Department of Mechanical Engineering

GRADUATE COURSE DESCRIPTIONS

15500   Advanced Engineering Math I   3 Cr.   Vectorspaces, linear transform- ations. Canonical forms. Operators and inner product spaces. Functions of matrices. Linear difference equations. Analytic functions and Calculus of residues.

15501   Continuum Mechanics I 3 Cr.   Cartesian tensors. Index notation. kinematics of a continuum. Stress tensor. Field equations. Motion and deformations. Conservation laws. Linear constitutive equations. Elasto-static and elasto-dynamic problems.

15502   Advanced Numerical Methods   3 Cr.   Interpolation. Integration. Solutions of algebraic equations. Least square curve-fitting and functional approximations. ODE's and PDE's.
Prerequisite: Advanced Engineering Math I 15500 or
Applied Mathematics 15600.

15503   Advanced Engineering Math II 3 Cr.   Applied complex analysis. Conformal mapping. Schwarz-Christoffel transformation. Complex formulation of hydrodynamic & plane elasticity. PDE's. Sturm-iouville problem. Gamma function. Bessel functions. Hypergeometric and confluent hypergeometric functions.
 Prerequisite: Advanced Engineering Math I 15500.

15504   Continuum Mechanics II 3 Cr.   Tensor algebra. Tensor analysis. Kinematics. Mass. Momentum. Force. Constitutive equations. Change in observer. Invariance of material response. Newtonian fluids. Finite elasticity.
Prerequisite: Continuum Mechanics I15501.

15505   Tensor Analysis   3 Cr.   Contravariant. Covariant and mixed tensors .Metric tensor

& line element. Curvature tensor. Geodisc deviation. Flat & constant curvature spaces. Differential geometry. Gauss-Codazzi equations. Applications in dynamics and fluid mechanics.
 Prerequisite: Advanced Engineering Math I 15500.

15506   Wave Propagation in Elastic Media   3 Cr.   Elastic waves in unbound- ed medium. Plane harmonic waves in waveguides. Forced motions of a half-space. Transient waves in layers and rods. Thermal and viscoelastic effects. Effects of anisotropy and nonlinearity.

15508   Fluid Film Lubrication   3 Cr.   Hydro- and elastohydro-dynamic lubrication. Thrust, squeeze film, hydrostatic, and journal bearings. Simplified solutions for stresses and deformations. Elastohydrodynamic lubrication of rectangular and elliptical contacts.

15511   Elasticity   3 Cr.   Equilibrium. Compatibility. Stress-strain relation .Compatibility equation in

polar & rectangular coordinates. General theorems .Energy method for structural analysis. Axisymmetric stress

and deformation in solid of revolution. Thermal stress.
15512   Advanced Dynamics   3 Cr.   Direction cosines. Euler and Rodrigues parameters. Successive rotation. Partial linear and angular velocities. Generalized forces. Kane's equations of motion. Constrained motion. Kane's method for simple non-holonomic systems.

15513   Advanced Vibrations   3 Cr.   Small oscillations of discrete or discretized systems of high dimensions. Free and forced vibrations. Modal expansion. Continuous systems. Exact and approximate solutions. FEM for reductions of continuous systems.

15514   Plasticity   3 Cr.   Theory of plasticity. Stress and strain in three dimen- sions. Yield criteria of metals. Stress-strain relation. Method of work-hardening characteristics. Plastic instability. Spline field theory. Load bounding.

15515   FEM in Solid Mechanics I   3 Cr.   Discretization. FEM for 2D and 3D structures using rod and/or beam elements. Shape function. Stiffness matrix for rectangular and triangular elements in planar stresses. Use of PVW. Hexahedral elements in 3D systems. FEM for structural vibrations.
 Prerequisite: Advanced Engineering Math I 15500 or Applied Mathematics 15600.

15516   Metal Forming 3 Cr.   Effect of mechanical work on metals. Hot working on metals. Effect of heat on cold-worked metals. Slip line theory & load bounding to deformation problems. Rolling. Extrusion. Forging. Stretch forming. Wire drawing. Deep drawing or pressing.

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15518   Advanced Computer Aided Design   3 Cr.   Weighted residues. Calculus of variations. Galerkin's method. Energy method. Matrix of bar and beam elements. Transformation matrix. Trusses and frames. Isoparametric elements. Stress in 2D problems. Vibration and continuum mechanics. Mesh generation.

15519   Advanced Mechanisms Design   3 Cr.   Geometry of constrained motion in three dimensions. Applications to design of mechanisms.

15521   Advanced Gas Dynamics   3 Cr.   Review of one-dimensional flow. Oblique shock waves. Prandtl-Meyer flow. Two-dimensional subsonic and supersonic flow. Method of characteristics.

15522   Advanced Fluid Mechanics   3 Cr.   Integral form of conservative laws .Vorticity transport equation. Inviscid flow. Vortex motion. Unsteady potential flow .Steady-state potential flow.

15523   Statistical Thermodynamics   3 Cr.   Statistical mathematics. Classical mechanics. Quantum mechanics. Energy storage. Degrees of freedom. Statistical mechanics and thermodynamics.

15524   Heat Transfer (Conduction)   3 Cr.   Formulation of heat conduction problems. Lumped, integral, and differential methods. Steady and unsteady, one- and multi-dimensional conduction. Melting and freezing.

15525   Heat Transfer (Convection)   3 Cr.   Differential and integral formulation of convective heat transfer. Laminar and turbulent flows. Convection in tubes and boundary layers. Free convection. Variable properties. High velocities.

15526   Heat Transfer (Radiation)   3 Cr.   Properties of surfaces and materials .Configuration factors. Radiation exchange in enclosure, absorbing, emitting, and scattering media. Radiation combined with conduction and/or convection.

15527   Boundary Layers   3 Cr.   Fundamental equations of viscous flows. Solution of Newtonian viscous flow equations. Laminar boundary layers. Stability of laminar flows. Turbulent boundary layers.

15528   Advanced Hydro-& Aero-Dynamics   3 Cr.   Potential flow theory. Flow about a body. Aerodynamic characteristics of airfoils. Finite wing theory. Panel methods. Compressible potential flow about wings and bodies.

15529   Two-Phase Flow & Heat Transfer 3 Cr.   Dynamics of bubble formation. Pool boiling. Boiling curve. Two-phase flow models. Subcooled boiling. Saturated boiling. Critical heat flux. Condensation.

15530   Nonlinear Elasticity   3 Cr.   Indicial notation. General tensors. Stress and strain tensors. Equations of equilibrium. Equations of compatibility. Finite deformation. Solutions of special problems.

15532   FEM in Solid Mechanics II   3 Cr.   Nonlinear theory. Geometrically nonlinear problems. Inelastic problems. Nonlinear material behavior. Stability of equilibrium. Nonlinear elasticity. Variational and residual methods.
Prerequisite: FEM in Solid Mechanics I 15515.

15535   Turbolence   3 Cr.   General concepts. Isotropic turbulence. Homogeneous shear flow turbulence. Transport processes in turbulence. Free and wall-bounded shear flows. Turbulence modeling.

15536   Advanced Gas Turbines 3 Cr.   Thermodynamics of gas turbines .Off-design performance of various types of gas turbine engines. Axial flow turbine design. Aspects of combustion chambers and their future.

15537   Numerical Methods in Heat Transfer   3 Cr.   CV-based difference method. Steady and unsteady heat conduction. Convection-diffusion problems .SIMPLE algorithm. Turbulent heat transfer. $k -$ and low-Re models.

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15538 **Advanced Thermodynamics** 3 Cr. Equilibrium. Constant chemical composition, ideal gas mixtures of constant composition, and gas mixtures with variable composition. Elastic systems, systems with surface tension, fuel cell, and reversible cell.

15539 **Propelling Systems** 3 Cr. Power cycles. Piston engines & propellers .Turboshaft & turboprop engines. Turbofan and jet engines. Rockets and ramjets .Sub- & super-sonic propelling nozzles. Gas turbine equipped with engines. Air screws and propellers.

15540 **Advanced Combustion** 3 Cr. Thermochemistry. Chemical equilibrium. Conservation equations. Burning of fuel droplets. Diffusion flame (laminar and turbulent). Chemical kinetics. Deflagration. Detonation. Well-stirred reactor. Flame stability. Premixed flame.

15541 **Mechanics of Robotic Systems** 3 Cr. Hardware structure of robots. Kinematics, dynamics, and control of manipulators. Trajectory planning. Joint and Cartesian spaces. Optimal design. Position and force control. Kinematic loops.

15549 **Analysis & Design of Robotic Systems** 3 Cr. Kinematic modeling. Dynamic task space motion. Parallel computation of manipulators for inverse and forward dynamics. Trajectory planning. Six d.o.f. robots motion. Force & moment analysis for arm and grippers.

15550 **Nonlinear Systems** 3 Cr. Nonlinear elements. ODE's with constant or periodic coefficients. Linearization. Local stability. Lyapunov and Poincare' stability theorems. Phase-plane method. Perturbation method. Describing function analysis.

15551 **Dynamic Systems** 3 Cr. System models (differential equations, transfer functions, state-space). Modeling of mechanical, electrical, fluid, and thermal systems. Analytical, digital and analog computer simulation methods. Time and frequency responses. Experimental modeling.

15552 **Theory of Plates & Shells** 3 Cr. Plate-bending theory. Circular, rectangular and other geometrical forms of plates. Plates under combined loading. Membrane and bending stresses in shells. Cylindrical shells. Applications.

15553 **Nonlinear Vibration** 3 Cr. Stability concepts. Phase-plane methods. Perturbation and averaging methods of analysis. Self-excited and parametrically-excited systems. Relaxation oscillations. High d.o.f. systems.

15555 **Hydraulics and Pneumatics** 3 Cr. Hardware and circuits. Graphic symbols. Fluid logic systems. Impedance. Transmission line dynamics. State-space modal approximation. Hydraulic pumps and motors. Actuator analysis. Characteristics of valves.

15556 **C. F. D. I** 3 Cr. PDE's. Finite difference methods. Diffusion equation. Convection-dominated equation and its applications. Inviscid flow, potential flow, and Euler equations.

15560 **C. F. D. II** 3 Cr. Governing equations. Generalized curvilinear coordinates. Grid generation. Boundary layer flow. Reduced Navier-Stokes equation.

15561 **Advanced Turbomachinery** 3 Cr. Energy transfer in turbomachines. Diffusion and diffusers. Axial flow turbines. Compressors and pumps. Radial machines. Convective heat transfer in blade cooling. Cavitation and two-phase flow in pumps.

15562 **Viscous Flow** 3 Cr. Navier-Stokes equantion, Governing equations. Boundary conditions. Vorticity equations, Cuette flow. Poiseville flow. Flow between rotating cylinders. Stoke's problems. Pulsating flow between parallel surfaces. Hiemez flow. Flow over a porous wall.

15565 **Optimization** 3 Cr. Optimization of design process. Case studies for nonlinear programming. Comparative examination of unconstrained algorithms. Development of methods for unconstrained cases.

15569 **Robust Control Systems** 3 Cr. Uncertainties. Robust stability against structured uncertainties (generalized Kharitonov theorem, edge theorem, value set approach). Maximal stability spheres and boxes. Introduction to QFT, LQG/LTR, H , and -synthesis design techniques.

15570 Advanced Control 3 Cr. State-space models. Linear spaces & operators. Solution of st-sp equations, stability, controllability, observability, and irreducibility. Canonical decomposition. State feedback. Optimal control. Observer design. LQG optimal control. Servomechanisms.

15571 Computer-Controlled Systems 3 Cr. Sampled-data systems. Sampling theorem for discretization. Difference eqns & Z-transfer function models. Analysis of Discrete-time systems. Reconstruction of sampled signals (ZOH). Time response of SD systems. Pole-placement. Optimal controllers. Observer design. LQG control.

15572 Elastic Stability 3 Cr. Elastic buckling of bars and frames. Torsional buckling. Energy methods in stability of equilibrium in general continuua. Introduction to inelastic instability.

15573 Fracture Mechanics 3 Cr. Stationary cracks under static loading. Energy balance and crack growth. Crack initiation and growth. Dynamic crack growth. Elements of applied fracture mechanics.

15574 MIMO Control Systems 3 Cr. Poles, transmission-blocking zeros, and singular values. Frequency-domain properties of MIMO control systems. Generalized Nyquist stability theorem. Characteristic loci (CL), INA, LQG, LQG/LTR, and H - optimal controller design techniques.

15590 Analysis of Metal Forming 3 Cr. Plastic metal forming. Tension, compression, & plane strain tests. Plastic stress-strain. Heat and strain rate. Plastic instability. Slab analysis. Slip-line method. Upper bound analysis. FEM. Computer simulation of processes.

15591 Automation 3 Cr. Mass production automation. Design of transporters & feeders. Robotics for automation. Automation for transportaion, manufacturing tools, storage facilities, inspection, quality control, and management.

15592 Design of Elements & Structure of Machine Tools 3 Cr. Machine frames and their components. Design & shape criteria for static, dynamic, and thermal loading. Guideways and bearings. Main drives. FEM for machine tool design.
Prerequisite: Advanced Engineering Math I 15500 or Applied Mathematics 15600; FEM in Solid Mechanics 15515.

15593 Metallurgy in Manufacturing 3 Cr. Plasticity. Flexible and deformable behavior of crystals. Fragile and formable fractures in metals and alloys. Metallurgical aspects of forming processes (rolling, casting, drawing, metal forming, and moulding).

15594 Advanced CNC Machines 3 Cr. Manual and computer-aided programming. Elements of NC systems (actuators and feedback elements). Interpolators. Control loops of NC machines. Adaptive control in CNC systems. Robots.

15595 Industrial Production Systems 3 Cr. Organization and information processing in manufacturing. Production planning systems. Traditional & CI manufacturing. CAD-CAM. Computerized manufacturing planning systems. Group technology.

15596 Welding 3 Cr. Technology of welding. Heat sources for welding and cutting. Heating effects before and after welding. Welding cracks. Effects of alloys on welded structures. Mechanical properties of welded structures.
Prerequisite: Metallurgy in Manufacturing 15593

15597 Mechanical Behavior of Advanced Composites 3 Cr. Micro - & macro - mechanical analysis of fiber reinforced composites. Characterization of physical & mechanical properties of composite materials. Dynamic behavior of laminated composites.

15598 Advanced Die Design 3 Cr. Progressive die design. Designing press tools for fine blanking. Deep-drawing dies. Non-traditional deep-drawing methods .Die casting and cold/hot extrusion dies. Plastic mould injection.

15599 Analog Control Systems 3 Cr. Systems models (transfer functions & block diagrams). Time response. Errors. PID controllers. Stability. Frequency response methods. State-space modeling and controller design technique.

15600   Applied Mathematics I   3 Cr.   Complex functions. Cauchy-Riemann conditions. Complex integration. Matrices and tensors. Eigenvalue problem .Laplace, and Melin transformations. Integral equations.

PDE's. Sturm-Lioville theory .Special functions. Perturbation techniques.

15601   Industrial Vibrations   3 Cr.   Multi-d.o.f. systems. Flexibility and stiffness matrices. Damping effects. Damping properties of machine tools. Vibration and shaking in machine tools. Vibration isolation. Vibration measurement and control.

Prerequisite: 15500 or 15600.

15602   Advanced Hydraulics   3 Cr.   Instrumentation. Three, four, and five-way servovalves. Forces in puppet valves. Hydraulic servomechanisms. Modeling and control of servo-hydraulic systems. Equilibrium problems.

15603   Industrial Robots   3 Cr.   Kinematics and dynamics of robots. Servo- control of robotic systems. Actuators, sensors, and grippers. Robot vision. Softwares for robotic systems. Industrial robotic systems. CAD-CAM. Intelligent robots.

15605   Buoyancy-Induced Flows   3 Cr.   External flow. Boundary layer approximation. Plane wall. Wall plumes. Inclined surfaces. Internal flow. Flow between parallel plates. Enclosure. Flow instability. Transition turbulence. Thermal instability. Bennard cells. Mixed convection.