MECHANICAL ENGINEERING DEPARTMENT

M.Tech. STRESS AND VIBRATION ANALYSIS

Course of Study & Scheme of Examination
2016-17

Maulana Azad National Institute of Technology
Bhopal

M.TECH. IN STRESS AND VIBRATION ANALYSIS

First Semester

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
MTH511E	Advanced Engineering Mathematics & Optimization Techniques	3	-	-	3
SV512	Theory of Elasticity	3	-	-	3
SV513	Theory of Vibrations - I	3	-	-	3
	Elective - 1	3	-	-	3
	Elective - 2	3	-	-	3
	Open elective-1	3	-	-	3
SV514	Vibration Analysis Laboratory	-	-	2	2
SV515	Seminar 1 and mini project	-	2	-	2
				Total credit 22	

Second Semester

Course Number	Subject	Scheme of Studies Periods per week			Total Credits
		L	T	P	
SV521	Experimental Stress Analysis	3	-	-	3
SV522	Theory of Plates	3	-	-	3
SV523	Theory of Vibrations - II	3	-	-	3
	Elective - 3	3	-	-	3
	Elective - 4	3	-	-	3
	Open elective-2	3	-	-	3
SV524	Experimental Stress Analysis Laboratory	-	-	2	2
SV525	Seminar 2 and mini project	-	2	-	2
				Total credit 22	

List of department Electives

SV531 Advanced Machine Design SV-532 Theory of Elastic Stability
SV533 Theory of Plasticity SV-534 Product Design & Development
SV535 Earthquake Engineering SV-536 Non-linear & Random Vibrations
SV537 Stress & Vibration Analysis in Turbo-machinery
SV538 Rotor Dynamics & Balancing SV-539 Analysis & Design of Shells
SV541 Analysis of Composite Structures SV542 Computer Aided Design
SV543 Mechanics of Composite Materials

List of Open Elective

SV 551 Finite Elements Method
SV552 Condition Monitoring

SYLLABUS

MTH 511E ADVANCED ENGINEERING MATHEMATICS & OPTIMIZATION TECHNIQUES

Numerical Methods: Solution of algebraic and transcendental equations, Solution of linear simultaneous equations, finite differences, Interpolation and Extrapolation, Inverse Interpolation, Numerical differentiation and integration, Numerical solution of ordinary and partial differential equations.

Introduction to optimization by linear programming, solution by graphical and simplex method, concept of degeneracy and duality, artificial variable techniques-Big-method, transportation and assignment problem.

References

1. Numerical Methods for Engineers — Stevan C. Chapra and Raymond P Canale.
2. Numerical Methods for Engineers — Iyengar and M.K.Jain.
3. Operation Research — S.D.Sharma.
4. Numerical Optimization Techniques with Applications — Suresh Chandra.

SV512 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 condtions, 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.

References

1. Theory of elasticity Timoshenko & Goodier
2. Theory of elasticity Sadhu Singh
3. Structural Analysis L S Negi and R S Jangid
4. Structural Analysis P Dayaratnam

SV 513 THEORY OF VIBRATIONS 1

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 eg. Scismic mass, vibrometer, Accelerometer. Energy dissipation. Forced vibration with coulomb hystersis or structural & viscous damping.

Torsional vibration of one, two and three rotor system. Equivalent shafting. Torsional vibration of a geared system. Torssional vibration with harmonic excitation. Critical speed of a shaft having a single disc and multiple disc with damping. Rotating unbalance, whirling of rotating shafts.

References:

1. Theory of Vibration with Application Thomson.
2. Mechanical vibration V.P.Singh
3. Mechanical vibration Schaum Series.
4. Mechanical Vibrations G.S. Grover & Nigam

SV 514 VIBRATION ANALYSIS LABORATORY

Uses of pick-ups, oscillator and amplifiers for measurement of vibration and acceleration. Recording instruments. Studies in damping behaviour. Mechanical models.

SV515 SEMINAR 1 & MINI PROJECT

Students have to collect a International Journal paper on the topics of their interest, prepare a write up and present with suitable demonstration by software or experimental work. Evaluation will be based on relevant topic student has studied, communication skill and reporting/documenting procedure

SECOND SEMESTER

SV 521: EXPERIMENTAL STRESS ANALYSIS

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

Photoelasticity, 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.

Brittle coating methods and its application in evaluation of stresses

References:

1. Experimental Stress Analysis Dally and Riley.
2. Experimental Stress Analysis J. Srinath.
3. Experimental Stress Analysis A. Mubeen.

SV 522 THEORY OF PLATES

The Differential equation of bending of a thin plate, boundary conditions for simply supported, fixed and free edges, Rectangular plates with different boundary conditions, Navier solution, Levy's solution, solution for different loading conditions such as UDL, hydrostatic, point load and partially loaded plates.

Thin plates with built-in edges, Strain energy stored in plate, energy method for solution, Numerical methods- Finite difference method for stress analysis of plate. Bending of circular plates,differential equation in polar coordinates and boundary conditions. Solution of symmetrical loaded circular plates.

References:

1. Theory of plates & shells Timoshenko
2. Stresses in plates and shells U.C. Ugural

SV 523: THEORY OF VIBRATIONS 2

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. Vibration Problems in engineering S.Timoshenko & Young
2. Elements of Vibration-Analysis L.Meirovitch.
3. Mechanical Vibration F.S. Tse, Morse & Hinkle
4. Theory of Vibration Thomson

SV524 EXPERIMENTAL STRESS ANALYSIS LABORATORY

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

SV525 SEMINAR 2 & MINI PROJECT

Students have to collect a International Journal paper on the topics of their interest, prepare a write up and present with suitable demonstration by software or experimental work. Evaluation will be based on relevant topic student has studied, communication skill and reporting/documenting procedure

DEPARTMENT ELECTIVES

SV531 ADVANCED MACHINE DESIGN

General consideration for design of machine elements. Types of loadings. Criteria for failure. Distinction between design approaches for static and fatigue loading and their influences on design criteria. Designing against fatigue, creep and impact loading.

Stress concentration and stress concentration factors. Residual stresses and their determination.

Types of drives. And their relative merits. Belt drives – design and performance. Chain drive. Gear drives. Strength of gear tooth surface. Beam strength. Strength, deflection and design of shafts.

Selection of bearings. Gear drive housing. Fluid power systems, pumps and accessories, circuit design and applications. Step less drives, P.I.V. drives. Power transmission in machine tools.

Stress intensification in presence of sharp notches and cracks. Design of machine elements in presence of cracks.

References

1. Advanced Machine Design Mubeen
2. Mechanical Engineering Design Shigley

SV 532 THEORY OF ELASTIC STABILITY

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.

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. Theory of Elastic Stability Timoshenko and Gere

SV533 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

References

1. Introduction to Engineering Plasticity G.K. Lal and N. Venkata Reddy
2. Finite Elements in Plasticity: Theory and Practice D.R.J. Owen and E. Hinton

SV 534 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. Acclerated 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. Ddevelopment 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

References

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

SV 535 EARTHQUAKE ENGINEERING

Elements of seismology: Definitions of the basic terms related to earthquake (magnitude, intensity, epicenter, hypocenter and earthquake waves), measurement of ground motions, Seismic regions, intensity and isosismals of an earthquake, seismic zoning, strong ground motion arrays.

Earthquake effects on structures: Sources of vibration, types of vibrations, degree of freedom (SDOFS/ MDOFS), equation of motion of single and multiple degrees of freedom, dry friction damping and negative damping, forced vibrations of a damped system, system subjected to transient forces

Continuous systems: Free vibration-frequencies and mode shapes, numerical techniques, forced vibration-earthquake excitations.

Earthquake motion and response: Strong motion earthquakes, numerical method for spectra, elastic spectra, concept of response spectra/ average response spectra/ design response spectra, inelastic spectra, evaluation of earthquake forces, IS Code 1893: 2002, effect of earthquake on different types of structures

Concepts of earthquake resistant design: Structural Systems/ Types of buildings, causes of damage, Earthquake resistant design of masonry buildings, Strength and structural properties of masonry, Design consideration Guidelines, Earthquake Resistant Design of R.C.C. Buildings, Material properties, Lateral load analysis, Design and detailing (IS:13920: 1993)

Aseismic design of structures: Design data and philosophy of design, seismic coefficients, multistory buildings, ductility provisions in reinforced concrete construction, water towers, bridges, gravity dams and retaining walls etc.

Reference

1. Elements of Earthquake Engineering — Jai Krishna and Chandrasekaran
2. Earthquake Engineering — A.K. Chopra
3. Earthquake Resistant of structures — Pankaj Agrawal and Manish Shrikande

SV 536 NON-LINEAR & RANDOM VIBRATIONS

Definition of non-linear systems and comparison between the behavior of linear and non-linear systems. Undamped and damped free and forced vibrations. Self excited oscillations, singular points, analytical methods. Stability concept, phase plane plots, limit cycle.

Probability density functions, characteristic functions. Stationary and non stationery random process, ergodic random process. Auto-correlation function. Power spectral density function.

References

1. Non-linear Oscillations N. Minorsky.
2. Advanced theory of vibrations J.S. Rao
3. Non linear vibrations Stoker
4. Random Vibration J.D. Robson
5. Application of Random Vibrations NC Nigam & S.Narayana

SV 537 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 turbine.

References

1. Mechanics of Materials Vol.II E.J.Hearn
2. Theory of Vibraations Thomson
3. Advanced Theory of Vibrations J.S.Rao
4. Blaade Vibrations J.S.Rao
5. Wind Engineering Design Eaglestone

SV 538 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.

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, 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

References

1. Rotor Dynamics J.S. Rao.

SV539: ANALYSIS & DESIGN OF SHELLS

Terminology related to theory of shells. Construction of shells of single and double curvature, shells of translation or rotation. Equation of bending of shells, equilibrium and compatibility equations. Stress, strain and displacement equations. Solution of cylindrical shells. Software for shells. Design aspects of shells

References

1. Theory of plates and shells S.Timoshenko.
2. Stresses in plates and shells U.C. Ugural

SV 541 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 relations. 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 specially 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.

References

1. Mechanics of laminated composite plates J.N.Reddy

SV542 Computer Aided Design

Computer aided design, hardware and software in CAD, solid modeling in CAD, computer graphics, generation of lines, curves, surfaces, two and three dimensional transformations, optimization methods, Integration of CAD and CAM, robotics, computer integrated systems, production management, NC programming, computer control, CAE systems and project management, computer aided project planning

References

1. CAD/CAM Mikell P.Groover & E.W. Zimmers, Jr.
2. OPTIMIZATION FOR ENGG. DESIGN KALYANMOY DEB

SV543 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.

Macromechanical 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. Special cases of laminate, stiffnesses, strength of Laminates. Design of Laminates.Bending buckling and vibration of laminated plates. Governing equation. Deflection & buckling. Vibrations.

References: Mechanics of Composite Materials R.M. Jones.

OPEN ELECTIVE