MECHANICAL ENGINEERING (4600)

4600:500. Thermal System Components. (3 Credits)
Performance analysis and design of basic components of thermal energy exchange and conversion systems. Components studied include heat exchangers, pumps, compressors, turbines and expansion engines.

4600:510. Heating & Air Conditioning. (3 Credits)
Prerequisite: permission. Thermodynamics of gas mixtures. Design and selection of air conditioning equipment. Control of gas mixtures, heating, cooling, and humidity.

4600:511. Compressible Fluid Mechanics. (3 Credits)

4600:512. Fundamentals of Flight. (3 Credits)
Introduction to basic aerodynamics, airplane performance, stability and control, astronautics and propulsion. Design considerations are emphasized.

4600:513. Introduction to Aerodynamics. (3 Credits)
Introduction of aerodynamic concepts; conformal transformations, theory of thin airfoils, 2-dimensional airfoil theory, wings of finite span, lifting line theories, lumped-vortex, vortex-lattice, and panel methods.

4600:514. Introduction to Aerospace Propulsion. (3 Credits)
Introduction to propulsion systems currently used in aerospace fields; propulsion principles for turbojets, chemical rockets, and electrical rocket propulsion.

4600:515. Energy Conversion. (3 Credits)
Prerequisite: permission. Topics from fields of internal combustion engines, cycle analysis, modern conversion devices.

4600:516. Heat Transfer Processes. (3 Credits)
Prerequisite: permission. Analysis, design of extended surfaces. Natural convection and mixed convection, combined modes of heat transfer with phase changes.

4600:522. Experimental Stress Analysis I. (3 Credits)
Prerequisite: permission. Experimental methods of determining stress or strain: brittle lacquer, strain gages, photoelasticity, full field thermal techniques.

4600:530. Machine Dynamics. (3 Credits)
Prerequisite: permission. Static and dynamic forces in machines, products of inertia, dynamic equivalence, flywheels. Balancing of rating, reciprocating, cyclic plane motion. Computer simulation of transient mechanism dynamics, other topics in advance dynamics.

4600:531. Fundamentals of Mechanical Vibrations. (3 Credits)
Prerequisite: permission. Undamped and forced vibrations of systems having one or two degrees of freedom.

4600:532. Vehicle Dynamics. (3 Credits)

4600:540. System Dynamics & Control. (4 Credits)

4600:541. Control Systems Design. (3 Credits)
Prerequisite: permission. Methods of feedback control design such as minimized error, root-locus, frequency domain. Compensation techniques. Multivariable and nonlinear design methods and computer-aided control design.

4600:542. Industrial Automatic Control. (3 Credits)
Prerequisite: permission. Operation of basic control mechanisms. Study of mechanical, hydraulic, pneumatic, fluidic control systems, including application areas. Tuning of control devices for optimum performance of system. Case studies on control applications from industry, e.g. boilers, furnaces, process heaters.

4600:543. Optimization Methods in Mechanical Engineering. (3 Credits)
Prerequisite: permission. Development and method of solution of optimization problems in mechanical engineering. The use of dynamic programming and operational research methods for optimization including computer utilization and applications.

4600:544. Robot Design, Control & Application. (3 Credits)
Prerequisite: permission. Robot design and control. Kinematic transformations, velocities and accelerations, path trajectories and dynamics, control and sensing in robotics. The automated factory with robot applications.

4600:550. Introduction to Computational Fluid Flow & Convection. (3 Credits)
Prerequisite: permission. Numerical modeling of fluid/thermal systems, numerical solution of the momentum and thermal boundary layer equations; flow simulation using advanced heat transfer/fluid/graphics packages.

4600:562. Pressure Vessel Design. (3 Credits)
Prerequisite: permission. Introduction to modern pressure vessel technology. Topics include basic structural considerations, materials and their environment and design-construction features.

4600:563. Computer Aided Design & Manufacturing. (3 Credits)
Prerequisite: permission. The use of computer systems to assist in the creation, modification, analysis, or optimization of engineering designs, and to plan, manage, and control manufacturing plants.

4600:600. Gas Dynamics. (3 Credits)

4600:608. Thermodynamics. (3 Credits)
Extension and generalization of basic laws of thermodynamics with application to a variety of physical and biological systems. Introduction to irreversible thermodynamics, the third law and statistical thermodynamics.

4600:609. Finite Element Analysis I. (3 Credits)
Prerequisite: 4600:622. Introductory development of finite element method as applied to various topics from continuum mechanics. Areas covered include plane; axisymmetric and 3-D stress analysis; conduction, fluid mechanics; transient problems and geometric and material nonlinearity.
4600:610. Dynamics of Viscous Flow I. (3 Credits)
Derivation and solution of equations governing laminar viscous flow. Applications include unsteady flows, slow viscous flows, parallel flows, lubrication theory and laminar boundary layers.

4600:611. Computational Fluid Dynamics I. (3 Credits)
Prerequisite: 4600:610 or permission of instructor. Study of numerical methods in fluids; numerical errors and stability; finite differencing; nonlinear convection terms; Poisson equations; boundary conditions; turbulence; spectral and finite element techniques.

4600:615. Conduction Heat Transfer. (3 Credits)
Study of one-, two- and three-dimensional heat conduction. Development of analytical techniques for analysis and design.

4600:616. Convection Heat Transfer. (3 Credits)
Heat transfer from laminar, turbulent external, internal flows. Convective heat transfer at high velocities. Heat transfer to liquid metals; high Prandtl number fluids.

4600:617. Radiation Heat Transfer. (3 Credits)
Study of governing radiation laws. Black and real systems, geometric factors, gray enclosures, non-gray systems, gaseous radiation, radiation equipment.

4600:618. Boiling Heat Transfer & Two-Phase Flow. (3 Credits)
Current techniques to determine heat transfer and pressure drop in components such as boilers, heat exchangers, and steam generators, with boiling. Boiling mechanism, slip ratio, critical heat flux and instabilities in boiling flow systems.

4600:620. Experimental Stress Analysis II. (2 Credits)
Prerequisite: 4600:522. Dynamic strain gage methods, transducer design, Moire fringe techniques and topics in photoelasticity.

4600:621. Introduction to Tire Mechanics. (3 Credits)
Prerequisite: permission. Topics include tire as vehicle component, tire traction and wear, laminated structures, tire stress and strains and advanced tire models.

4600:622. Continuum Mechanics. (3 Credits)
Prerequisite: permission. Analysis of stress and deformation at a point. Derivation of fundamental field equations of fluid and solid mechanics by applying basic laws of dynamics, conservation of mass and energy. Development of constitutive laws.

4600:623. Applied Stress Analysis I. (3 Credits)
Prerequisite: 4600:622. Continuation of 4600:622 with specific application to solid mechanics. Development of energy theorems due to Reissner, Washizu and generalized Hamilton's principle. Solutions to static and dynamic problems.

4600:624. Fundamental of Fracture Mechanics. (3 Credits)

4600:625. Analysis of Mechanical Components. (3 Credits)
Theories of failure and plastic flow. Fatigue, creep analysis and introduction to fracture mechanics.

4600:626. Fatigue of Engineering Materials. (3 Credits)
Prerequisite: 4600:624 or permission. Quasi-static and cyclic behavior; dislocation networks and their interactions; correlation of dislocation-microstructure interactions; crack initiation; crack propagation; short cracks; crack closure; environmental effects.

4600:627. Advanced Materials & Manufacturing Processes. (3 Credits)
Manufacturing processes for advanced materials; classification; technological aspects of bulk deformation, casting, joining, forming, machining, molding, powder metallurgy, rapid solidification; economic aspects; technical activity.

4600:628. Mechanical Behavior of Materials. (3 Credits)
Prerequisite: permission. Mechanical behavior of engineering materials; metallurgy of deformation; dislocation effects and deformation; strengthening mechanisms; thermomechanical processing; mechanical testing.

4600:629. Nonlinear Engineering Problems. (3 Credits)

4600:630. Vibrations of Discrete Systems. (3 Credits)
Prerequisite: 4600:531 or equivalent. Study of vibrations of multidegree of freedom systems including free and forced vibrations, damped and transient response, normal mode vibrations and matrix iteration techniques. Application to seismic design and shock design.

4600:631. Kinematic Design. (3 Credits)
Prerequisite: permission of instructor. The geometry of constrained motion. Analysis of relative plane motion using vectors and the digital computer. Curvature theory. Synthesis of linkages and gearing. Introduction to computer-aided design.

4600:632. Reliability in Design. (3 Credits)

4600:633. Computerized Modal Analysis of Structures. (3 Credits)
Prerequisite: 4600:630 or equivalent. Modal analysis theory and measurement techniques, digital signal processing concepts, structural dynamics theory, modal parameter estimation with "hands-on" experience in the application of modal measurement methods in vibration analysis.

4600:634. Advanced Dynamics of Rotating Machinery. (3 Credits)
Prerequisite: 4600:530 or equivalent. Dynamic modeling and simulation of complex rotor-bearing systems. Steady state, transient and stability analysis with inertia, gyroscopic, imbalance, rotor-bow, disk-skew and impeller-pit interaction effects.

4600:635. Stress Waves in Solids & Fluids. (3 Credits)

4600:642. System Analysis & Control Design. (3 Credits)
Uniform methods of modeling and response analysis, controllability and observability, stability theory and analysis of linear and nonlinear engineering processes. Design of feedback controls for optimum performance for multivariable real-time control application.

4600:645. Process Identification & Computer Control. (3 Credits)
Prerequisite: permission. Obtaining mathematical models of processing from noisy observations. Methods of digital control design. Case studies on computer control of selected processes.
4600:646. Expert Systems in Controls & Manufacturing. (3 Credits)  
Prerequisite: 4600:540 or equivalent or by permission. Expert system methodologies for process control, computer integrated flexible manufacturing and robotics.

4600:647. Neural & Fuzzy Control Systems. (3 Credits)  
Prerequisite: 4600:540 or permission of instructor. Analysis and design of intelligent control systems. Neural networks and fuzzy sets for process identification and controller design. Applications and case studies in industry.

4600:650. Tribology. (3 Credits)  
Fundamentals of friction lubrication and wear treated; includes basic theory, advanced topics, applications to bearings, seals, gears, cams. Specific topics include adhesive and abrasive friction/wear, boundary lubrication, fluid film lubrication and bearings, rolling element bearings, bearing dynamics.

4600:655. Micro- and Nano-Fluid Dynamics. (3 Credits)  
Prerequisite: 46900:611 or permission of instructor. The course includes fundamentals of the analytical and numerical solutions of the problems pertinent to fluid mechanics on nano- and micro- scales. Applications will include micro-engines, MEMS, micro-filters, and synthesis of nanomaterials.

4600:658. Mechanical Behavior of Nanostructured Materials & Composites. (3 Credits)  
The course is open to students in mechanical engineering, polymer science and polymer engineering, biology and all other engineering disciplines. Some prior consultation with the instructor is encouraged. The course is considered as a graduate elective in ME. An Overview of Lattice Dislocation Theory, Nanostructured Materials: Processing and Properties, Grain Boundaries, Nanoindentation, Electron Microscopy, Atomic Force Microscopy, Carbon Nanotubes, Polymer and Bio-MEMS.

4600:660. Engineering Analysis. (3 Credits)  
Prerequisite: B.S. in engineering. Study of analysis techniques as applied to specific engineering problems. Applications include beam deflections, acoustics, heat conduction and hydrodynamic stability.

4600:661. Failure Analysis of Mechanical Systems. (3 Credits)  
Prerequisites: 4600:625 or permission by instructor. This course emphasizes engineering techniques for predicting yielding, buckling, fracture and fatigue of mechanical systems. Students will be taught how to link theory with practice by examining case studies of structural and mechanical failures and will obtain practical experience in modeling real complex systems in an end-of-term project.

4600:662. Microscale Heat and Mass Transfer. (3 Credits)  
Prerequisites: 4600:608 and 4600:615 or permission. Kinetics theory, classical and quantum statistics, structure of solids, phonons in solids, free electrons in metals, Boltzmann transport theory, hyperbolic heat conduction, thermal conductivity of thin films, laser materials processing.

4600:663. Web-Based Solid Modeling and e-Manufacturing. (3 Credits)  
Prerequisite: 4600:563 or equivalent, or permission. Team-based collaborative design with a web-based solid modeling library, feature-based manufacturing analysis, and process planning using cross-platform interoperable tools including JAVA, VRML for optimized product realization.

4600:664. Fundamentals of Crystallization and Solidification. (3 Credits)  
Prerequisite: 4600:608 or equivalent, or permission. Fundamental theories and modeling of crystalline nucleation and growth, interface stability and morphology, nucleation, and growth. Applications in casting, welding, laser processing, and single crystal growth.

4600:666. Analysis of Manufacturing Systems. (3 Credits)  
This course will examine general problems in the design, planning, and control of manufacturing systems. No prerequisites or corequisites are required.

4600:670. Integrated Flexible Cellular Manufacturing System-Analysis & Design. (3 Credits)  
Prerequisite: 4600:563 or equivalent or by permission of instructor. The analysis of integrated computer-aided manufacturing systems, design of automated manufacturing components and simulations of flexible cellular manufacturing systems.

4600:671. Fundamentals and Applications of Micro Electro. (3 Credits)  
Prerequisite: consent of instructor. Fundamentals of MEMS based sensors and actuators, MEMS materials, bulk and surface micromachining and MEMS device testing. Applications in optics, automotive, and biomedical instrumentation.

4600:672. Design of Microsystems and Nano Devices. (3 Credits)  
Prerequisite: consent of instructor. Design principles of various micro and nano sensors and actuators, microfluidic devices, microstructure analysis and simulation, microfabrication process design rule. Applications in MOEMS, Lab-on-a-chip devices, BioMEMS and NEMS.

4600:693. Measurements Methods & Experimental Error in ThermoFluid Sciences. (3 Credits)  
Prerequisites: viscous flow, conduction heat transfer convection heat transfer. The course will incorporate elements of experimental error analysis, optics, and optical ray tracing, principles of testing, methods and devices for fluid flow quantization and temperature measurements. Laboratory work with hands-on experience.

4600:694. Deformation and Failure of Polymers and Soft Materials. (3 Credits)  
This course introduces the concepts of deformation, fracture and failure analyses of engineering polymers, soft and biological materials.

4600:696. Special Topics in Mechanical Engineering. (1-4 Credits)  
Prerequisite: Permission. For qualified candidate for graduate degree. Supervised research in the student's major field of training or experience. Credit depends upon nature and extent of project as determined by advisor and department chair.

4600:697. Engineering Report. (2 Credits)  
Prerequisite: Permission of advisor. A relevant problem in mechanical engineering for students electing the non-thesis option. The final engineering report must be approved by the advisor and the advisory committee.

4600:698. Master's Research: Mechanical Engineering. (1-6 Credits)  
Prerequisite: Permission of advisor. (May be repeated.) Research on a suitable topic in mechanical engineering culminating in a master's thesis.

4600:699. Master's Thesis. (1-6 Credits)  
Prerequisite: permission of advisor. (May be repeated.) Supervised research in a specific area of mechanical engineering.

4600:704. Finite Element Analysis II. (3 Credits)  
4600:705. Finite Element Analysis III. (3 Credits)

4600:710. Dynamics of Viscous Flow II. (3 Credits)

4600:711. Computational Fluid Dynamics II. (3 Credits)
Prerequisite: 4600:611 or permission of instructor. Development of advanced computational techniques for convection-dominated flows. Higher order explicit and implicit schemes including nonoscillatory front-capturing methods applied to benchmark problems.

4600:715. Hydrodynamic Stability. (3 Credits)

4600:719. Advanced Heat Transfer. (3 Credits)
Prerequisites: 4600:615, 4600:616. Topics include nonhomogeneous or nonlinear boundary value problems of heat conduction, heat transfer with melting, solidification and ablation, heat transfer in porous systems and hydrodynamically and thermally unsteady convection.

4600:723. Applied Stress Analysis II. (3 Credits)
Prerequisite: 4600:623. Continuation of 4600:623. Development of approximate solution techniques including finite elements, method of weighted residuals (Rayleigh-Ritz, Galerkin, Trefftz, collocation, least squares, etc.) and finite differences.

4600:726. Non-Linear Continuum Mechanics. (3 Credits)
Prerequisite: 4600:622. Finite deformation and strain, stress, constitutive equations, strain energy functions. Solution of finite deformation problems in hypoelasticity, coupled thermoviscoelasticity and plasticity, electroelasticity and micropolar theories.

4600:730. Vibrations of Continuous Systems. (3 Credits)
Prerequisite: 4600:630. Continuation of 4600:630. Analysis of continuous vibrating systems, using separation of variables, energy, variational, Rayleigh-Ritz and other approximate techniques. Concepts and solutions of integral equations as applied to continuous systems.

4600:732. Advanced Modal Analysis of Structures. (3 Credits)

4600:741. Optimization Theory & Applications. (3 Credits)
Prerequisite: permission. Theory of optimization in engineering systems, development and method of solution optimization problems for physical processes, large systems. Use of dynamic programming, operational research methods of system optimization, control.

4600:763. Advanced Methods in Engineering Analysis. (3 Credits)
Applications of finite difference and finite element methods, variational methods, integral methods and similarity transforms to engineering problems in heat transfers, fluid mechanics and vibrations.