FEM.

Introduction, basic concept, comparison with finite difference method;

Variational methods: Calculus of variation, Rayleigh-Ritz and Galerkin methods;

One-dimensional problems: Formulation by different approaches, derivation of elemental equations, assembly, solutions and post-processing, bending of beams, analysis of truss and frame, other problems of solid mechanics, fluid mechanics and heat transfer;

Two-dimensional problems: Modeling of single variable problems, triangular and rectangular elements, applications in solid mechanics, fluid mechanics and heat transfer;

Numerical considerations: Numerical integration, error analysis, mesh refinement;

Plane stress and plane strain problems; Bending of plates; Eigenvalue and time dependent problems;

Discussion about preprocessors, postprocessors;

Application of commercial software packages;

Assignment and mini-project.

Course outcomes:

CO1:   Learn the behaviour and uses of different types of elements.
CO2:   Find stress, strain and deformation of engineering problems of any dimensions using FEM.
CO3:   Understand the concepts behind variation methods in FEM.
CO4:   Solve complicated integration problem by using numerical integration technique.
CO5:   Built FE model, analyze, solve and design of complex geometric problems using the commercial FE software package.
CO6:   Pursue research in the field of FEM.

Textbooks
1. Chandrupatla T.R. and Belegundu, A.D. *Introduction to Finite Elements in Engineering*, Vol. 1 (Prentice Hall, 2002)
2. Bathe K.J. *Finite Element Procedures in Engineering Analysis* (Prentice Hall, 1996)

References

1. Reddy J.N. *An introduction to the Finite Element Method* (McGraw-Hill, 2006)
2. Cook R.D., Malkus, D.S. and Plesha, M.E. *Concepts and Applications of Finite Element Analysis* (Wiley, 2007)
3. Hughes T.J.T. *The Finite Element Method* (Dover Publications, 2000)
4. Zienkiewicz C. and Taylor, R.L. *The Finite Element Method* (McGraw-Hill, 1989)

ME-510: Engineering Design Laboratory   **L-T-P-CH-CR: 0-0-3-6-3**

Course objectives:

    i.   To introduce with design and modeling software for drafting and modeling of parts.
    ii.   To introduce with FEM packages like ANSYS for stress analysis of a certain class of engineering problems.
    iii.   To provide a thorough understanding of programming with MATLAB to solve design problems numerically.
    iv.   To provide a thorough understanding of programming with C programming to solve design problems
    v.   To introduce with MATLAB Simulink and different toolboxes.
    vi.   To provide a brief introduction of different experimental methods for stress analysis.
    vii.   To understand the significance of experimental data and their statistical analysis.

Introduction to Computer-Aided Design and Analysis: Basic Drafting, Modelling of Parts, Assembly. Introduction to Finite Element Programmimg: Basic engineering analysis of Beams, Trusses, Plates; Stress analysis of structure with individual and combined loading; Sensitivity analysis; Solution to problem with Mechanical, Thermal and Thermo-Mechanical loading.

Introduction to computational modeling: Introduction to MATLAB; MATLAB Basics: Arrays and Matrix Operations; Programming with MATLAB; Calling MATLAB in-built Functions; User-defined Functions; Plotting with MATLAB; Introduction to different tool-boxes & Simulink.

Experiments with Solids: Material properties; Experimental measurement of force, torque, stress, strain, and displacement in solids and structures; Photo-elasticity and strain gauges; Investigation of the micro-structure of materials; Digital image correlation technique.

    Analysis of Experimental Data: Error analysis, Uncertainty analysis, Data reduction techniques, Statistical analysis of data, Probability distributions and curve fitting.

Course outcomes:

CO1:   Use of Design software for drawing drafting and modeling of engineering parts
CO2:   Use of FEM packages like ANSYS for solving any engineering problems from basic to complex type.
CO3:   Write program in C language to solve a class of engineering problems.
CO4:   Write program in MATLAB to solve a class of engineering problems.
CO5:   Understand different experimental process and techniques for different experimental

analysis.

CO6: Analyze experimental data to conclude on their significance and basic of statistical tool

Textbooks
1. Wheeler A.J. and Ganji, A.R. *Introduction to Engineering Experimentation* (Pren-tice Hall, 2003)
2. Chapman S. J. *MATLAB Programming for Engineers* (Cengage Learning, 2007)

References
1. Munford P., Normand, P. *Mastering Autodesk Inventor 2016 and Autodesk In-ventor LT 2016* (John Wiley Sons, 2016)
2. Kent L.L. *ANSYS Workbench Tutorial Release 14* (SDC Publications, 2012)
3. Doeblin E.O., *Engineering Experimentation* (McGraw-Hill, 1995).
4. Chapra S.C., *Applied Numerical Methods with MATLAB for Engineering and Science* (McGraw-Hill Science, 2004).
5 MATLAB Handbook

ME-592: Term Paper   **L-T-P-CH-CR: 0-0-0-4-2**

Course objectives:

   i. To make students understand and learn how to survey literature on a particular research area or topic.
  ii. To make students learn how to write a research article.

This is a course of bit different flavor, aiming to help students to learn some research works beyond the normal curriculum. The main features of the course are:

(a) The course does not have any fixed syllabus, and hence no lecture, tutorial and practical.
(b) A student on consultation with a faculty member will survey literature on any research area of interest.
(c) The student will periodically present his/her observation to a board of faculty members.
(d) Finally the student will submit a report on his/her observation.
(e) An interested student will have the provision to carry out his/her MTech Thesis on the surveyed area.

Course outcomes:

Generally, the time required for literature survey and problem formulation affects many M.Tech students in performing quality research works in the limited period of one year for the same. On completion of this course:

CO1: A student would likely be able to complete the literature survey and problem formulation of the research work to be carried out in the M.Tech final year, thus to maximize the time

for conducting the research work.

CO2: Students would be able to organize and write research articles on a conducted research work.

New elective courses

SN	Course Code	Course Title	L-T-P-CH-CR
1.	ME-511	Experimental Stress Analysis for Design	3-0-1-5-4
2.	ME-512	Theory of Plasticity	3-0-0-3-3
3.	ME-513	Introduction to Fracture Mechanics	3-0-0-3-3
4.	ME-521	Robotics	3-1-0-4-4
5.	ME-606	Stability Problem in Applied Mechanics	3-0-0-3-3
6.	ME-607	Soft Computing Technique in Engineering	3-0-0-3-3
7.	ME-608	Mechatronics and Industrial Automation	3-0-0-3-3
8.	ME-609	Design of Internal Combustion Engine	3-0-0-3-3
9.	ME-610	Kinematics and Dynamics of Internal Combustion Engine	3-0-0-3-3
10.	ME624	Design of Internal Combustion Engine Auxiliary System	3-0-0-3-3

Syllabus (New elective courses)

ME-511: Experimental Stress Analysis for Design   **L-T-P-CH-CR: 3-0-1-5-4**

Course objectives:

  i.   To understand 'Stress Analysis' in a complete sense.
 ii.   To provide a clear understanding of the analytical, numerical and experimental analysis of stresses.
iii.   To introduce with different experimental methods for the analysis of in-service stresses.
 iv.   To introduce with different experimental techniques for the analysis of residual stresses.

Review of Stress and Strain Analysis: Stress-strain relations and general equations of elasticity;

Strain Measuring Devices: Various types of strain gauges, Electrical resistance strain gauges: gauge factor, types, gauge materials, backing materials, adhesives, protective coatings, bonding of strain gauges, lead wires and connections, Semiconductor strain gauges,
Performance of Strain Gauges: Temperature compensation, transverse sensitivity, gauge length, response, excitation level, stability;
Strain gauge circuits, recording instruments for static and dynamic applications, strain gauge rosettes analysis, stress gauge;
Photoelasticity: Theory of photoelasticity, analysis techniques, three dimensional photoelasticity;
Brittle coating methods of strain indication;
Introduction to Moiré fringe technique;
Residual Stress Analysis: Analytical and numerical solution of residual stresses in metal working processes (autofrettage, welding etc.), Experimental methods for assessing residual stresses: Sachs boring, X-ray diffraction, neutron diffraction and hole drilling method, inference of residual stresses from microhardness test.

Course-outcomes:

CO1:   Understand the basic difference among analytical, numerical and experimental stress analysis techniques and their need.
CO2:   Understand the different experimental measurement techniques for in-service stresses and the underlying physical principle of each of the technique.
CO3:   Understand the different destructive and non-destructive techniques for experimental measurement of residual stresses and the underlying physical principle of each of the technique.
CO4:   Select a suitable method for experimental determination of stresses for a problem on hand.
CO5:   Interpret and Analyze the experimental data obtained from different experimental stress measurement methods.
CO6:   Understand the different influential parameters affecting the measurement in each experimental stress analysis method and associated errors.

Textbooks
1. Dove R.C. and Adams P. H. *Experimental Stress Analysis* (McGraw Hill, 1992)
2. Dally J.W. and Riley W.F. *Experimental Stress Analysis* (McGraw-Hill Inc., New York, 1998)
3. Srinath, L.S. and Raghavan M.R. *Experimental Stress Analysis* (Tata McGraw-Hill, 1998).

References
1. Freddi A. Olmi G. and Cristofolini L. *Experimental Stress Analysis for Materials and Structures* (Springer, Switzerland, 2015)
2. Timoshenko S.P. and Goodier J.N. *Theory of elasticit*, (McGraw-Hill International Editions, 1970)
3. Sharpe W.N. *Handbook of Experimental Solid Mechanics* (Springer, 2008)
4. Noyan I.C. and Cohen J.B. *Residual Stress* (Springer, 1987)
5. Kandil F.A., Lord J.D., Fry A.T. and Grant P.V. *A review of residual stress measurement methods—A guide to technique selection* (NPL Report MATC(A)04, February 2001, NPL

Materials Centre Queens Road, Teddington, Middlesex, UK)
6. Kamal S.M. Borsaikia A. and Dixit U.S. Experimental assessment of residual stresses induced by the thermal autofrettage of thick-walled cylinders, *Journal of Strain Analysis*, Vol. 51(2), pp. 144−160, 2016.

ME-512: Theory of Plasticity   **L-T-P-CH-CR: 3-0-0-3-3**

Course objectives:

   i.   To introduce theoretical fundamentals of theory of plasticity.
   ii. To be able to derive and apply equations in the theory of plasticity for solving engineering problems.
   iii. To be able to apply established plasticity models in the analysis of elastic-plastic problems of practical importance.
   iv. To introduce with the recent research trends in the area of plasticity theory.

Stresses and Strain: Stress and strain behavior of materials, plastic and tangent modulus, strain hardening, plastic instability in tensile test, empirical stress-strain equations, effect of pressure, strain-rate and temperature. Analysis of stress tensor, eigenvalues, decomposition of stress tensor into deviatoric and hydrostatic components, octahedral stresses. Analysis of strain and strain-rates. Stress equilibrium and virtual work, objective stress rates.

The criteria of yielding. Isotropic and anisotropic hardening. Rules of plastic flow: Levy-Mises and Prandtl-Reuss equations. Hill's 1948 and 1979 yield criteria for anisotropic yielding. Anisotropic flow rule. Upper bound and lower bound theorems with a few applications.

Axisymmetric elastic-plastic problems: Hydraulic autofrettage, Swage autofrettage and Thermal autofrettage; Expansion of hole in a plate.

Plane stress elastic-plastic problems: Bending of beam.

Indentation problem: by upper bound and cavity method

Dynamics Elasto-plastic problems: Longitudinal stress wave propagation in a rod, Taylor rod problem.

Introduction to Updated Lagrangian and Eulerian formulations.

Course-outcomes:

CO1:   Understand the basic concepts of fundamental variables such as stress, strain and displacement tensor under the application of load, strain-rate, strain-hardening.
CO2:   Understand typical plastic yield criteria established in constitutive modeling.
CO3:   Understand the anisotropic yield criterion, e.g., Hill's 1948 and 1979 criterion.
CO4:   Apply basic analytical equations and constitutive models in the analysis of structures subjected to plastic deformation.
CO5:   Analyze axisymmetric elastic-plastic problems of practical importance and indentation problems using the principles of plasticity theory.
CO6:   Understand the principles of new autofrettage techniques such as thermal and

rotational autofrettage.

Textbooks
1. Dixit P.M. and Dixit U.S. *Plasticity: Fundamentals and Applications* (CRC Press, 2015)
2. Chakrabarty J. *Theory of Plasticity* (Elsevier Butterworth-Heinemann, 2006)

References
1. Dixit P.M. and Dixit U.S. *Modeling of Metal Forming and Machining Processes by Finite Element and Soft Computing Methods* (Springer, 2008)
2. Rees D.W.A. *Basic Engineering Plasticity* (Elsevier Butterworth-Heinemann, 2006)
3. Lal G.K. and Reddy N.V. *Introduction to Engineering Plasticity* (Narosa, 2009)
4. Kamal S.M. and Dixit U.S. Feasibility study of thermal autofrettage of thick-walled cylinders, *ASME Journal of Pressure Vessel and Technology*, Vol. 137(6), pp. 061207-1−061207-18, 2015.

ME513: Introduction to Fracture Mechanics   **L-T-P-CH-CR: 3-0-0-3-3**

Fatigue: Mechanisms of fatigue crack initiation and propagation; Notch sensitivity; Factors influencing fatigue strength, Prevention of fatigue failure.
Introduction to fracture: Failure and fracture, Types of fracture, Modes of fracture failure.
Energy of Fracture: Energy balance during crack growth, Griffith's theory, Crack stability, Fracture criterion, Strain energy release rate.
Linear Elastic Fracture Mechanics: Analysis of crack tip stress, Irwin's fracture criterion, Determination of stress intensity factor, Fracture toughness.
Elastic-Plastic Fracture Mechanics: Crack tip opening displacement, J-Integral and its applications;
Computational Fracture Mechanics: Finite element method, Virtual crack extension, Virtual crack closer integral;
Advanced Topics: Fracture in composite, Fracture in nanometer scale.
Case studies on fracture failure.

Textbooks
1. Kumar, P. *Elements of Fracture Mechanics* (Tata McGraw-Hill, New Delhi, 2009)
2. Anderson, T.L. *Fracture Mechanics: Fundamentals and applications* (3rd ed., CRC Press, 2005)

References
1. Sanford R.J. *Principles of Fracture Mechanics* (Prentice Hall, 2003)
2. Bolotin V.V. *Mechanics of Fatigue* (CRC Press, 1999)
3. Broek, D. *Elementary Engineering Fracture Mechanics* (Kluwer Academic Publishers, 1986)
4. Rolfe S.T. and Barsom J.M. *Fracture and Fatigue Control in Structures: Applications of Fracture Mechanics* (Butterworth-Heinemann, 2000)
5. Maiti S.K. *Fracture Mechanics: Fundamental and Applications* (Cambridge University Press, 2015)
6. Kundu T, *Fundamental of Fracture Mechanics* (CRC Press, Taylor & Francis, 2008)
7. Kuna M. *Finite Elements in Fracture Mechanics* (Springer, 2013)
8. Gdoutos E. E. *Fracture of Nano and Engineering Materials and Structures* (Springer, 2006)

ME521: Robotics   **L-T-P-CH-CR: 3-1-0-4-4**

Course Objectives:

    i.   To introduce the concept of robotics.
    ii.   To introduce mathematical representation of robots.
    iii.   To introduce forward and inverse kinematics of manipulators.
    iv.   To familiarize students with the concepts like Jacobian, workspace, singularity etc.
    v.   To introduce forward and inverse dynamics of manipulators.
    vi.   To discuss various schemes of trajectory planning.
    vii.   To introduce feedback control, PID control, stability analysis.
    viii.   To discuss various elements of a robotic system: Actuators, Transmission & Sensors.

Introduction: A brief history; Types of robots; Basic principles in robotics; Notation.

Mathematical Representation of Robots: Position & orientation of a rigid body; Transformation between coordinate systems; Homogeneous transformation and its properties; Representation of joints; Representation of links using Denavit-Hartenberg parameters; Link transformation matrices.

Kinematics of Serial Manipulators: Degrees of freedom; Direct kinematics problem; Inverse kinematics problem; Redundant manipulators.

Velocity Analysis and Statics of Manipulators: Linear and angular velocities of a rigid body; Linear and angular velocities of links in serial manipulators; Jacobian; Singularities of serial manipulators; Statics of serial manipulators; Redundancy resolution.

Elements of Kinematics of Parallel Manipulators: Degrees of freedom; Direct kinematics problem; Inverse kinematic problem; Mobility of parallel manipulators; Jacobian, Statics & Singularity.

Dynamics of Manipulators: Forward and inverse dynamics of manipulators; Newton-Euler and Lagrangian formulations.

Trajectory Planning and Generation: General considerations in path description and generation; Joint space schemes; Cartesian space schemes.

Position and Force Control of Manipulators: Feedback control of a single-link manipulator; PID control of a multi-link manipulator; Non-linear control of manipulators; Partitioning a task for force and position control; Hybrid position/force controller; Stability analysis.

Elements of a Robot: Actuators, Transmission & Sensors.

Course outcomes (COs):

CO1:   Understand the concept of robotics.
CO2:   Represent robots in mathematical form.
CO3:   Understand forward and inverse kinematics of manipulators.
CO4:   Understand concepts like Jacobian, workspace, singularity etc.
CO5:   Understand forward and inverse dynamics of manipulators.
CO6:   Plan robot trajectory in various schemes.
CO7:   Control robot using feedback control, PID control and do stability analysis.

CO8: Develop robotic system using its components, which are Actuators, Transmission & Sensors.

Textbooks
1. Ghosal A. *Robotics - Fundamental concepts & Analysis* (Oxford university press, 2006)
2. Craig J. J. *Introduction to Robotics - Mechanics & Control* (Addison - Wesley Publishing Company, New York, 1986)

References
1. Asada H. and Slotine J. E. *Robot Analysis & Control* (John Wiley & Sons, New York, 1986)
2. Nakamura Y. *Advanced robotics - Redundancy & Optimization* (Addison - Wesley Publishing Company, New York, 1991)
3. Merlet J.P. *Parallel Robots* (Kluwer Academic Publishers, Netherlands, 2000)

ME606: Stability Problems in Applied Mechanics　　　　　　**L-T-P-CH-CR: 3-1-0-4-4**

*Basic Dynamic Considerations***:**
Introduction; One-Dimensional Flows: Flows on the Line; Parameter Dependent Flows & Bifurcations; Flows on the Circle;
Two Dimensional Dynamic Systems: Phase-plane Description; Linearized Stability Analysis; Limit cycle and its Stability; Parametric Instability: Floquet Theory.
*Stability of Static Equilibrium***:**
Introduction; Euler's Method: Buckling of Columns; Energy Method: Approximate Solution; Non-adjacent Equilibrium Configuration: Snap Buckling; Asymmetric Deformation, Imperfection Sensitivity; Buckling due to Follower Load: Insufficiency of Static Analysis; Euler Buckling Load Revisited: Dynamic Analysis; Second Revisit of Buckling of Column (Euler Load); Other Examples of Instability.
*Stability Problems in Dynamics***:**
Introduction; Different Notions of Stability; Stability of Equilibrium Configuration; Stability of a Rotating Rigid Body; Parametric Instability of a Linear Continuous System; Periodic Solution of Non-Linear Oscillators and its Stability.
Emergence of Length Scale and Pattern Formation:
Introduction; Stripes of Zebra Skin; Turning Pattern; Rayleigh-Taylor Instability; Staffman-Taylor Instability; Rayleigh-Plateau Instability; Rayleigh Benard Convection; On the Nature of Bifurcation; Faraday Instability; Rotating Couette Flow; Hydraulic Jump.

Textbooks:
1. Mallik, A. K. and Bhattacharjee, J. K. *Stability Problems in Applied Mechanics*, Narosa Publication (2005)

References:
1. Dym, C.L., *Stability Theory & its application to Structural Mechanics*, Noordhoff International Publications, Holland (1974)
2. Baznat, Z.P. and Cedolin, L., *Stability of Structures*, Oxford University Press, NY (1991)
3. Timoshenko, S.P. and Gere, J.M., *Theory of Elastic Stability*, Mc-Graw Hill, New York (1961)

4. Strogatz, S. H., *Nonlinear Dynamics & Chaos*, Addison-Wesley Pub. Co. Reading (1994)
5. Jordan D.W.and Smith, P., *Nonlinear Ordinary Differential Equations*, Clarendon Press, Oxford (1999)

ME-607: Soft Computing Techniques in Engineering   **L-T-P-CH-CR: 3-0-0-3-3**

Course objectives:

i. The main objective of this course is to impart the knowledge of different Artificial intelligence based system.
ii. Utilize computer program, toolbox and functions in manufacturing system to develop solutions to practical engineering problems.
iii. Student can learn and understand the relation between real life system and its model and analysis to deal with such system.
iv. Understand advanced technology in the field of engineering with intelligent system.
v. Since the modern artificial intelligence system has been growing both in quality and quantity, this course will give a wide field for discussion of such advances.

Introduction to soft computing, hard computing, Need for soft computing;
Neurons and neural networks; Basic models of artificial neural networks – single-layer perceptron, multilayer perceptron; Radial basis function networks; SOM; Recurrent neural networks; Training of neural network; Applications of neural networks in mechanical engineering;
Introduction to fuzzy sets, Fuzzy reasoning and clustering;
Optimization tools: Traditional and non-traditional, genetic algorithms, simulated annealing etc.;
Combined techniques: Genetic Algorithms–Fuzzy Logic, Genetic Algorithms–Neural Networks, Neural Networks–Fuzzy Logic.
Support Vector Machine (SVM) - introduction, principle and application.

Course outcomes:

CO1: Understand advanced techniques of soft computing in design and manufacturing process.
CO2: Critical thinking and critical judgment on practical implementation of soft computing tools.
CO3: Interpretation on design and analysis of engineering problems and use the artificial module in different application.
CO4: Establish links between theoretical and practical applications.
CO5: In hand practice to software packages, programming and problem solving.

CO6: Student would be able to know the different technologies involved in advanced automated system, robotics and expert system
CO7 Students will learn how to design and work with system by imparting human cognitive intelligence

Textbooks:
1. Pratihar D. K. *Soft Computing* (Narosa Publishing House, 2015)

2. Haykin S. *Neural Networks: A Comprehensive Foundation* (Pearson Education, 2nd ed., 2009)
3. Chen G. and Pham T.T. *Introduction to Fuzzy Sets, Fuzzy Logic, and Fuzzy Control Systems* (CRC Press, 2001)

References:
1. Dixit, P. M. and Dixit, U. S., *Modeling of metal forming and machining processes: by finite element and soft computing methods*, (Springer, 1st ed., 2008)
2. Deb K. *Optimization for Engineering Design: Algorithms and Examples* (Prentice Hall, 2006)
3. Aliev R.A. and Aliev R.R. *Soft Computing and its Applications* (World Scientific Publishing, 2001)

ME-608: Mechatronics and Industrial Automation   **L-T-P-CH-CR: 3-0-0-3-3**

Course Objectives:

  i. To give framework of knowledge that allows students to develop an interdisciplinary understanding and integrated approach to practical and applied engineering problems.
  ii. To introduce about mechatronics systems and its components.
  iii. To understand principles of sensors, its characteristics and actuators.
  iv. To understand the concept of PLC system and its ladder programming, and significance of PLC systems in industrial application
  v. To familiarize with the basics of automation technology.

Introduction to Mechatronics: Introduction, Elements of Mechatronics system, Applications.

Sensors and Actuators: Sensing principle, Electrical actuators, Hydraulic and Pneumatic actuators.

Signal Processing: Signal conditioning devices, Protection, Conversion and pulse width modulation, Data conversion devices.

Microprocessors: Introduction to microprocessors, Introduction to microprocessor programming, Internal architecture of 8085 microprocessor.

Principles of Automation Technology: Automation system components, Discrete manufacturing automation, Continuous process automation.

Programmable Logic Controllers (PLC): Industrial Control, Structure of PLC, Programming languages for PLC, Boolean logic for process control, Timers, Counters and other functions.

Feedback Control: Continuous and Time- Discrete control, On/Off control, PID control, Distributed Control System (DCS)

Man machine communication: Supervisory control and data acquisition (SCADA)
Assignment and mini-project.

Course outcomes (COs):

CO1: Identify key elements of mechatronics system and its components.
CO2: Understand the concept of signal processing
CO3: Interface sensors, actuators using appropriate micro-controller

CO4:   Understand microprocessor and its architecture.
CO5:   Understand the importance and application of PLC in automation in industries
CO6:   Control mechatronic systems.
CO7:   Understand automation technology in industries.
CO8:   Interface using HMI.

Textbooks
1. Bolton W. *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering* (Pearson education, 2007)
2. Lamb F. *Industrial Automation: Hands-On* (McGraw-Hill Education, 2013)

References
1. Appukuttan K.K. *Introduction to mechatronics* (Oxford University Press, 2007)
2. Stenerson J. *Industrial automation and process control* (Prentice Hall, 2003)

ME-609: Design of Internal Combustion Engine   **L-T-P-CH-CR: 3-0-0-3-3**

Prerequisite for engineering design and design conditions of internal combustion engine components, Design of parts working under alternating loads, piston, piston ring and pin, Design of connecting rod small end, big end, shank and bolts, pressure on crank pin and journals, Design of crank web, inline and V engine crankshafts, Design of cylinder block, upper crankcase, liner, cylinder head and studs, Design of cam profile, harmonics of cam, valve gear, valve spring and camshaft, electronic control system for IC engine.

Textbooks
1. Hoag, K. and Dondlinger, K. *Vehicular Engine Design* (Springer, New York, 2016)
2.   Smith, J. H. *An Introduction to Modern Vehicle Design* (Butterworth-Heinemann, Oxford, 2002)

References
1. Kolchin, A. and Demidov, V. *Design of Automotive Engine* (Mir Publisher, Moscow, 1984)
2. Fenton, J. *Hand Book of Vehicle Design Analysis* (Mechanical Engineering Publication Limited, London, 2013).

**ME-610: Kinematics and Dynamics of Internal Combustion   L-T-P-CH-CR: 3-0-0-3-3
Engine**

Fundamentals of kinematics and dynamics, Different components of internal combustion engine, Types of IC Engine (Petrol, Diesel, 4 stroke , 2 strok4), Speed characteristics, Kinematics of crank mechanism comprising of piston stroke, speed and acceleration, Dynamics of crank mechanism comprising of gas pressure forces, masses of crank mechanism, inertial forces, total forces acting in crank mechanism, forces acting on crank pins, forces acting on main journals, crankshaft journals and pin wear, Balancing of diverse types of engines, uniformity of engine torque.

Textbooks
1. Hoag, K. and Dondlinger, K. *Vehicular Engine Design* (Springer, New York, 2016)
2. Smith, J. H. *An Introduction to Modern Vehicle Design* (Butterworth-Heinemann, Oxford, 2002)

References
1. Kolchin, A. and Demidov, V. *Design of Automotive Engine* (Mir Publisher, Moscow, 1984)
2. Fenton, J. *Hand Book of Vehicle Design Analysis* (Mechanical Engineering Publication Limited, London, 2013).

Existing elective courses related to Machine Design

SN	Course Code	Course Title	L-T-P-CH-Cr
1.	ME-503	Mechanics of Composite Materials	3-1-0-4-4
2.	ME-504	Failure Analysis of Materials	3-0-0-3-3
3.	ME-505	Advanced Dynamics	3-1-0-4-4
4.	ME-506	Theory of Elasticity and Plasticity	3-0-0-3-3
5.	ME-507	Theory of Plates and Shells	3-0-0-3-3
6.	ME-508	Continuum Mechanics	3-0-0-3-3
7.	ME-525	Tribology	3-0-0-3-3
8.	ME-527	CAD-CAM	3-0-0-3-3
9.	ME-538	Computer-Aided-Design in Engineering	3-1-0-4-4

ME-503: Mechanics of Composite Materials   L-T-P-CH-CR: 3-1-0-4-4

Course objectives:

   i.   understand the importance of composites materials.
  ii.   be familiar with the properties and characteristics of composite materials.
 iii.   acquire the concept of tailored design philosophy.
 iv.   acquire knowledge on the role of interface between fiber and the matrix.
  v.   design and analysis of laminated composites

Introduction - classifications, terminologies, manufacturing processes and applications of composite materials;

Macro-mechanical behavior of lamina - stress-strain relations, engineering constants for orthotropic materials, transformation of stress and strain, strength and stiffness of lamina, biaxial strength theories;
Micro-mechanical behavior of lamina – volume and mass fractions;
Macro-mechanical behavior of laminates – single-layered configurations, symmetric laminates, anti-symmetric laminates, strength of laminates;
Hygro-thermal analysis of lamina and laminates;
Design of laminates – symmetric, cross-ply, angle-ply and anti-symmetric laminates;
Failure analysis – failure criteria and failure modes, buckling and vibration of laminated beams, plates and shells; Assignment and mini-project.

Course outcomes:

CO1: acquire knowledge on the types, advantages, applications, and manufacturing processes of composite materials.
CO2: analyze macro-mechanical and micro-mechanical behavior of lamina.
CO3: analyze macro-mechanical behavior of laminate.
CO4: design and analyze of laminated composites materials.
CO5: design and analyze of laminated composite structure using software packages.
CO6: acquire knowledge on recent advancement of composite materials and do research on such advanced material in future.

Textbooks
1. Daniel, I.M. and Ishai, O. *Engineering Mechanics of Composite materials* (Oxford University Press, 2005)
2. Jones, R.M. *Mechanics of Composite Materials* (Taylor & Francis, 1999)
References
1. Agarwal, B.D., Broutman, L.J. and Chandrashekhara, K. *Analysis and Performance of Fiber Composites* (John Willey &Sons, 2006)
2. Kaw, A.K. *Mechanics of Composite Materials* (Taylor & Francis, 2006)
3. Reddy, J.N. Mechanics of Laminated Composite Plates (CRC Press, 1997)

ME-504: Failure Analysis of Materials   L-T-P-CH-CR: 3-0-0-3-3

Course Objectives:
(i) give detailed knowledge on principles of fracture and failure.
(ii) generate ideas on different modes of failure under different conditions of engineering applications.
(iii) introduce different procedures for destructive material testing.
(iv) apply failure analysis of materials for mechanical design.

Introduction, common causes of failure, failure investigation, principle of failure analysis;
Fracture mechanics – energy approach and stress intensity factor approach to linear elastic fracture mechanics, concept of crack tip opening displacement and J-integral fracture criteria, mechanisms

of fracture, evaluation of fracture toughness, fracture in composite materials, computational fracture mechanics analysis, fracture mechanics in nano materials and structures;

Creep - stress-time-temperature relations, creep curve;

Fatigue - stresses in cyclic loading, fatigue testing, S-N curves and endurance limit, mechanisms of fatigue crack initiation and propagation, influence of stress concentration on fatigue strength, notch sensitivity, factors influencing fatigue behavior, prevention of fatigue failure;

Assignment and mini-project.

Course outcomes:

CO1: identify the different principles, causes and modes of fracture and failure.

CO2: apply knowledge of fracture and failure in the field of mechanical design.

CO3: present the outcome in the form of group projects on advanced design of mechanical/structural components considering the in-depth knowledge of material failure.

CO4: correlate design considerations with material strength and properties of failure.

Textbooks
1. Kumar, P. *Elements of Fracture Mechanics* (McGraw-Hill, 2009)
2. Anderson, T.L. Fracture Mechanics: Fundamentals and Applications (CRC Press, 2004)

References
1. Bruck, D. Elementary Engineering Fracture Mechanics (Springer, 1986)
2. Barson, J.M. and Rolfe, S.T. *Fracture and Fatigue Control in Structures* (Butterworth-Heinemann, 1999)
3. Dieter, G. *Mechanical Metallurgy* (McGraw-Hill, 1986)
4. Calister, W.D. *Material Science and Engineering: An Introduction* (John Wiley & sons, 2009)
5. Gdoutos, E.E. *Fracture of Nano and Engineering Materials and Structures* (Springer, 2006)

ME-505: Advanced Dynamics　　　　　**L-T-P-CH-CR: 3-1-0-4-4**

Newton and Euler equations of motion for constrained systems;

D'Alembert's principle, Lagrange's equations, Hamilton's equations;

Rigid body kinematics and dynamics;

Differential approaches for equations of motion;

Integral approach for equations of motion - Hamilton's principle, Boltzmann-Hamel equation;

Stability analysis of dynamic systems;

Numerical solutions of nonlinear algebraic and differential equations governing the behaviour of multiple degree of freedom systems;

Computer simulation of multi-body dynamic systems;

Assignment and mini-project.

Textbooks
1. Meirovitch, L.M. *Methods of Analytical Dynamics* (McGraw-Hill, 1988)

2.   Baruh, H. *Analytical Dynamics* (McGraw-Hill, 1999)
References
1.   Greenwood, D.T. *Principles of Dynamics* (Prentice Hall, 1988)
2.   Shabana, A.A. *Computational Dynamics* (John Wiley & Sons, 2010)

ME-506: Theory of Elasticity and Plasticity   L-T-P-CH-CR: 3-0-0-3-3

Basic elasticity - cartesian tensor, three dimensional stress and strain systems, Navier's equations, Airy's stress function, Mohr's circle for three-dimensional stress and strain systems, viscoelasticity;
Torsion - torsion of noncircular bars, elastic analysis, membrane analogy;
Introduction to plasticity - mechanical behaviour in the plastic range, fundamentals of plasticity theory, solution of elastoplastic problem, Bausschinger effect-yield locus, yield surface;
Yield criteria and flow rules - Tresca theory and von Mises yield criterion, their geometrical representation, experimental evidence for the criteria;
Slip line field theory – two-dimensional plasticity, slip lines, basic equations, Hencky's first theorem, Geiringer's velocity equation, application of slip line field theory to plane strain problems;
Application to metal forming, plastic analysis of structures;
Assignment and mini-project.

Textbooks
1.   Timoshenko, S.P. and Goodier, J.N. *Theory of Elasticity* (McGraw-Hill, 1970)
2.   Chakroborty, J. Theory of Plasticity (McGraw Hill, 1987)
References
1.   Sokolnikoff, I.S. *Mathematical Theory of Elasticity* (McGraw-Hill, 1957)
2.   Khan, A. and Huang, S. *Continuum Theory of Plasticity* (Wiley, 1995)

ME-507: Theory of Plates and Shells   L-T-P-CH-CR: 3-0-0-3-3

Definition of plate and shells;
Small deflections of transversely loaded isotropic thin plates;
Equations and boundary conditions for thin rectangular and circular plates;
Different types of supports associated with plate and shells;
Shell behaviour, shell surfaces and characteristics, classifications of shells, equilibrium equations in curvilinear coordinates, force displacement relations;
Moment theory;
Rotationally symmetric shells;
Shallow shell theory;
Assignment and mini-project.

Textbooks
1.   Timoshenko, S. and Woinowsky-Krieger, S. *Theory of plates and shells* (McGraw-Hill, 1959)
2.   Ugural, A.C. *Stress in Plates and Shells* (McGraw-Hill, 1998)

ME-508: Continuum Mechanics   **L-T-P-CH-CR: 3-0-0-3-3**

Concept of continuum mechanics, mathematical preliminaries related to continuum mechanics;
Kinematics – motion of a continuum, displacement vector, deformation and deformable bodies, deformation gradient, strain tensor, equation of continuity, polar decomposition, volumetric and deviatoric strains, transformation of tensor, plane strain deformation;
Kinetics – traction boundary conditions, stress tensor, transformation of stress tensor, deviatoric stress, von Mises stress, balance of energy, entropy inequality;
Constitutive relations for various elastic materials such as thermoelastic material, isotropic thermoelastic material, transversely isotropic thermoelastic material, orthotropic thermoelastic material, incompressible elastic material, thermoviscoelastic material;
Applications to engineering problems such as torsion of a circular cylinder, bending of beams, expansion in pressure vessels, fluid flow between over plates and in circular pipes;
Assignment and mini-project.

Textbooks
1. Lai, W.M., Krempl, E. and Rubin, D. *Introduction to Continuum Mechanics* (Elsevier, 1996)
2. Gurtin, M.E. *An Introduction to Continuum Mechanics* (Academic Press, 1981)

References
1. Batra, R.C. *Elements of Continuum Mechanics* (AIAA, 2005)
2. Dill, E.H. *Continuum Mechanics: Elasticity, Plasticity, Viscoelasticity* (CRC Press, 2006)
3. Fung, Y.-C. *A First Course in Continuum Mechanics* (Prentice-Hall, 1977)
4. Mase, G.T. *Continuum Mechanics for Engineers* (CRC Press, 1999)

ME-527: CAD-CAM   **L-T-P-CH-CR: 3-0-0-3-3**

Course objectives:

  i. Provide a more rigorous basis for understanding the computer based design and manufacturing.
 ii. Utilize computer aided design and computer aided manufacturing system to develop solutions to practical engineering problems.
iii. Proficient in design analysis, transformations, alternative measures to deal with design and manufacturing challenges.
 iv. Understand the advanced technology in the field of engineering by CAD-CAM.
  v. Proficiency in use of CAD and CAE packages for design and analysis.

Introduction and Overview: Components of Computer aided design (CAD), Components of Computer aided manufacturing (CAM)/Computer aided engineering (CAE) systems.

Basic concepts and Application: Basic concept of graphics programming; Transformation matrix-Rendering Graphical user interface; Computer aided drafting systems.

Geometric modeling systems: Wire-frame surface and solid modeling systems Non-manifold systems; Assembly and web-based modeling systems.

Numerical control: Concepts for manual and computer assisted part programming; NC, CNC and DNC Virtual engineering – components and applications.

Introductory laboratory work: laboratory work on CAD (Solid modeling software), laboratory work on CAE (Finite element analysis) software

Course outcomes:

CO1: Have the knowledge of computer aided design and manufacturing for solving related application-oriented problems.

CO2: Understand the advanced design and manufacturing process to cope with latest technology.

CO3: Critical thinking and critical judgment on practical implementation so as to face real life problem solving.

CO4: Interpretation on design and analysis of engineering problems and clear concept and observation.

CO5: Establish links between theoretical and practical applications in real life cases.

CO6: Undertake problem identification, formulation and solution for industrial application.

Textbooks

1. Kunwoo Lee, *Principles of CAD/CAM/CAE systems*, Addison Wesley, 1999.
2. Mikell P. Groover and Emory W. Zimmers *,CAD/CAM: Computer aided design manufacturing*, Prentice Hall, 1996.

Reference Books:

1. Mark E. Coticchia, George W. Crawford, and Edward J. Preston, *CAD/CAM/CAE systems: justification, implementation and productivity measurement* , 2nd edition, New York, Marcel Dekker, 1993.

2. Chris Macmahon and Jimmie Browne *CADCAM: principles, practice and manufacturing management*, 2nd edition, Addison Wesley, 1998.

P. Radhakrishnan, S. Subramanyan, and V. Raju *,CAD/CAM/CIM* , 2nd edition, New Age,

ME-538: Computer-Aided-Design in Engineering   L-T-P-CH-CR: 3-1-0-4-4

Overview of computer aided engineering design;
Transformation - representation and transformation of points, homogeneous coordinates, rotation, reflection, translation, scaling and sharing of lines, combined transformation, solid body transformation;
Projections - orthographic, axonometric, oblique and perspective projections;
Plane curves - parametric and nonparametric curves like circle, ellipse, parabola and hyperbola; Conic sections;
Space curves - cubic splines, parabolic blending, Bézier curves and B-spline curves;
Surface Generation - surface of revolution, sweep surface, quadric surface, bilinear surface, ruled and developable surfaces, Coons linear surface, Coons bicubic surface, Bézier surface, B-spline surface and composite surface;
Solid body modeling - designing three-dimensional models like machine parts, hidden line and surface removal;
Application of commercial solid modelers; Assignment and mini-project.

Textbooks
1.   Rogers, D.F. and Adams, J.A. *Mathematical Elements for Computer Graphics* (Tata McGraw-Hill, 2002)
2.   Mortenson, M.E. *Mathematics for Computer Graphics Applications* (Industrial Press, 1999)

References
1.   Plastock, R.A. and Kalley, G. *Computer Graphics* (McGraw-Hill, 1986)
2.   Mortenson, M.E. *Geometric Modeling* (John Wiley & Sons, 1985)
3.   Ryan, D.L. *Computer-Aided Graphics and Design* (Marcel Dekker, 1994)

Additional elective courses offered for M.Tech in Mechanical Engineering (Specialization: Machine Design)

ME-539: Optimization Techniques in Engineering   L-T-P-CH-CR: 3-0-0-3-3

Course objectives:

i. The main objective of the course is to introduce classical optimization methods to students.
ii. To impart knowledge to students on selection and application of appropriate classical optimization methods for handling different classes of single-objective optimization problems in both continuous and discrete search space.

Introduction – definition and importance of optimization, basic terminologies, general problem formulation;
Single variable unconstrained optimization – first and second order optimality criteria, bracketing and refining optimum point, direct search methods, gradient-based search methods;
Multi-variable unconstrained optimization - first and second order optimality criteria, unidirectional search, direct search methods, gradient-based search methods;
Constrained linear programming problems – simplex method, duality in linear programming;
Constrained nonlinear programming problems - Kuhn-Tucker conditions, sensitivity analysis, penalty function methods, method of multipliers, direct search methods, sequentially linearized methods, feasible direction method, gradient-based search methods, quadratic programming;
Specialized algorithms for integer and geometric programming problems;
Application of different optimization methods to mechanical design problems;
Assignment and mini-project.

Course-outcomes:

On completion of the course, students would be able to:

CO1:   Formulate different types of single-objective optimization problems
CO2:   Select and apply appropriate optimization techniques to problems at hand
CO3:   Solve nonlinear problems using both exact and numerical methods
CO4:   Solve linear problems using exact methods
CO5:   Solve discrete problems using specialized methods

Textbooks
1.   Deb, K. *Optimization for Engineering Design – Algorithms and Examples* (Prentice-Hall of India, 1995)
2.   Arora, J.S. *Introduction to Optimum Design* (Academic Press, 2004)
References
1.   Belegundu, A.D. and Chandrupatla, T.R. *Optimization Concepts and Applications in Engineering* (Pearson Education, 1999)
2.   Rao, S.S. *Optimization: Theory and Applications* (Wiley Eastern, 1984)

ME-540: Evolutionary Algorithms for Optimum Design   **L-T-P-CH-CR: 3-0-0-3-3**

Course objectives:

i. To introduce students with evolutionary algorithms (EAs) for solving such problems for which classical optimization methods are not adequate.
ii. To introduce EAs covering both single-objective and multi-objective optimization in both continuous and discrete regions, constraint handling, elite preservation, as well as performance metrics and statistical methods for evaluating performances of multi-objective optimizers.

Introduction - brief review of classical optimization methods, definition and importance of nontraditional techniques; Evolutionary algorithms (EAs) – solution representations for different types of variables, population initialization and evolution;
Genetic algorithm - selection, crossover and mutation operators; Differential evolution – mutation, crossover and selection operators; Particle swarm optimization – personal and global best particles, velocity and position of a particle;
Constraints handling and elite preservation in EAs; Influence of algorithmic parameter values in EAs and hybridized EAs;
Multi-objective optimization – concept of dominance, non-dominated sorting, diversity of solutions, Pareto front;
EAs to different types of problems, in particular to mechanical design problems including structural shape design;
Performance measurements of multi-objective optimizers - concept of dominance relation among Pareto fronts, performance metrics and their properties, statistical methods for comparing performances of multi-objective optimizers;
Assignment and mini-project.

Course-outcomes:

CO1: Understand the need of evolutionary algorithms (EAs) over classical optimization methods
CO2: Learn the general working procedure of EAs
CO3: Learn some well-established EAs in detail
CO4: Learn how multi-objective EAs work
CO5: Evaluate performances of multi-objective EAs

Textbooks
1. Sivanandom, S.N. and Deepa, S.N. *Introduction to Genetic Algorithms* (Springer, 2010)
2. Price, K.V., Storn, R.M. and Lampinen, J.A. *Differential Evolution: A Practical Approach to Global Optimization* (Springer, 2005)
3. Olsson, A.E. *Particle Swarm Optimization: Theory, Techniques and Applications* (Nova Science Pub, 2011)
4. Deb, K. *Multi-Objective Optimization using Evolutionary Algorithms* (John Wiley & Sons,

2001)

References
1.   Coello Coello, C.A., Lamont G.B. and van Veldhuizen, D.A. *Evolutionary Algorithms for Solving Multi-Objective Problems* (Springer, 2007)
2.   Tan, K.C., Khor, E.F. and Lee, T.H. *Multiobjective Evolutionary Algorithms and Applications* (Springer, 2005)
3.   Chakraborty, U.K. *Advances in Differential Evolution* (Springer, 2008)
4.   Clerc, M. *Particle Swarm Optimization* (John Wiley & Sons, 2010)
5.   Mann, P.S. *Introductory Statistics* (John Wiley & Sons, 2004)

ME-572: Advanced Engineering Materials   **L-T-P-CH-CR: 3-0-0-3-3**

Course Objectives:
(i)   give detailed knowledge on structure and properties of advanced engineering materials for design purposes.
(ii)   increase interest on advanced materials and advanced design / manufacturing technology.
(iii) understand the criteria for selection of materials during advanced design and manufacturing for specialized engineering applications.

Advanced materials for engineering applications, engineering materials - metals, polymers, composites and ceramics;

Structure-property correlation - role of crystal structure, substructure and microstructure on material properties;

High performance structural metallic alloys and their applications, surface engineering of materials and their applications;

Piezoelectric materials, shape memory alloys, smart materials and composite materials and their applications;

Micro-electro-mechanical systems (MEMS) - characteristics of materials for MEMS applications and manufacturing techniques for MEMS components;

Materials for high temperature applications - various alloys and composites, diffusion bond coating;

Powder metallurgy; Selection of materials - materials aspects, cost and manufacturing considerations;

Applications of materials to automobile and transport vehicles, aerospace, power generation, armament, marine environment and ocean structures, materials for other specialized applications; Assignment and mini-project.

Course outcomes:
On successful completion of this course, students will be able to:

CO1:   gain detailed knowledge on advanced materials, their structure, properties and applications.
CO2:   understand the need of advanced and non-conventional materials for

contemporary and specialized engineering applications.

CO3: correlate material properties with design considerations and materials selection.

CO4: prepare for advanced design and manufacturing technology.

CO5: present the outcome in the form of group projects on material characterization and advanced design and manufacturing.

Text Books:
a. Calister, W.D. Material Science and Engineering - An Introduction (John Wiley & sons, 1997)

Reference Books:
a. Gandhi, M.V. and Thompson, B.S. Smart Materials and Structures (Chapman and Hall, 1992)
b. Otsuka, K. and Wayman, C.M. Shape Memory Materials (Cambridge University Press, 1999)
c. Taylor, W. Pizoelectricity (Taylor & Francis, 1985)
d. Mallick, P.K. Fiber Reinforced Composites Materials, Manufacturing and Design (Marcel Dekker, 1993)

ME-575: Advanced Material for Design　　　　　　**L-T-P-CH-CR: 3-0-0-3-3**

Course Objectives:
   i. give detailed knowledge on structure and properties of advanced engineering materials for design purposes.
   ii. increase interest on advanced materials and advanced design / manufacturing technology.
   iii. understand the criteria for selection of materials during advanced design and manufacturing for specialized engineering applications.

Advanced materials for modern Engineering Design: Metals, Polymers, Composites and Ceramics; Proper material selection for design considerations **(5 lectures)**

Structure-property correlation for design purposes: Role of crystal structure, substructure and microstructure on material properties and machine design

Metallic alloys for high performance structural design and their applications, Surface engineering of materials and their applications

Applications of Piezoelectric materials, Shape memory alloys, Smart materials and Composite materials in design of modern engineering components

Micro-electro-mechanical systems (MEMS) for design: Characteristics of materials for MEMS applications and MEMS components

Designing components for high temperature applications: Various alloys and composites, Diffusion bond coating

Application of Powder metallurgy technique in design: Selection of materials, Cost, Design and Manufacturing considerations involved

Advanced materials for design of Automobile and Transport vehicles, Aerospace, Power generation, Armament, Marine environment and Ocean structures, Materials for other specialized applications

Advanced material testing for machine design considerations

Assignment and mini-project.

Course outcomes:

On successful completion of this course, students will be able to:

CO1: gain detailed knowledge on advanced materials, their structure, properties and applications.

CO2: understand the need of advanced and non-conventional materials for contemporary and specialized engineering applications.

CO3: correlate material properties with design considerations and materials selection.

CO4: prepare for advanced design and manufacturing technology.

CO5: present the outcome in the form of group projects on material characterization and advanced design and manufacturing.

Textbooks:
1. Callister, W. D. Material Science and Engineering - An Introduction. John Wiley & Sons, 7th edition, 2007.
2. Mallick, P.K. Fiber Reinforced Composites Materials, Manufacturing and Design. Marcel Dekker, 2007.

References:
1. Otsuka, K. and Wayman, C.M. Shape Memory Materials. Cambridge University Press, 1999.
2. Gandhi, M.V. and Thompson, B.S. Smart Materials and Structures. Chapman and Hall, 1992.