M. TECH – ENGINEERING DESIGN

Department of Mechanical Engineering

This program is designed to enable an engineering graduate to develop specific capabilities in design, synthesis and analysis of a wide variety of mechanical engineering systems. The program is planned and organized in such a way as to make the student imbibe the spirit of innovative thought process and research.

Besides core courses (which are mandatory), a variety of electives are also offered to suit the taste of each individual student so that he/she can specialize in a particular area of Engineering Design. The students are periodically assessed by teachers who are experts in chosen areas of engineering design, to ensure the quality of education. During the programme of study, the students are required to undertake design tasks which involve high degree of research orientation supplemented with practical insights. On the whole, the Masters Program is committed to produce design engineers with excellent creative capabilities and calibre to solve real life problems, in tune with the objectives envisioned by the University.

Attested true copy

Dr.K. Sankaran
Registrar
Amrita Vishwa Vidyapeetham
Amrita Nagar, COIMBATORE - 641 112

CURRICULUM

First Semester

Course Code	Type	Course	L T P	Cr
MA601	FC	Advanced Engineering Mathematics	4 0 0	4
ED600	FC	Theory of Elasticity and Plasticity	4 0 0	4
ED601	FC	Mechanical Vibrations	3 0 1	4
ED602	FC	Optimization Techniques in Engineering	3 0 1	4
ED650	SC	Reliability Methods	3 0 0	3
ED691	SC	Engineering Design Lab-I	0 0 1	1
	HU	Cultural Education*		P/F
			Credits	20

* Non-Credit Course

Second Semester

Course Code	Type	Course	L T P	Cr
ED651	SC	Mechanical Analysis and Design	3 0 0	3
ED652	SC	Fluid Dynamics	3 0 0	3
ED653	SC	Finite Element Methods	3 0 1	4
ED654	SC	Mechanical Behaviour of Engineering Materials	3 0 0	3
	E	Elective I	3 0 0	3
ED692	SC	Engineering Design Lab-II	0 0 1	1
			Credits	17

Third Semester

Course Code	Type	Course	L T P	Cr
ED655	SC	Mechanism Analysis and Synthesis	3 0 0	3
	E	Elective II	3 0 0	3
	E	Elective III	3 0 0	3
	E	Elective IV	3 0 0	3
	E	Elective V	3 0 0	3
ED798	P	Minor Project		4
			Credits	19

Fourth Semester

Course Code	Type	Course	L T P	Cr
ED799	P	Dissertation		10
			Credits	10

Total Credits 66

List of Courses

Foundation Core

Course Code	Course	L T P	Cr
MA601	Advanced Engineering Mathematics	4 0 0	4
ED600	Theory of Elasticity and Plasticity	4 0 0	4
ED601	Mechanical Vibrations	3 0 1	4
ED602	Optimization Techniques in Engineering	3 0 1	4

Subject Core

Course Code	Course	L T P	Cr
ED650	Reliability Methods	3 0 0	3
ED651	Mechanical Analysis and Design	3 0 0	3
ED652	Fluid Dynamics	3 0 0	3
ED653	Finite Element Methods	3 0 1	4
ED654	Mechanical Behaviour of Engineering Materials	3 0 0	3
ED655	Mechanism Analysis and Synthesis	3 0 0	3
ED691	Engineering Design Lab-I	0 0 1	1
ED692	Engineering Design Lab-II	0 0 1	1

Attested True copy

Dr.K. Sankaran
Registrar
Amrita Vishwa Vidyapeetham
Amrita Nagar, COIMBATORE - 641 112

Electives

Course Code	Course	L T P	Cr
	Elective - I		
ED700	Theory of Elasticity	3 0 0	3
ED701	Mechanics of Composite Materials	3 0 0	3
ED702	Random Vibrations	3 0 0	3
ED703	Meso- and Micro- Manufacturing	3 0 0	3
	Elective - II		
ED704	Design for Manufacture and Assembly	3 0 0	3
ED705	Plasticity Modeling and Computation	3 0 0	3
ED706	Nonlinear Vibrations	3 0 0	3
ED707	Experimental Stress Analysis	3 0 0	3
	Elective - III		
ED708	Modelling, Simulation and Analysis of Engineering Systems	3 0 0	3
ED709	Theory of Plates and Shells	3 0 0	3
ED710	MEMS (Micro-Electro-Mechanical Systems)	3 0 0	3
ED711	Machine Condition Monitoring	3 0 0	3
	Elective - IV		
ED712	Geometric Modelling	3 0 0	3
ED713	Integrated Design and Manufacturing	3 0 0	3
ED714	Selection of Materials and Processes	3 0 0	3
ED715	Product Lifecycle Management (PLM) Systems	3 0 0	3
	Elective - V		
ED716	CAD in Product Development	3 0 0	3
ED717	Tribology	3 0 0	3
ED718	Boundary Element and Mesh Free Methods	3 0 0	3
ED719	Bio-MEMS and Medical Micro-devices	3 0 0	3

Project Work

Course Code	Course	L T P	Cr
ED798	Minor Project		4
ED799	Dissertation		10

MA601 ADVANCED ENGINEERING MATHEMATICS 4-0-0-4

Vector spaces, sub spaces, linear independence, basis, dimension, null space, rank and nullity inner product, orthogonality, orthogonal basis, Gram Schmidt process change of basis, general linear transformation, kernel and range, inverse linear transformation.

Fourier series – Fourier Transforms – Laplace Transforms of partial derivatives - Applications

Review of concepts of PDEs – Integral Transforms - Canonical Forms, Solution of initial and boundary value problems – characteristics – D'Alembert's solution – characteristic curves – Laplace transforms solutions for displacement in a long string – a bar with prescribed force on one end.

Review of Probability Concepts – Random Variables – One and two dimensional Probability Distributions and Densities – Expectations and Chebychev's Theorem – Population and Sampling Distributions – Central Limit Theorem – Point and Interval Estimation – Confidence Intervals.

TEXT BOOKS/REFERENCES:

1. *Douglas C. Montgomery and George C. Runger, "Applied Statistics and Probability for Engineers", Third Edition, John Wiley & Sons, 2003.*
2. *Ronald E. Walpole, Raymond H. Myers, and Sharon L. Myers, "Probability and Statistics for Engineers and Scientists", Seventh Edition, Pearson Education, 2002.*
3. *Howard Anton and Chris Rorres, "Elementary Linear Algebra", Ninth Edition, John Wiley & Sons, 2000.*
4. *Gilbert Strang, "Linear Algebra and Applications", Fourth Edition, Wellesley Publishers, 2006.*
5. *Elsgolts, "Differential Equations and the Calculus of Variations", MIR Publishers. Moscow, 1980.*

ED600 THEORY OF ELASTICITY AND PLASTICITY 4-0-0-4

Analysis of Stress and Strain: Stress at a point; stress tensor; stress transformations; principal stresses; octahedral stress; equations of equilibrium. Strain tensor; principal strains; strain-displacement relations; compatibility conditions. Constitutive Equations: General theory; generalised Hooke's law - Equations of Elasticity: Mitchel-Beltrami and Navier equations. Energy methods: Principle of superposition – Elastic strain energy - reciprocal relation – Maxwell Betti–Rayleiph Reciprocal theorem – First theorem of Castigliano – Expression for strain energy – theorem of virtual work – Kirchhoff's theorem – second theorem of Castigliano – Engessers theorem.

Formulation of the general elasticity problem: Boundary Value Problems, Boussinesq

problem-Three-dimensional problems, torsion and bending of non - circular prismatic bars (Saint-Venant's solution)-Membrane analogy; the role of thermodynamics in real materials. Definition of yield criterion. Theories of failure – Yield criteria: Tresca, von Mises - Halgh-Westergaard stress space –yield surface - Representation of failure theories in stress space- stress tensor: hydrostatic and deviatoric components. Plastic stress-strain analysis: Effective stress and Effective strain - Flow rule - Prandtl-Reuss and Levy-Mises equations - Deformation in plane stress: yielding of thin sheet in biaxial and uniaxial tension - Plane strain deformation - Plastic Potential - Material Behaviour: Work hardening; Strain rate and strain rate tensor-.Effects of strain rate and temperature on flow stress - plastic instability - Principle of maximum dissipation of work - Torsion of Prismatic Bar.

TEXT BOOKS/ REFERENCES:

1. *Timoshenko, S. P. and Goodier, J. N., "Theory of Elasticity", Third Edition, McGraw Hill, 1970.*
2. *Johnson, W. and Mellor, P. B., "Engineering Plasticity", Van Nostrand Reinhold, 1983.*
3. *Chakrabarthy, J., "Theory of Plasticity", McGraw Hill, 1987.*
4. *Dieter, G. E., "Mechanical Metallurgy", McGraw Hill, 1988.*

ED601 MECHANICAL VIBRATIONS 3-0-1-4

Introduction-Derivation of equation of motion-Free vibration of undamped single degree of freedom systems-Free vibration of damped single degree of freedom systems-Forced response of single degree of freedom systems-Rotating unbalance, support motion, whirling of shafts-Vibration isolation, vibration measuring instruments-Different types of damping-Response of s.d.o.f systems to arbitrary excitation-convolution integral, Fourier transforms method-Free vibration of undamped two degree of freedom systems-formulation and solution of matrix Eigen value problem, natural modes-Elastic and mass coupling, orthogonality of modes, natural coordinates-Response of two d.o.f systems to harmonic excitation-Undamped vibration absorbers-Matrix formulation for multi degree of freedom systems, influence coefficients-Undamped free vibration of mdof systems, formulation of eigen value problem-Orthogonality of modal vectors, expansion theorem-Solution of eigen value problem by characteristic determinant-Free vibration of continuous systems, Eigen value problem-Axial vibration of rods, bending vibration of bars-Natural modes of a bar in bending vibration-Introduction to the computational methods, solution of Eigen value problem by matrix iteration, power method using matrix deflation-Introduction to the classical methods for the solution of vibration problems-Rayleigh method, Dunkerleys equation, Lagrange's equation. Active Vibration Control-Smart materials and Structures.

TEXT BOOKS/REFERENCES:

1. *Leonard Meirovitch, "Elements of Vibration Analysis", Second Edition, McGraw Hill, 1986.*
2. *Thomson, T., "Theory of Vibration with Applications", Fifth Edition, Pearson Education, 2003.*
3. *Leonard Meirovitch, "Analytical Methods in Vibrations", Macmillan, 1967.*
4. *Rao, S. S., "Mechanical Vibrations", Second Edition, Addison-Wesley, 1990.*

ED602 OPTIMIZATION TECHNIQUES IN ENGINEERING 3-0-1-4

Introduction to Optimization: Engineering application of Optimization – Statement of an optimization problem - Optimal Problem formulation - Classification of optimization problems. Definition of Global and Local minima.

Unconstrained Optimization: Optimality Conditions – Algorithms for univariate optimization – Algorithms for multivariate optimization – Convergence of algorithms - Engineering applications of unconstrained algorithms.

Lagrange multiplier Theory & Duality: Lagrange multipliers - Kuhn-Tucker Optimality Conditions and sufficiency for convex problems – Lagrangian duality – Saddle point Conditions.

Constrained Optimization: Optimality Conditions – Feasible direction methods – Frank-Wolfe algorithm – Gradient Projection – Active set methods - Penalty function methods – Constrained steepest descent method.

Stochastic processes – Introduction to Stochastic Linear & Non – Linear Programming – Optimization of probabilistic models – case studies.

Modern methods of Optimization: Genetic Algorithms - Simulated Annealing – Tabu search - Ant Colony optimization – Particle Swarm Optimization – Neural-Network based Optimization – Fuzzy optimization techniques.

Introduction to Multi-Objective optimization – Classical methods – Pareto Optimality – use of evolutionary algorithms for solving Multi-Objective optimization problems.

Lab Practice:

Use of programming languages and Matlab to solve the optimization problems.

TEXT BOOKS/ REFERENCES:

1. *Kalyanmoy Deb, "Optimization for Engineering Design Algorithms and Examples", Prentice Hall, 2000.*
2. *Rao, S. S., "Engineering Optimization Theory and Practice", Fourth Edition, New Age International, 2009.*
3. *Saravanan, R., "Manufacturing Optimization through Intelligent Techniques", Taylor & Francis, 2006.*
4. *Ravindran, Phillips, and Solberg, "Operations Research Principles and Practice", Wiley India, 2007.*
5. *Hadley, G., "Non Linear and Dynamic Programming", Addison-Wesley, 1964.*

ED650 RELIABILITY METHODS 3-0-0-3

Concept and definition of reliability (Reliability Mathematics) - Failure distributions, hazard models – exponential, Rayleigh, Weibull, Normal and Lognormal distributions -MTTF, MTBF. Reliability of systems – series and parallel configurations - Reliability improvement, redundancy, k-out-of-n systems - Reliability of complex configurations-Reliability of three-state devices – Markov analysis-Physical reliability models – random stress and random strength-Design for reliability-Reliability allocation, derating-Maintainability - Design for maintainability – Availability - Maintenance and space provisioning. Failure data analysis - Reliability Testing - Identifying failure distributions – parameter estimation.

TEXT BOOKS/REFERENCES:

1. *Charles Ebeling, "An Introduction to Reliability and Maintainability Engineering", Tata McGraw Hill, 2000.*
2. *Lewis, E. E., "Introduction to Reliability Engineering", Second Edition, John Wiley & Sons, 1995.*
3. *Rao, S. S., "Reliability Based Design", McGraw Hill, 1992.*
4. *Barlow, R. E., Proselan, F., and Hunter, L. C., "Mathematical Theory of Reliability", John Wiley & Sons, 1965.*
5. *Sigmund Halpern, "Assurance Sciences - An Introduction to Quality Control and Reliability", Prentice Hall, 1978.*

ED651 MECHANICAL ANALYSIS AND DESIGN 3-0-0-3

Overview of product development process - Role of design in product development - Nature of design problem – Design methodology – Systems engineering concepts: requirements, physical and functional partitioning, allocation of requirements, requirement traceability. Quality function deployment – Failure modes – Failure Mode Effects Analysis (FMEA) in product development - Analysis and synthesis

Review of stress and strain analyses – Review of failure theories – Review of basic fatigue theory – Design for finite life and multiple stress levels - Review of multi-axial stress situations – Review of fracture mechanics and applications to fatigue.

Introduction to material selection – Indices of merit for various load applications.

Basic plate and shell theory.

Thermal stress for axial and multi-axial cases – Creep and Relaxation – Bolted pre-loaded joints. Design of components in impact.

Buckling – Application of Johnson column theory- Buckling of plates and shells.

Design of axisymmetrically loaded members – Thin and thick shells - pressure vessel theory – rotating cylinders – interference fits.

Design of components in flexure – review of curved beam theory, beams on elastic foundation – Discontinuity stresses in pressure vessels.

Case studies in design - Typical examples

TEXT BOOKS/REFERENCES:

1. *Arthur H. Burr and John B. Cheatham, "Mechanical Analysis and Design", Prentice Hall, 1997.*
2. *Jack Collins, "Mechanical Design of Machine Elements and Machines – A Failure Perspective", John Wiley & Sons, 2002.*
3. *Jeffrey Grady, "Systems Requirements Analysis", Elsevier Academic Press, 2006.*
4. *Raymond J. Mikulak, Robin McDermott, and Michael Beauregard, "The Basics of FMEA", CRC Press, 2008.*
5. *Timoshenko, "Strength of Materials - Part II", Third Edition, Kriger, 1983.*

ED652 FLUID DYNAMICS 3-0-0-3

Review of vectors and tensors -Lagrangian and Eulerian description, fluid deformation, fluid element strain-material derivative, stress and strain tensors, vorticity, circulation, stream function, velocity potential.

Reynolds transport theorem- Conservation laws, constitutive equations, differential equation for conservation of mass, momentum and energy.

Exact solutions for laminar flows, similarity solutions, creeping flow approximation, laminar boundary layer- similarity solutions- flow over a flat plate and Falkner-Skan wedge flows, separation-Introductory vorticity dynamics

Turbulent flows: Introduction, characteristic features of turbulence, definitions; Reynolds decomposition, turbulent shear stress and the closure problem, turbulent kinetic energy, Kolmogorov's contributions.

Numerical solution of ordinary differential equations: Initial and Boundary value problem- Numerical solution of elliptic, parabolic and hyperbolic equations-Finite difference and finite volume schemes- Explicit and Implicit methods for transient problems – solution of viscous incompressible flows by stream function-vorticity formulation, primitive variable formulation. Flow in simple geometries and validations.

TEXT BOOKS/REFERENCES:

1. *Kundu, P. K. and Cohen, I. M., "Fluid Mechanics", Second Edition, Academic Press, 2002.*
2. *Panton, R. L., "Incompressible Flow", Second Edition, John Wiley & Sons, 2005.*
3. *Hoffman, J. D., "Numerical Methods for Engineers and Scientists", Second Edition, Marcel Dekker, 2001.*
4. *Hoffmann, K. A. and Chiang, S. T., "Computational Fluid Dynamics", Fourth Edition, Engineering Education System, 2000.*
5. *Ferziger, J. H. and Peric, M., "Computational Methods for Fluid Mechanics", Third Edition, Springer, 2002.*

ED653 FINITE ELEMENT METHODS 3-0-1-4

Fundamentals of partial differential equations – Governing equations in Solid Mechanics and Heat Transfer.

Formulating the finite element equations – Variational formulation - Weighted residual method – Galerkin formulation – Element types - Basic and higher order – Coordinate systems.

Finite elements in Solid Mechanics - analysis of trusses, beams and frames – Plane stress and plane strain elements – Axisymmetric elements – Isoparametric formulation.

Finite elements in Heat Transfer - Formulations and solution procedures in one-, two-, and three- dimensional heat transfer problems.

Structural dynamics - Formulation – Element mass matrices – Evaluation of Eigen values and Eigen vectors – Natural frequencies and mode shapes – Numerical time integration.

Field problems in Solid Mechanics, Heat transfer and Structural Dynamics, using computational packages like Abaqus and Ansys.

TEXT BOOKS/REFERENCES:

1. *Rao, S. S., "The Finite Element Method in Engineering", Elsevier, 2007.*
2. *Jacob Fish and Ted Belytschko, "A First Course in Finite Elements", Wiley Inter Science, 2007.*
3. *David V. Hutton, "Fundamentals of Finite Element Analysis", McGraw Hill, 2005.*
4. *Cook, R. D. and David, S. M., "Concepts and Applications of Finite Element Analysis", Fourth Edition, John Wiley & Sons, 1995.*
5. *Daryl L. Logan, "A First Course in the Finite Element Method", Fourth Edition, Cengage Learning, 2007.*

ED654 MECHANICAL BEHAVIOR OF ENGINEERING MATERIALS 3-0-0-3

Structure of solid materials, Defects in crystals, Types of Mechanical Behavior, Physical Mechanisms controlling Behavior, Elasticity, Stress , strain, compliances and stiffness tensor's, Generalized Hook's law-application to crystals, Anisotropic behaviors, visco-elasticity, Continuum Plasticity, True stress-strain curve Necking criterion, Yield Criteria and locus, isotropic and kinematic hardening, plastic stress-strain relations. Micro structural aspects of plasticity, Strengthening Mechanisms Fracture Mechanics, Griffith theory, Crack driving force and Energy Release Rate, Modes of fracture, Stress Intensity Factor, Crack tip plasticity, plastic zone, Fracture toughness, Micro structural aspects, Fatigue Total Life approaches, Fatigue design approaches, HCF and LCF, Fatigue crack Growth, Paris law and models, Threshold, Damage Tolerant approach, striations, Stages of Fatigue crack growth.

TEXT BOOKS/REFERENCES:

1. *Hertzberg, R. W., "Deformation and Fracture Mechanics of Engineering Materials", John Wiley & Sons, 1995.*
2. *Marc Meyers and Chawla, "Mechanical Behaviour of Materials" Meyers, 2007.*
3. *Dowling, N. E., "Mechanical Behaviour of Materials Engineering - Methods for Deformation, Fracture and Fatigue", Third Edition, Prentice Hall, 2007.*
4. *Thomas H. Courtney, "Mechanical Behaviour of Materials", McGraw Hill, 2000.*
5. *Dieter, G. E., "Mechanical Metallurgy", McGraw Hill, 1988.*

ED655 MECHANISM ANALYSIS AND SYNTHESIS 3-0-0-3

Review of mechanism theory, systems and systematics, review of planar velocity and acceleration analyses. Planar Kinematics - Kinematics constraints - Kinematic modeling.

Computer aided kinematic analysis - Euler parameters - Co-ordinates of a body, Identities with Euler parameters. Spatial Kinematics - Relative constraints between two vectors - Relative constraints between two bodies - Concept of equivalent mechanisms.

Synthesis of mechanisms - Three position and four position synthesis - Chebyshev spacing of precision points - Computer aided synthesis.

Curvature theory – Velocities and accelerations – Review of instant centre concept - Euler – Savary equations - Bobillier theorem - Cubic of stationary curvature - Ball's point.

Review of basic concepts in dynamics - Planar dynamics - Equations of motion - System of equations of motion - Computer assisted dynamic force analysis of planar mechanisms – Introduction to spatial dynamics.

TEXT BOOKS/REFERENCES:

1. *Parviz Nikravesh, "Computer Aided Analysis of Mechanical System", Prentice Hall, 1986.*
2. *Sandor, G. N. and Erdman A. G., "Advanced Mechanism Design: Analysis and Synthesis", Vol-II, Prentice Hall, 1984.*
3. *Uicker J. J., Pennock, G. R., and Shigley, J. E., "Theory of Machines and Mechanisms", Oxford University Press, 2003.*
4. *Chung-Ha Suh and Charles Radcliffe, "Kinematics and Mechanism Design", John Wiley & Sons, 1978.*
5. *Robert L. Norton, "Design of Machinery – An Introduction to the Synthesis and Analysis of Mechanisms and Machines", Second Edition, McGraw Hill, 1999.*

ED691 ENGINEERING DESIGN LAB-I 0-0-1-1

Vibration Lab

1. Simulation of vibration problems using Matlab.
2. Modal testing and extraction of modal parameters.

Modelling and Analysis Lab

1. Modelling of complex assemblies using modelling softwares.
2. Finite element analysis-structural, thermal, coupled analysis using analysis software packages.

Experimental Stress Analysis Lab

1. Verification of stresses in a cantilever beam using strain gauges.
2. Calibration of torsional load cell.

ED692 ENGINEERING DESIGN LAB-II 0-0-1-1

Tribology Lab

1. Wear measurement of various materials (polymers, metals) using friction and wear monitoring apparatus.
2. Comparison of actual and theoretical values of wear using analysis software.

Synthesis & Simulation Lab.

1. Design synthesis of simple mechanisms like sewing machine, grass cutter etc. using synthesis tools.

Machine Condition Monitoring Lab

1. Machine vibration studies using the FFT analyzer and virtual instrumentation tools.

ED700 THEORY OF ELASTICITY 3-0-0-3

Fundamentals-Stress at point-stress tensor - Analysis of stress and strain – Governing equations. Energy methods – Hooke's law & principle of superposition – Elastic strain energy - reciprocal relation – Maxwell Betti–Rayleiph Reciprocal theorem – First theorem of Castigliano – Expression for strain energy – Theorem of virtual work – Kirchhoff's theorem – second theorem of Castigliano – Engessers theorem

Theories of failure – Mohr's theory of failure - stress space – Yield surfaces of Tresca and Von Mises.Formulation of the general elasticity problem-Boundary Value

Problems, Boussinesq problem-Three-dimensional problems, torsion and bending of non - circular prismatic bars-Membrane analogy.

Straight beams and Asymmetrical bending- Euler – Bernoulli Hypothesis - Centre of flexure- shear stresses in thin walled open section – bending of curved beam – Thick walled cylinder subjected to internal & external pressures – stresses in composite tubes – sphere with purely radial displacements – stresses due to gravitation-rotating disks of uniform thickness – Disks of variable thickness – rotating shafts and cylinder

TEXT BOOKS/REFERENCES:

1. *Timoshenko, S. P. and Goodier, J. N., "Theory of Elasticity", Third Edition, McGraw Hill, 1970.*
2. *Sokolnikoff, I. S., "Mathematical Theory of Elasticity", Second Edition, McGraw Hill, 1956.*
3. *Den Hartog, J. P., "Advanced Strength of Materials", Dover Publications, 1987.*
4. *Boresi, A. P., Schmidt, R. J., and Sidebottom, O. M., "Advanced Mechanics of Materials", Fifth Edition, John Wiley & Sons, 1993.*
5. *Dally, J. W. and Riley, W. F., "Experimental Stress Analysis", Third Edition, McGraw Hill, 1991.*

ED701 MECHANICS OF COMPOSITE MATERIALS 3-0-0-3

Composite materials and its characteristics-Analysis of an orthotropic lamina-Analysis of laminated composites-Fracture mechanics-Determination of strain energy release rate-Manufacturing Processes-Testing of Composites-Stress analysis - interlaminar stresses and free edge effects-Failure Criteria-Whitness nuismer failure criteria-Vibration and stability analysis-Design and Analysis of mechanically fastened joints.

TEXT BOOKS/REFERENCES:

1 *Mallick, P. K., "Fiber Reinforced Composite Materials - Manufacturing and Design", Marcel Dekker, 1993.*
2 *Halpin, J. C., "Primer on Composite Materials Analysis", Techomic, 1984.*
3 *Mallick, P. K. and Newman, S., "Composite Materials Technology - Processes and Properties", Hansen, 1990.*
4 *Agarwal, B. D. and Broutmen, L. J., "Analysis and Performance of Fibre Composites", John Wiley & Sons, 1990.*

ED702 RANDOM VIBRATIONS 3-0-0-3

Concept of probability - Theory of random variables - Probability structure of random variable - Stationary and non-stationary random process - Calculus of

random process - Spectral decomposition of random process - Gaussian, Poisson and Markov process - Response of single degree of freedom, multi degree of freedom and continuous systems to random excitation - Failure modes in random vibration-level crossing statistics-First excursion failure-Rice formula - Fatigue failure - Palurgen – Miner cumulative damage law - Application to civil, mechanical and ocean structures - Introduction to non linear random vibration.

TEXT BOOKS/REFERENCES:

1. *Nigam, N. C., "Introduction to Random Vibrations", MIT Press, 1983.*
2. *Lin, Y. K. and Cai, G. K., "Probabilistic Structural Dynamics", McGraw Hill, 1995.*
3. *Crandall, S. H., "Random Vibrations - Vol. I and II", MIT Press, 1962.*
4. *Newland, D. E., "An Introduction to Random Vibrations and Spectral Analysis", Longman, 1984.*

ED703 MESO- AND MICRO- MANUFACTURING 3-0-0-3

Meso and Micro-systems, Typical micro-system products. Materials for Microsystems manufacture-Substrates and Wafers, active substrate materials, silicon and silicon components. Manufacturing technologies-Conventional: micro machining, micro drilling, and micro forming.-Unconventional: Micro Electro Discharge Machining, Micro Electro Chemical Machining and Micro Ultra Sonic Machining.-Photolithography based micro fabrication processes - Photoresist development - etching-chemical, plasma- resists removal. Large aspect ratio micro manufacturing - LIGA, Deep Reactive Ion Etching. Bonding and Packaging- Microsystem packaging, levels, die preparation, surface bonding, wire bonding, sealing-Inspection of Microsystems and Micro Metrology Applications - automotives and home electronics- Integrated Microsystems- Micro-sensors, Micro-actuators, Micro-accelerometers and Gyroscope - medical engineering-bio sensors.

TEXT BOOKS/REFERENCES:

1. *Tai–Ran Hsu, "MEMS and Microsystems: Design and Manufacturing", Tata McGraw Hill, 2002.*
2. *Marc J. Madou, "Fundamentals of Microfabrication", Second Edition, CRC Press, 2002.*
3. *Jain, V. K., "Introduction to Micromachining", Narosa Publishing House, 2010.*
4. *Mohamed Gad-el-Hak, "The MEMS Handbook", CRC Press, 2002.*

ED704 DESIGN FOR MANUFACTURE AND ASSEMBLY 3-0-0-3

DFM approach, DFM guidelines, Standardization. Group technology, Value engineering, Poke - Yoke principles. Tolerance analysis-Process capability, cost

aspects, geometric tolerances, cumulative effect of tolerances, Interchangeable and selective assembly, - Models. Control of axial play. Grouped datum systems. True position theory, functional and paper layout gauging. Form design of castings and weldments, Tolerance charting technique, centrality analysis. Design for machining, functional and manufacturing datum features, redesign for manufacture.

TEXT BOOKS/ REFERENCES:

1. *Boothroyd, G., Dewhurst, P., and Knight, W., "Product Design for Manufacture and Assembly", Second Edition, Marcel Dekker, 2002.*
2. *Harry Peck, "Designing for Manufacture", Pitman Publications, 1983.*
3. *Spotts, M. F., "Dimensioning and Tolerance for Quantity Production", Prentice Hall, 1983.*
4. *Boothroyd, G., "Design for Assembly: The Road to Higher productivity", Assembly Engineering, 1982.*
5. *Creveling, C. M., "Tolerance Design - A Hand Book for Developing Optimal Specifications", Addison-Wesley Longman, 1997.*

ED705 PLASTICITY MODELLING AND COMPUTATION 3-0-0-3

Introduction - Plasticity in one dimension- Nonlinear Problems, Numerical Solution Procedures, Isotropic, and Kinematic Hardening. Deviatoric Plasticity-Flow rule, Isotropic, kinematic and combined hardening, Plastic dissipation. Introduction to algorithms for Deviatoric Plasticity.

Mohr-Coulomb, Dracker-Prager, Cap models, critical state models, three-invariant models, return-mapping in principal directions; Spectral decomposition Advanced Plasticity Models, Material Instability and Bifurcation.

TEXT BOOKS/REFERENCES:

1. *Fung, Y. C., "A First Course in Continuum Mechanics", Second Edition, Prentice Hall, 1977.*
2. *Hill, R., "The Mathematical Theory of Plasticity", Clarendon Press, Oxford Classic Series, 1998.*
3. *Simo, J. C. and Hughes, T. J. R., "Computational Inelasticity", Springer Verlag, 1998.*
4. *Desai, C. S. and Siriwardane, H. J., "Constitutive Laws for Engineering Materials", Prentice Hall, 1984.*

ED706 NONLINEAR VIBRATIONS 3-0-0-3

Basic concepts in nonlinear dynamics-Examples of nonlinear dynamical systems in mechanical and electrical systems-Vander Pol and Duffing oscillators-Approximate solution techniques-Concept of phase plane, limit cycle, Poincare maps, Strange

attractors-Bifurcations, types of bifurcations, periodic doubling-Measure of chaos-auto correlation, power spectrum, Lyapunov exponents-Fractals and dimensions-multi fractals and fractal basin boundaries-Computational aspects –numerical integration, cell mapping-Galerkin-harmonic balancing-shooting method –parameter continuation and path following-Application of computational aspects to mechanical systems.

TEXT BOOKS/REFERENCES:

1. *Francis C. Moon, "Chaotic and Fractal Dynamics", John Wiley & Sons, 1992.*
2. *Hayashi, C., "Nonlinear Oscillations in Physical Systems", Wiley, 1979.*
3. *Nayfeh, A. H. and Balachandran, B., "Applied Nonlinear Dynamics", Wiley, 1995.*
4. *Stoker, "Nonlinear Oscillations in Mechanical and Electrical systems", Wiley, 1992.*

ED707 EXPERIMENTAL STRESS ANALYSIS 3-0-0-3

Strain gauges - mechanical, optical, acoustic, pneumatic and electrical strain gauges- strain measurement-Electrical resistance strain gauges-Wheat stone bridge, Strain gauge rosettes-Semiconductor strain gauges-Photo-elasticity, stress optic law, stress freezing technique-Fringe sharpening-Methods of slicing-Separation of principle stresses-Scattered light photo-elasticity-Moire fringe method-Separation of isochromatic and isopachic fringe pattern-Theory of photo elastic coating, - crack detection methods-Brittle coating method – Isostatics and isoentacties.

TEXT BOOKS/REFERENCES:

1. *Dally, W. and Riley, F., "Experimental Stress Analysis", McGraw Hill, 1978.*
2. *Dove and Adams, "Experimental Stress Analysis and Motion Measurement", Prentice Hall, 1965.*

ED708 MODELLING, SIMULATION AND ANALYSIS OF ENGINEERING SYSTEMS 3-0-0-3

Introduction to linear systems, principle of super position-Modelling of engineering systems-mechanical, electrical, fluid, thermal and mixed discipline systems-Free, forced and transient response of first and second order systems-Solution of differential equation using Laplace Transforms-Time domain and Frequency domain analysis-State space representation-System characteristics from state space representation-Solving the state equations-Stability criterion through the state transition matrix-Control system design in state space-Linear optimal control.

TEXT BOOKS/REFERENCES:

1. *Philip D. Cha, James J. Rosenberg, and Clive L. Dym, "Fundamentals of Modelling and Analysis of Engineering systems", Cambridge University Press, 2000.*

2. *Woods Robert, L. and Lawrence Kent, L., "Modelling and Simulation of Dynamic Systems", Prentice Hall, 1997.*
3. *Ashish Tiwari, "Modern Control Design with MATLAB and SIMULINK", John Wiley, 2002.*

ED709. THEORY OF PLATES AND SHELLS 3-0-0-3

Introduction - Formulation of governing equations and associated boundary conditions by equilibrium and energy methods, Rectangular plates - Solution of equation by double and single series, Circular plates - Symmetric and unsymmetric loading cases, Continuous Plates, Plates with various plan forms, Plates with variable flexural rigidity, Plates on elastic foundation. Numerical and Approximate Methods - finite difference method - finite element method, energy methods and other variational methods

Introduction, Theory of Surfaces - first and second fundamental forms - principal curvatures, Formulation of governing equations in general orthogonal curvilinear coordinates based on classical assumptions - various shell theories, Membrane theory - governing equations - shells of revolution - application to specific geometric shapes - ax symmetric and non-axisymmetric loading cases. General theory of shells - governing equations and associated boundary conditions for specific geometry of shells (cylindrical, conical and spherical shells) - classical solutions - finite difference and finite element methods applied to shell problems.

TEXT BOOKS/REFERENCES:

1. *Vardhan, T. K. and Bhaskar, K., "Analysis of Plates: Theory and Problems", John Wiley & Sons, 1999.*
2. *Timoshenko, S. and Woinowsky Krieger, S., "Theory of Plates and Shells", McGraw Hill, 1969.*
3. *Chandrashekhara, K., "Theory of Plates", University Press, 2001.*

ED710 MEMS (MICRO-ELECTRO-MECHANICAL SYSTEMS) 3-0-0-3

Introduction: MEMS and Microsystems, Typical MEMS and microsystem products, evolution of micro-fabrication. Mechanics for Micro System Design: Static bending of thin plates, mechanical vibration – micro accelerometer- design theory- resonant micro sensors, thermo mechanics, and fracture mechanics- interfacial fracture mechanics, Finite element stress analysis. Thermo-fluid Engineering: Basic Equations in Continuum Fluid Dynamics, Fluid flow in Sub micrometer and nanoscale, Heat Conduction - multilayered thin films-solids in sub micrometer scale.

Scaling Laws: Geometry, dynamics, electrostatic forces, electromagnetic forces, fluid mechanics and heat transfer. Micro System Fabrication Processes: Photolithography, Chemical vapour Deposition, Physical vapour Deposition, Etching-

chemical, plasma, Bulk and Surface Micro Manufacturing, LIGA.
Micro system packaging- levels- die preparation, surface bonding, wire bonding, sealing, -assembly of Microsystems- packaging materials, signal mapping and transduction.

TEXT BOOKS/REFERENCES:

1. *Tai–Ran Hsu, "MEMS and Microsystems Design and Manufacturing", Tata McGraw Hill, 2002.*
2. *Marc J. Madou, "Fundamentals of Microfabrication", Second Edition, CRC Press, 2002.*
3. *Mohamed Gad-el-Hak, "The MEMS Handbook", CRC Press, 2002.*

ED711 MACHINE CONDITION MONITORING 3-0-0-3

Transducers and Data acquisition – Maintenance-Sensors & Transducers - Parameters for CM - Signal conditioning - Data acquisition. Signal analysis-Fourier Transform, Series, FFT and its applications-Feature extraction techniques-Wavelets-Artificial Neural Network-Data mining – Decision Tree-Fuzzy logic-Support Vector Machines-NDT Methods-NDT methods in condition monitoring-Wear and debris analysis-Case studies in condition monitoring.

TEXT BOOKS/REFERENCES:

1. *Rao, J. S., "Vibratory Condition Monitoring of Machines", Techmedia, 1999.*
2. *Randall, R. B., "Frequency Analysis", Bruel and Kjaer, 1986.*
3. *Bendat, J. S. and Piersol, A. G., "Engineering Application of Correlations and Spectral Analysis", John Wiley & Sons, 1980.*

ED712 GEOMETRIC MODELLING 3-0-0-3

Wireframe models - Curve representation, parametric representation - Synthetic curve - Curve manipulation - Design application - Surface Models, surface representation, parametric - Synthetic surface - Surface manipulations - Design application - Solid Models - Boundary representation (B-rep) - Constructive solid geometry (CSG) - Sweep representation - Solid manipulations – Applications - Geometric transformation-Transformations of geometric models - Mapping of geometric models - Inverse transformations - Projections of geometric models.

TEXT BOOKS/REFERENCES:

1. *Donald Hearn and Pauline Baker, M., "Computer Graphics", Prentice Hall, 1997.*
2. *Alberto Paoluzzi, M., Vicentino, C., Baldazzi, and Valerio Pascucci, "Geometric Programming for CAD", John Wiley & Sons, 2001.*

3. *Michel E. Mortenson, "Geometric Modelling", John Wiley & Sons, 1985.*
4. *David F. Rogers and Alan Adams, J., "Mathematical Elements for Computer Graphics", Tata McGraw Hill, 2002.*
5. *Ibrahim Zeid, "CAD/CAM - Theory and Practices", Tata McGraw Hill, 2008.*

ED713 INTEGRATED DESIGN AND MANUFACTURING 3-0-0-3

Computer Aided Design-The design process-product cycle- sequential and simultaneous engineering, Computer Aided Engineering, Geometric modeling, Parametric design. Design for manufacturability, Data Exchange Formats. Computer Aided Manufacturing-Computer Assisted Programming, Virtual Manufacturing, NC verification. Reverse Engineering-Conventional Vs Reverse Engineering process, Basic phases, cloud point generation. Rapid Prototyping (RP)-Product development, need for time compression in product development, Rapid product development-RP Data formats and information workflow, characteristics of generative manufacturing processes, Industrial Rapid prototyping system- Technical characteristics and Technological capabilities of RP systems - Concept Modelers - RP process optimization. Rapid Tooling (RT)-Direct and Indirect tooling. Application of RP and RT in industrial product development-Medical Models-Engineering analysis models-Art and Architecture models, scope for research. Concepts for Integrated Inspection – recent advances in Computer Aided Inspection – Integrated inspection.

TEXT BOOKS/REFERENCES:

1. *Ibrahim Zeid, "CAD-CAM Theory and Practices", Tata McGraw Hill, 2008.*
2. *Groover and Zimmers, "CAD-CAM - Computer Aided Design and Manufacturing", Prentice Hall of India, 1994.*
3. *Pham, D. T. and Dimov, S. S., "Rapid Manufacturing - The Technologies and Application of Rapid Prototyping and Rapid Tooling", Springer Verlag, 2001.*
4. *Andreas Gebhardt, "Rapid Prototyping", Hanser Publishers, 2003.*
5. *Lii, L., Fuh, J. Y. H., and Wong, Y. S., "Laser Induced Materials and Processes for Rapid Prototyping", Kluwer Academic Publishers, 2001.*

ED714 SELECTION OF MATERIALS AND PROCESSES 3-0-0-3

Overview of materials properties - mechanical, thermal, oxidation, corrosion and wear. Classification of materials - metals, ceramics, glasses, polymers, elastomers, composites, foams.
Basis of materials selection - Design of components - functions, constraints, objectives and free variables - translation, screening, ranking, supporting information - Multiple constraints and objectives - Design of hybrid materials - Illustration of the principles with case studies.

Principles of process selection and classification processes - casting, forging, molding, fabrication, welding, joining, machining, powder processing, composite processing. Illustration of the principles with case studies.

TEXT BOOKS/REFERENCES:

1. *Michael F. Ashby, "Materials Selection in Mechanical Design", Third Edition, Elsevier, 2005.*
2. *"ASM Handbook for Materials Selection and Design", 1996.*

ED715 PRODUCT LIFECYCLE MANAGEMENT (PLM) SYSTEMS 3-0-0-3

Introduction - Domain of PLM - Motivation for PLM.-Part Data Management-Concept of part.
Engineering Release Process - Importance of organization - Users, groups, roles Security and access control.
Assemblies - Building assembly structures - Concept of instance or occurrence - Top-down (BOM-driven) and bottom-up (CAD-driven) design approaches.
Revising Parts and Assemblies - Revising parts - Implications of revisions to CAD data.
Configuration Management of Assemblies - Configuring assemblies by revision rules – Effectivity - Precise and imprecise assemblies - Alternates and substitutes - Options and variant data.
Searching for Parts - Where-used search - Part search based on attributes.
Exchange of Part Data.

TEXT BOOKS/REFERENCES:

Stephen M. Samuel, Eric D. Weeks, and Mark A. Kelley, "Team Center Engineering and Product Data Management Basics", Design Visionaries, 2006.

ED716 CAD IN PRODUCT DEVELOPMENT 3-0-0-3

Basic Concepts - Types of mechanical drawings/models - Geometric model vs. Motivation for solid models in mechanical engineering design - Limitations of solid models - Basic concepts - Part, Component, Assembly, Part Geometry, Drawing.
Part Design Methodology - Fundamental paradigm shift from 2D to 3D - Separation of geometry from drawing – master model concept - Explicit modeling - Dimension-driven parametric modeling - Feature-based modeling.
Assembly Modeling - Basic concepts – instances (occurrences), assembly tree, BOM, parts list - Top-down assembly design - Bottom-up assembly design Bill of Materials (BOM) and parts list - Indented BOM and exploded BOM - Interaction between BOM and CAD - Revisions to components and assemblies - Configuring assemblies.

Drawing Generation for parts and assemblies - Generation of views and dimensioning - Parts list generation - Exploded views.

TEXT BOOKS/REFERENCES:

1. *Kunwoo Lee, "Principles of CAD/CAM/CAE Systems", Prentice Hall, 1999.*
2. *Ibrahim Zeid, "CAD/CAM Theory and Practice", Tata McGraw Hill, 2008.*

ED717 TRIBOLOGY 3-0-0-3

Engineering Surfaces - surface topography-Analysis of surface roughness-Conformal and non-conformal surfaces-Greenwood and Williamson Model-Contact mechanics, Dry contacts-Friction, Modern theories of friction-Stick-Slip Phenomenon-Liquid-Mediated contacts-Wear, Effect of surface roughness, friction, and sliding speed on wear-Ferrography - Oil Analysis Program - Basic equations of Flow, Navier-Stokes equation, Generalized Reynolds's equation-Hydrodynamic lubrication-Boundary lubrication-Bearing materials-Hydrodynamic real (finite) bearings-Design considerations in journal and thrust bearings-Hydrodynamic instability-Hydrodynamic and hydrostatic gas bearings-Idealized slider and journal bearings-Oil flow and Thermal analysis of bearings-Bearing selection and design-Dynamically loaded bearings-Squeeze film bearings.

TEXT BOOKS/REFERENCES:

1. *Majumdar, B. C., "Tribology of Bearings", A. H. Wheeler and Company, 1986.*
2. *Bharat Bhushan, "Introduction to Tribology", John Wiley & Sons, 2002.*
3. *Moore and Desmond, F., "Principles and Applications of Tribology", Pergamom Press, 1975.*
4. *Dudley D. Fuller, "Theory and Practice of Lubrication for Engineers", John Wiley & Sons, 1984.*
5. *Johnson, K. L., "Contact Mechanics", Cambridge University Press, 1987.*

ED718 BOUNDARY ELEMENT AND MESH FREE METHODS 3-0-0-3

Boundary Element Method - Comparison of Boundary Element Method and Finite Element Method-Direct and Indirect Boundary Element Method-Approximate and Boundary Methods-Introduction-Dirac delta functions-Integral equations-Boundary Integral Equation and Fundamental Solution-One dimensional potential problems-Beam problem-2D potential problems constant, linear element and Isoparametric elements-Three-dimensional problem-constant triangular and quadrilateral element-Discontinuous element-Infinite boundary element-2D problems of elasticity - Bettis theorem - Somiglianas identity - Plate bending problem - Hin plate flexure theory-boundary integral equation for plate flexure-Fundamental solutions-surface loads - Computer codes.
Mesh Free Methods - Modelling the geometry-Node generation - Shape function

creation-M-free method procedure – M-free Shape function construction - Element Free Galerkin (EFG) formulation with Lagrange multipliers-Penalty method-constrained moving least square method-Mesh free methods for beams.

TEXT BOOKS/REFERENCES:

1. *Wrobel, L. C. and Aliabadi, M. H., "The Boundary Element Method", John Wiley & Sons, 2002.*
2. *Brebbia, C. A. and Dominguez, J., "Boundary Elements: An Introductory Course", Second Edition, WIT Press, 1992.*
3. *Becker, A. A., "The Boundary Element Method in Engineering: A Complete Course", McGraw Hill, 1992.*
4. *Banerjee, P. K., "The Boundary Element Methods in Engineering", McGraw Hill, 1994.*
5. *Liu, G. R., "Mesh Free Methods - Moving Beyond the Finite Element Method", CRC Press, 2003.*

ED719 BIO-MEMS AND MEDICAL MICRO-DEVICES 3-0-0-3

Introduction to Bio-MEMS, Silicon Microfabrication, Soft Fabrication Techniques, Polymer Materials, Microfluidic Principles, Sensor Principles and Microsensors, Microactuators and Drug Delivery, Clinical Laboratory Medicine, Micro-Total-Analysis Systems (μTAS) and lab-on-chip devices (LOC), Detection and Measurement Methods, Proteomics and Protein Microarrays, Genomics and DNA Microarrays, Emerging applications in medicine, research and homeland security, Packaging, Power systems, Data communications and RF Safety, Biocompatibility, FDA, and ISO 10993 biological evaluation.

TEXT BOOKS/REFERENCES:

1. *Steven S. Saliterman, "Fundamentals of BioMEMS and Medical Microdevices", SPIE Press, 2006.*
2. *Wanjun Wang and Steven A. Soper, "Bio-MEMS: Technologies and Applications", CRC Press, 2007.*
3. *Mauro Ferrari, Mihrimah Ozkan, and Michael J. Heller, "BioMEMS and Biomedical Nanotechnology: Volume II - Micro/Nanotechnology for Genomics and Proteomics", Springer, 2006.*
4. *Mauro Ferrari, Tejal Desai, and Sangeeta Bhatia, "BioMEMS and Biomedical Nanotechnology: Volume III - Therapeutic Micro/Nanotechnology", Springer, 2006.*
5. *Mauro Ferrari, Rashid Bashir, and Steve Wereley, "BioMEMS and Biomedical Nanotechnology: Volume IV – Biomolecular Sensing, Processing and Analysis", Springer, 2006.*

M.TECH – INTEGRATED DESIGN AND MANUFACTURING

Department of Mechanical Engineering

This program focuses on the requirements of the manufacturing industry embracing the areas of production planning and control, design, materials, processes, maintenance and quality control. The curriculum has been framed drawing course contents from traditional fields such as materials and processes, mechanical engineering, industrial engineering, and management. The syllabus for various courses has been designed in general to introduce the application of analytical and quantitative methods in manufacturing and expose the students to develop skills in the utilization the modern tools such as simulation, optimization, statistical data analysis, and finite element analysis. During the course of study, the students will be exposed to solve practical problems encountered in manufacturing.

Attested true copy

Amrita Vishwa Vidyapeetham ★ Coimbatore - 641 112 ★ अद्धावान् लभते ज्ञानम्

Dr.K. Sankaran
Registrar
Amrita Vishwa Vidyapeetham
Amrita Nagar, COIMBATORE - 641 112