Maulana Azad National Institute of Technology, Bhopal
Department of Mechanical Engineering

M.Tech. in Stress and Vibration Analysis

SCHEME OF STUDY (wef July 2021)

First Semester:

Course No.	Subjects	Scheme of studies period per week			Total Credits
		L	T	P	
MTH 515	Advanced Engineering Mathematics	3	-	-	3
SV 511	Theory of Elasticity	3	-	-	3
SV 512	Theory of Vibrations-1	3	-	-	3
SV 513	Finite Element Methods	3	-	-	3
HUM 511	Communications Skills	2	-	-	2
	Elective-1 (A)	3	-	-	3
	Elective -2 (B)	3	-	-	3
SV 514	Vibration Analysis Lab.	-	-	2	1
SV 515	Seminar-1	-	-	2	1
Total Hours: 30 Total Credits: 22		Total Semester Credits			22

Second Semester:

Course No.	Subjects	Scheme of studies period per week			Total Credits
		L	T	P	
SV 521	Experimental Stress Analysis	3	-	-	3
SV 522	Theory of Plasticity	3	-	-	3
SV 523	Theory of Vibrations-II	3	-	-	3
	Elective -3 (A)	3	-	-	3
	Elective- 4 (A)	3	-	-	3
	Elective -5 (C)	3	-	-	3
ME 524	Research Methodology	1	1	-	2
SV 525	Experimental Stress Analysis Lab.	-	-	2	1
SV 526	Seminar-2	-	-	2	1
Total Hours: 30 Total Credits: 44		Total Semester Credits			22

Third Semester:

Course No.	Subjects	Scheme of studies period per week			Total Credits
		L	T	P	
SV 611	Dissertation Phase - I	-	-	32	16
Total Hours: 32 Total Credits: 60		Total Semester Credits			16

Fourth Semester:

Course No.	Subjects	Scheme of studiesperiod per week			Total Credits
		L	T	P	
SV 621	Dissertation Phase - II	-	-	40	20
Total Hours: 40 Total Credits: 80		Total Semester Credits			20

List of Program Electives A	
SV 551	Advanced Computational Methods
SV 552	Vibrations of Plates
SV 553	Non-linear and Random Vibrations
SV 554	Stress and Vibration Analysis in Turbo-machinery
SV 555	Rotor Dynamics and Balancing
SV 556	Condition Monitoring
SV 557	Advanced Optimization Techniques
SV 558	Analysis of Composite Structure
SV 559	Mechanics of Composite Materials
SV 560	Non-linear Finite Element Methods
SV 561	Engineering Fracture Mechanics
SV 564	Surface Engineering
SV 565	Theory of Elastic Stability
SV 567	Product Design & Development
List of Departmental Electives B	
ID 512	Accelerated Product Design & Development
ID 514	Advanced Computer Graphics
ID 553	Detailed Design of Rotating Machines
ID 556	Advanced Dynamics of Machine
ID 561	Additive Manufacturing
TH 551	Renewable Energy
AM 557	Product Design & Material Selection

SV-511 THEORY OF ELASTICITY

State of stress and strain at a point in two and three dimensions, stress and strain invariants, Generalized Hooke's law, plane stress and plane strain problems, equations of equilibrium, boundary conditions, compatibility equations, two dimensional problems in cartesian coordinates, solution by Airy's stress function, Saint Venant's principle, solution of beam problems, two dimensional problem in polar coordinates, general equations, stress distributions symmetrical about an axis, pure bending of curved beam, stress concentration, problem of torsion, membrane analogy method, bending of bars with circular, elliptic and rectangular cross section and shear center, fatigue failure theories, fracture and creep.

Textbooks/References:

[1] Timoshenko and Goodier, Theory of Elasticity, McGraw-Hill International, 3rd edition, 1970.
[2] I. S. Sokolnikoff, Mathematical Theory of Elasticity, McGraw-Hill International, 2nd ed., 1957.
[3] Y C Fung, Foundation of Solid Mechanics, Prentice Hall Inc., 1965.
[4] Xu Zhilun, Applied Elasticity, Willey Eastern Ltd., 1992

SV-512 THEORY OF VIBRATIONS-I

Elements of a vibrating system. Free vibration of single-degree of freedom linear systems. Methods of vibration analysis: Energy method, Newton's method & Rayleigh method. Differential equations of motion for first order and second order linear systems. Transverse vibration of beams. Damped free vibration, viscous, coulomb damping dry friction logarithmic Decrement. Forced Vibration of single degree of freedom linear systems. Response of first orders systems to harmonic excitation. Frequency response. Response of second order systems to harmonic excitation. Harmonic motion of the base, vibration isolation, transmissibility, force transmission to foundations. Vibration measuring Instruments e.g. Seismic mass, vibrometer, Accelerometer. Energy dissipation. Forced vibration with coulomb hysteresis or structural & viscous damping, Dynamics of rotors, Torsional vibration of one, two and three rotor system. Equivalent shafting. Torsional vibration of a geared system. Torsional vibration with harmonic excitation. Critical speed of a shaft having a single disc and multiple disc with damping. Rotating unbalance, whirling of rotating shafts, Continuous systems, Vibration control in structures.

Textbooks/References:

[1]. L. Meirovitch, Elements of Vibration Analysis, McGraw Hill, 2nd edition, 1986.
[2]. L. Meirovitch, Principles and Techniques of Vibrations, Prentice Hall International (PHIPE), 1997.
[3]. W. T. Thomson and M. D. Dahleh, Theory of Vibration with Applications, 5th edition, Pearson, 1997.
[4]. F. S. Tse, I. E. Morse and R. T. Hinkle, Mechanical Vibrations, 2nd edition, CBS Publications, 2004.
[5]. J. S. Rao and K. Gupta, Introductory course on Theory and Practice of Mechanical Vibrations, 2nd edition, New Age Publication, 1999.

SV-513 FINITE ELEMENT METHODS

Various approaches in finite element method (FEM), direct stiffness method, energy approach and Galerkin's approach, detailed method for structural analysis problems, various elements, development of element stiffness matrices, applications to bar, beam, truss, spring, shaft problems, two dimensional elements, plane stress and plane strain problems, three dimensional elements and their applications, iso-parametric elements, plate bending and shell elements, axi-symmetric problem, metal forming problem, applications to fluid flow and heat transfer problems, Introduction of non-linear FEM, Discussion about pre-processors, postprocessors and finite element packages.

Textbooks/References:

[1]. J N Reddy, An introduction to the Finite Element Method, McGraw-Hill, New York, 1993.
[2]. K J Bathe, Finite Element Procedures in Engineering Analysis, Prentice-Hall, Englewood Cliffs, NJ, 1982.
[3]. O C Zienkiewicz and R L Taylor, The Finite Element Method, 3rd ed. McGraw-Hill, 1989.
[4]. U S Dixit, Finite Element Methods for Engineers, Cengage Learning, 2009.
[5]. P Seshu, Finite Element Analysis, PHI Learning Limited, 2010.
[6]. R D Cook, D S Malkus and M E Plesha, Concepts and Applications of Finite Element Analysis, 3rd ed., John Wiley, New York, 1989.
[7]. T J T Hughes, The Finite Element Method, Prentice-Hall, Englewood Cliffs, NJ, 1986.

SV-514 VIBRATION ANALYSIS LABORATORY (Laboratory-I)

Uses of pick-ups, oscillator and amplifiers for measurement of vibration and acceleration. Recording instruments. Studies in damping behavior. Mechanical models, critical speed of short and long bearings.

SV-521: EXPERIMENTAL STRESS ANALYSIS

Review of analysis of stress and strain – basic equations of elasticity. Introduction to ideal requirements of strain measuring devices – mechanical, optical and electrical strain gauges Electrical Resistance Strain Gauges, Types of strain gauges, resistance wire strain gauges, materials and cementing methods, temperature compensation, circuits and measuring techniques, strain gauge rosettes, testing and selection of gauges, mounting and installation of electrical resistance gauges. Photo-elasticity, polariscope and its elements, isoclinics and isochromatics, stress optic law, compensation techniques, methods to evaluate principal stresses, photoelastic materials, three- dimensional photoelasticity, stress freezing and slicking method. Moiré's fringes studies, brittle coating methods and its application in evaluation of stresses

Textbooks/References:

[1] J. W. Dally and W. P. Riely, Experimental Stress Analysis, McGraw-Hill Book Co., 1965.
[2] L. S. Srinath, M. R. Raghavan, Experimental Stress Analysis, Tata McGraw-Hill, 1984.
[3] A. W. Hendry, Elements of Experimental Stress Analysis, Pergamon Press, 1977.

SV-522 THEORY OF PLASTICITY

Plastic behavior, true stress and true strain, temperature and strain rate effects, Mechanism of plastic deformation, stress invariants, deviatoric stress, Elastic plastic stress-strain relations, yield and flow conditions, von-Mises yield criterion and determination of constants, flow rule, Generalized stress and generalized strain increment, Tresca yield criterion, Hill yield criteria Plastic Anisotropy, slip line field theory, α and β lines, stress equations, Hencky's first and second theorems, stress discontinuities, Interface with sliding friction, construction of hodograph, Application of slip-line field technique Limit theorem, principle of virtual work, principle of maximum plastic work, lower bound theorem, upper bound theorem

Textbooks/References:

[1]. Lubliner, Jacob. Plasticity theory. Courier Corporation, 2008.
[2]. Kachanov, Lazar′ Markovich. Fundamentals of the Theory of Plasticity. Courier Corporation, 2004.
[3]. Bigoni, Davide. Nonlinear solid mechanics: bifurcation theory and material instability. Cambridge University Press, 2012.
[4]. Dixit, Prakash Mahadeo, and Uday S. Dixit. Plasticity: Fundamentals and Applications. CRC press, 2014.
[5]. Chakrabarty, Jagabanduhu. Theory of plasticity. Elsevier, 2012.
[6]. G.K. Lal and N. Venkata Reddy, Introduction to Engineering Plasticity, Narosa, 2009.

SV-523: THEORY OF VIBRATIONS- I I

Transient & self-excited vibrations, Numerical methods for multidegree of freedom systems. Influence coefficients Dunkerlay's method, matrix iteration method. Orthogonality of principal modes. Comparison of behaviour between linear & non-linear systems. Eigen value & eigen vector. Holzer method for three and multi rotors and branched torsional systems. Mykelstad method, Stodola Method, Effect of shear deformation and rotary inertia. Vibration of continuous, longitudinal transverse and torsional systems. Vibrations of plates and shells. Static and dynamic balancing of Rotors. Balancing of thin discs. Field balancing of long rotors. Vibration Analysis by FEM.

References:

[1]. Weaver Jr, William, Stephen P. Timoshenko, and Donovan Harold Young. Vibration problems in engineering. John Wiley & Sons, 1990.
[2]. Meirovitch, Leonard. Elements of vibration analysis. McGraw-Hill Science, Engineering & Mathematics, 1975.
[3]. Tse, Francis Sing, Ivan E. Morse, and Rolland Theodore Hinkle. Mechanical vibrations. Boston: Allyn and Bacon, 1963.
[4]. Tse, Francis Sing, Ivan E. Morse, and Rolland Theodore Hinkle. Mechanical vibrations. Boston: Allyn and Bacon, 1963.

SV-525: EXPERIMENTAL STRESS ANALYSIS LABORATORY (Laboratory-II)

Use of strain gauges for determination of stress and forces. Load cells, strain indicators, CRO, Oscillograph and recorders for dynamic strain measurements. Photo elasticity- determination of iso-clinics and iso-chromatics and photography. Material calibration. Reflection polariscope. Brittle coating and Moire's fringes studies. NDT methods.

Sr. No.	LIST OF EXPERIMENTS
1.	Determination of stress Concentration in circular ring specimen using circular polariscope
2.	Determination of stress Concentration in circular disc specimen using circular polariscope
3.	Determination of stress Concentration in I-section specimen using circular polariscope
4.	Determination of stress Concentration in crane hook specimen using circular polariscope

List of Electives: A

SV-551: Advanced Computational Methods

Introduction to Computational Methods, Significant digits, Types of errors; Stability; Accuracy; Solutions of Linear Algebraic Equations: Direct elimination methods, Pitfalls of elimination methods, Norm and condition number; Iterative methods, Accuracy and convergence of iterative methods; Solution of Eigenvalue Problems; Solutions of Nonlinear Equations: Newton's method, System of nonlinear equations, Convergence and Error analysis; Interpolation: Lagrange polynomials, Divided difference polynomials, Hermite and cubic spline interpolation, Least square approximation; Numerical Differentiation – Unequally spaced data and Equally spaced data, Error estimation and extrapolation; Numerical quadrature – Newton-Cotes, Gauss quadrature, Multiple integrals; Initial and boundary value problems – Classification of ODEs, One step methods, Convergence and numerical stability analysis, Solution of higher order equations, Multistep methods, Convergence and stability analysis.

Texts/References

[1]. M. T. Heath, Scientific Computing - An Introductory Survey, Revised Second Edition, SIAM, 2018.
[2]. S. D. Conte and C. de Boor, Elementary Numerical Analysis, Third Edition, Tata McGraw-Hill Education, 2005.
[3]. F.B. Hildebrand, Introduction to Numerical Analysis, Second (Revised) Edition, Courier Dover Publications, 1987.
[4]. E. Kreyszig, Advanced Engineering Mathematics, Tenth Ed., John Wiley and Sons, 2010.
[5]. R. L. Burden and J. D. Faires, Numerical Analysis, 9th Edition (second Indian Reprint 2012), Brooks/Cole, 2011.
[6]. L.N. Trefethen, David Bau III, Numerical Linear Algebra, SIAM, 1997.
[7]. A.Quarteroni, R. Sacco, and F. Saleri. Numerical Mathematics, Springer-Verlag, New York, 2000.
[8]. J. D. Hoffman, Numerical Methods for Engineers and Scientists, Second Edition (Special Indian Edition), CRC Press, 2001.
[9]. K. E. Atkinson. An Introduction to Numerical Analysis, Second Edition, Wiley, 2004.
[10]. R. W. Hamming, Numerical Methods for Scientists and Engineers, Second Edition, Dover, 1986.

SV-552: Vibrations of Plates

Starting with displacements in curvilinear coordinates, deformations and strains are obtained which are linearized. The differential element and its deformation are derived using Lame parameters and radii of curvature. Then stresses and force resultants are derived. These are used in the Hamilton's Law to derive the most general set of equations of motion for a thin shell of any general geometry. These equations are then specialized for different systems: beams, plates, shells of various shapes and geometries. Next, boundary conditions are applied and mode shapes and resonances are derived.

Following this the forced response is derived for different types of forces. Lastly, combinations of systems is studied using the receptance method

Reference Books:

[1]. Soedel, Werner. Vibrations of shells and plates. CRC Press, 2004.
[2]. S.S. Rao, Vibration of Continuous Systems, Wiley, 2007

SV-553: Non-Linear and Random Vibrations

Introduction, Fundamentals of probability theory: probability space, random variables, functions of random variables, Stochastic processes and random signals: stationarity, ergodicity, power spectrum, covariance functions, calculus of random processes, Linear single and multi-degree of freedom structural systems: input-output relations, time domain and frequency domain analysis, linear and nonlinear systems, the fokker-Planck equation, Computational issues, Level crossing and first passage times, extreme value and peak distributions, Applications: random fatigue, probabilistic crack growth, risk analysis.

Textsbooks:

[1] Nayfeh, A. H., and Mook, D. T., Nonlinear Oscillations, Wiley-Interscience, 1979.
[2] Hayashi, C. Nonlinear Oscillations in Physical Systems, McGraw-Hill, 1964.
[3] Evan-Ivanowski, R. M., Resonance Oscillations in Mechanical Systems, Elsevier, 1976.
[4] Nayfeh, A. H., and Balachandran, B., Applied Nonlinear Dynamics, Wiley, 1995.
[5] Seydel, R., From Equilibrium to Chaos: Practical Bifurcation and Stability Analysis, Elsevier, 1988.
[6] Moon, F. C., Chaotic & Fractal Dynamics: An Introduction for Applied Scientists and Engineers, Wiley, 1992.
[7] Srinivasan, P. Nonlinear Mechanical Vibrations, New Age International, 1995.
[8] Rao, J. S., Advanced Theory of Vibration: Nonlinear Vibration and One-dimensional Structures, New Age International, 1992
[9] D. E. Newland, An Introduction to Random Vibrations and Spectral Analysis, Second Ed., Longman Inc., NewYork, 1984
[10] N. C. Nigam, Introduction to Random Vibrations, MIT Press, Cambridge, 1983

SV-554 STRESS & VIBRATION ANALYSIS IN TURBO-MACHINERY

Stresses in rotating discs and blade, disc of uniform strength, temperature stresses, general blade stress equation, blade design for strength. Determination of blade natural frequencies. Coupling of torsional and bending vibrations due to pre-twist and eccentricity of shear center. Effects of rotor speed, disc-coupling, shrouding, lacing wires and geometry on natural frequencies of blades. Root fixing of blades to the disc. Analysis of aerodynamic forces acting on the blades of gas turbines. Vibration of low aspect ratio blades. Vibration of aircraft wings. Aerodynamic analysis of wind turbines. Load calculations in wind turbine design. Stress and Vibration analysis of blades, hub and axle and tower in wind turbines.

References

[1]. Dahleh, Marie Dillon, and William T. Thomson. "Theory of vibration with applications." Prentice-Hall Inc (1998).
[2]. Rao, J. S. Turbomachine blade vibration. New Age International, 1991.

SV-555 ROTOR DYNAMICS AND BALANCING

Dynamic of rotating machinery: Critical speeds of rotors, Factors effecting the critical speeds such as gyroscopic action internal damping unequal moments of inertia of shaft section, bearing elasticity and oil film cushioning, Torsional frequencies of multi-mass rotors, Vibration of discs, blades and propeller which affect the rotor motion. Transfer matrix Analysis, Optimum design of bearings for minimum unbalance response. Stability of rotors under various influences: stability of rotors on elastically mounted supports and combined effect of bending and torsion. Resonance vibration of rotors with non-linear factors taken into account stability of rotors in flow medium. Sources of unbalance in rotors, balancing machines, balancing criteria, specification and tolerances. Balancing in two planes correction methods used in industries, cradle balancing of rigid rotors, automatic balancing field balancing of rotors. Balancing of flexible rotors.

Textbooks:

[1] J. S. Rao, Rotor Dynamics, Third ed., New Age, New Delhi, 1996.
[2] M. J. Goodwin, Dynamics of Rotor-Bearing Systems, Unwin Hyman, Sydney, 1989.

SV-556 CONDITIONING MONITORING

Introduction to machinery maintenance, basic vibration theory, fundamentals of data acquisition, principles of condition monitoring, transducers for condition monitoring, fault diagnosis in rotating machines, NDT methods in condition monitoring, wear and debris analysis, case studies in condition monitoring.

Textsbooks:

[1] R. A. Collacott, Vibration Monitoring and Diagnosis, Willey, New York, 1979
[2] H. P. Bloch and F. P. Geitner, Practical Machinery Management for Process Plants, Vol. 1, 2 3 & 4., Gulf Publishing Company, 1983
[3] H. M. Harris and C. E. Crede, Shock and Vibration Handbook, McGraw-Hill Book Company, 1994
[4] A. V. Oppenheim and R.W. Shafer, Digital Signal Processing, Prentice-Hall, Inc., 1975
[5] V. Wowk, Machinery Vibration Measurement and Analysis, McGraw-Hill, Inc., 1991
[6] R. B. Randall, Frequency Analysis, Bruel & Kjaer Publication, 1986
[7] J. S. Bendat and A. G. Piersol, Engineering applications of correlation and Spectral Analysis, John Wiley & Sons, 1980

SV-557 ADVANCED OPTIMIZATION TECHNIQUES

Introduction to optimization; Formulation of optimization problems; Classical optimization techniques; Linear Programming; Non-linear Programming; single variable, multi-variable and constrained optimization; Specialised algorithms for integer programming and geometric programming; Non-traditional optimization algorithms

Textsbooks:

[1] S. S. Rao, Optimization: Theory and Applications, 2nd ed. Wiley Eastern, 1984.

[2] K. Deb, Optimization for Engineering Design-Algorithms and Examples, PrenticeHall India, 1995.

[3] J. S. Arora, Introduction to Optimum Design, MCGraw-Hill, 1989.

[4] G. V. Reklaitis, A. Ravindran and K. M. Ragsdell, Engineering OptimizationMethods and Applications, Wiley, 1983

[5] R. L. Fox, Optimization Methods for Engineering Design, Addison Wesley, 1971.

SV-558: ANALYSIS OF COMPOSITE STRUCTURES

Equations of anisotropic elasticity. Kinematics, Kinetics, thermodynamic and constitutive equations. Thermo elasticity, Electro elasticity and hygro thermal elasticity. Virtual work principles and variational methods. Classification of structural theories for composite plates.

Classical Laminated Plate Theory. Lamina constitutive relation. Laminate constitutive equations. First order laminated plate theory. Shear correction factor, laminate stiffness,

symmetric and anti symmetric laminates. Quasi isotropic laminates. One dimensional analysis of laminated plates. Analysis of laminated beams. Analysis of especially orthotropic plates. Bending of rectangular plates with various boundary conditions. Vibrations of composite plates. Transient analysis. Analytical solutions of rectangular plates using CLPT and FSDT. Finite

Element Analysis of Composite plates. Refined theories of laminated composite plates.

Textsbooks/References

[1] Jones, R M, Mechanics of Composite Materials, Scripta Book Co.

[2] Agarwal, B D and Broutman, J. D, Analysis and Performance of Fiber Composites, New York, John Willey and Sons, 1990

[3] Mallik, P. K, Fiber reinforced composites : materials, manufacturing and design, New York-Marcel and Dekker, 1993 (2ndedition).

[4] Mallik, P. K, Composite Engineering Hand Book, New York, Marcel and Dekker, 1997 (2nd edition).

SV-559 MECHANICS OF COMPOSITE MATERIALS

Classification and characteristics of composite materials, Mechanical Behaviour of composite materials. Lamina and Laminates. Manufacture of Laminated fiber – reinforced. Composite Materials. Macro-mechanical behaviour of lamina, stress strain relations for anisotropic, orthotropic and isotropic materials. Engineering constants. Stress strain relation for plane stress in orthotropic materials. Invariant properties. Strength of an orthotropic lamina, Experimental determination of

strength, Biaxial strength theories: Maximum stress theory, Maximum strain theory, Tsai-Hill theory and Tsai-Wu theory. Classical Lamination theory. Analysis of laminates, Special cases of laminate, stiffnesses, strength of Laminates. Design of Laminates. Bending, buckling, deflection and vibration of laminated plates.

Textsbooks/References

[1] Jones, R M, Mechanics of Composite Materials, Scripta Book Co.
[2] Mallik, P. K, Fiber reinforced composites: materials, manufacturing and design, New York-Marcel and Dekker, 1993 (2ndedition).
[3] Arthur, K Kaw, Mechanics of Composite Materials, CRC Press, 1997.
[4] Reddy J N, Mechanics of Laminated Composite Plates, CRC Press, 1990.

SV-560 NONLINEAR FINITE ELEMENT METHODS

Fundamentals of finite deformation mechanics-kinematics: Stress measures, Balance laws, Objectivity principle: Newton-Raphson procedure. Finite element formulation for plasticity and nonlinear elasticity: Stress update algorithms for plasticity. Finite element procedures for dynamic analysis: Explicit and implicit time integration. Finite element modelling of contact problems: Slide-line methods and penalty approach, Adaptive finite element analysis: Automatic mesh generation, Error estimation, Choice of new mesh, Transfer of state variables.

Textbooks/References:

[1]. K.J. Bathe, Finite Element Procedures, Second Edition, Prentice Hall, 1996.
[2]. Daryl L. Logan, Finite Element Method, Fifth Edition, 2012
[3]. T. Belythschko, W.K. Liu and B. Moran, Nonlinear Finite Elements for Continua and Structures, Wiley, 2000.
[4]. P.K. Kythe, D.Wei, An Introduction to Linear and Nonlinear Finite Element Analysis: a Computational Approach, Birkhauser, 2004.
[5]. P. Wriggers, Nonlinear Finite Element Methods, Springer, 2008.

SV- 561 ENGINEERING FRACTURE MECHANICS

Basic aspects of Engineering Fracture Mechanics. Spectacular failures that triggered the birth of fracture mechanics, Modes of loading, Classification as LEFM and EPFM, Crack growth and fracture mechanisms, Energy release rate, Resistance, Griffith Theory of fracture, Extension of Griffith Theory by Irwin and Orowan, R-Curve, Pop-in phenomena, Crack branching. Necessary and sufficient conditions for fracture, Stress and Displacement fields in the very near and near-tip fields, Westergaard, Williams and Generalized Westergaard solutions, Influence of the T-stress and higher order terms, Role of photoelasticity on the development of stress field equations in fracture mechanics, Equivalence between SIF and G, Various methods for evaluating Stress Intensity Factors, Modeling plastic zone at the crack-tip, Irwin and Dugdale models, Fracture toughness testing, Residual strength diagram, Paris law, J-integral, HRR field, Mixed-mode fracture, Crack arrest methodologies.

Textbooks/References:

[1]. K. Ramesh, e-Book on Engineering Fracture Mechanics, IIT Madras, 2007.
[2]. Prashant Kumar, Elements of Fracture Mechanics, Tata McGraw Hill, New Delhi, India, 2009.
[3]. K. R.Y. Simha, Fracture Mechanics for Modern Engineering Design, Universities Press (India) Limited, 2001
[4]. D. Broek, Elementary Engineering Fracture Mechanics, Kluwer Academic Publishers, Dordrecht, 1986.
[5]. T.L. Anderson, Fracture Mechanics Fundamentals and Applications, 3rd Edition, Taylor and Francis Group, 2005.

SV-564 Surface Engineering

Fundamentals of surface engineering: definition, scope, classification, and general principles, surface dependent properties and failures, Surface and surface energy: Structure and types of interfaces. Conventional surface engineering practice: Surface engineering by material removal: like etching, grinding, polishing, etc. Surface engineering by material addition: like hot dipping, Electro-plating, carburizing, Cyaniding, etc. Advanced surface engineering practices: Surface engineering by energy beams: Laser assisted microstructural modification like surface melting, hardening, shocking etc., Laser assisted compositional modification like surface alloying, surface cladding, composite surfacing etc. Ion beam assisted microstructure and compositional modification, Surface engineering by spray techniques like Flame spray, cold spray etc., Sputter deposition of thin films & coatings, PVD coating processes, Chemical vapour deposition and PECVD Characterization of coatings and surfaces: Measurement of coatings thickness, porosity & adhesion of surface coatings, Measurement of residual stress & stability, Surface microscopy, topography and Spectroscopic analysis of modified surfaces.

References:

[1]. P. A. Dearnley, Introduction to Surface Engineering, Cambridge University Press, 2017.
[2]. Davis, Joseph R., ed. Surface engineering for corrosion and wear resistance. ASM international, 2001.
[3]. Kwok, Chi Tat, ed. Laser surface modification of alloys for corrosion and erosion resistance. Elsevier, 2012.
[4]. K.G. Budinski, Surface Engineering for Wear Resistances, Prentice Hall, Englewood Cliffs, 1988.
[5]. Tadeusz Burakowski Tadeusz Wierzchon: "Surface Engineering of Metals: Principles, Equipment, Technologies", CRC, 1998 6. ASM Hand book – Surface Engineering

SV-565 THEORY OF ELASTIC STABILITY

Introduction Fundamental principles and models for elastic stability Stability of column; Classification of dynamical systems, linear and nonlinear eigenvalue problems. Differential equations for beam-columns, beam-column with concentrated lateral load, beam column with built-in ends, beam-columns with elastic restraints Elastic buckling of bars under axial loading, Energy

method, Alternate form of the differential equation for determining critical loads. beams and arches Lateral buckling of beams, combined bending and axial, combined bending and torsion. Inelastic buckling of bars, Inelastic bending, Inelastic buckling of bars with end condition. Buckling of rings & curved bars. Bending of thin curved bar with a circular axis. Effect of uniform pressure on bending of a circular ring Buckling of thin plates. Methods of calculation of critical loads. Buckling of simply supported rectangular plates. Buckling of shells, symmetrical buckling of a cylindrical shells.

References

[1]. Timoshenko, Stephen P., and James M. Gere. *Theory of elastic stability*. Courier Corporation, 2009.

[2] Y C Fung, Foundation of Solid Mechanics, Prentice Hall Inc., 1965.

[3] Xu Zhilun, Applied Elasticity, Willey Eastern Ltd., 1992

SV-567: PRODUCT DESIGN & DEVELOPMENT

Elements of successful product design in their specialist market place. Study of Engineering / Marketing relationship. The buying motivation and perception of industrial buyers. Individual customers, industry and government departments. Presentation of designs to potential customers. Accelerated product development. Variety proliferation. Differential product "fast to market". Forecasting and market research for a new product. Purchasing and sales procedure. Demand analysis for new product. Intellectual property right. Introduction to IPR laws, nature, types of intellectual property, IPPP as an economic entity. Development of IPR copyright, patents, design, trademarks, forms, global IP structure and IPRS in India, Infringement and remedies available, patent search, contractual agreements involving patents. Case studies testing & refinement Prototyping basics, principle of prototyping, prototyping technologies, planning for prototypes.

Textbooks/References:

[1]. Product design and development Karl Ulrich and Steven D Eppinger

[2]. K.T. Ulrich & S.D. Eppinger, Product Design & Development, TMH,2003

[3]. Cross N., Engineering Design Methods-Strategies for Product Design, John Wiley & sons, 2008