

## MECHANICAL ENGINEERING

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## COLLEGE OF ENGINEERING

**Abrate, Serge**, Professor, Ph.D., Purdue University, 1983; 1995. Impact, penetration, structural dynamics, composites.

**Agrawal, Om**, Professor, Ph.D., University of Illinois-Chicago, 1984; 1985. Computer-aided analysis and design of rigid/flexible multibody systems, numerical analysis, finite element methods, and continuum mechanics, CAD/Simulation of mechanical systems.

**Blackburn, James W.**, Professor, Ph.D., University of Tennessee, Knoxville, 1988; 1995. Biokinetics, biotechnology, chemical and bioprocesses reduction and control of organic wastes/by-products; pollution prevention through tuning complex chemical processes and bioprocesses, bioprocess treatment of waste and wastewater, scale-up and application of bioremediation processes, reduction or control of organic air emissions.

**Chen, Juh W.**, Professor, *Emeritus*, Ph.D., University of Illinois, 1959; 1965.

**Chu, Tsuchin P.**, Professor, Ph.D., University of South Carolina, 1982; 1990. CAD/ CAM, imaging systems, mechanical vibrations, computer graphics, machine vision, optical methods in experimental mechanics and manufacturing, image processing.

**Don, Jarlen**, Associate Professor, Ph.D., Ohio State University, 1982; 1985. Materials creep and creep fatigue, surface phenomena, carbon-carbon composites, composite materials, friction materials.

**Esmaceli, Asghar**, Assistant Professor, Ph. D., University of Michigan, 1995; 2000. CFD, two-phase heat transfer.

**Farhang, Kambiz**, Professor, Ph.D., Purdue University, 1989; 1990. CAD/CAM, controls, vibrations, kinematics, dynamics, control and stability of flexible and rigid-body mechanical, electromechanical, mechanical-drive systems; manufacturing processes and process control.

**Filip, Peter**, Professor, Ph.D., Technical University Ostrava, Czech Republic, 1989; 2004. Friction materials, biomaterials.

**Helmer, Wayne A.**, Professor, *Emeritus*, Ph.D., Purdue University, 1974; 1974.

**Hippo, Edwin J.**, Professor, Ph.D., Pennsylvania State University, 1977; 1984. Liquefaction, coal conversion, chemical and physical cleaning of coal, coal structure, carbon materials, STM.

**Jefferson, Thomas B.**, Professor, *Emeritus*, Ph.D., Purdue University, 1955; 1969.

**Kent, Albert C.**, Professor, *Emeritus*, Ph.D., Kansas State University, 1968; 1966.

**Koc, Rasit**, Professor, Ph.D., University of Missouri-Rolla, 1989; 1994. Ceramic materials, powder processing, nonstoichiometry of oxides; sintering of oxide and non-oxide ceramics, methods preparing high purity oxides from organo-metallics, perovskites for use as high temperature electrodes, synthesizing submicron carbide, nitride and boride powders.

**Mahajan, Ajay**, Professor, Ph.D., Tulane University, 1994; 1998. Robotics, controls, intelligent sensors, autonomous systems, machine learning, navigation of mobile robots, ultrasonic 3D position estimation systems, mechatronics and virtual reality.

**Mathias, James A.**, Assistant Professor, Ph.D., Ohio State University, 2001; 2003. Nanotechnology, microchannels, heat transfer, thermodynamics, energy utilization.

**Mondal, Kanchan**, Assistant Professor, Ph.D., SIUC, 2001; 2006. Electrochemistry, energy from coal, catalysis, reactor systems and design.

**Muchmore, Charles B.**, Professor, *Emeritus*, Ph.D., Southern Illinois University Carbondale, 1969; 1966.

**Nsofor, Emmanuel C.**, Associate Professor, Ph.D., Mississippi State University, 1993; 1999. Experimental and computational flow and heat transfer, advanced energy systems, HVAC & R, energy storage, environmental engineering, thermodynamics and combustion.

**O'Brien, William S.**, Associate Professor, *Emeritus*, Ph.D., West Virginia University, 1972; 1973.

**Orthwein, William C.**, Professor, *Emeritus*, Ph.D., University of Michigan, 1958; 1965.

**Rajan, Suryanarayaniah**, Professor, *Emeritus*, Ph.D., University of Illinois, 1970; 1977.

**Swisher, George M.**, Professor, *Emeritus*, Ph.D., Ohio State University, 1969; 1999.

**Swisher, James H.**, *Emeritus*, Professor, Ph.D., Carnegie-Mellon, 1963; 1983.

**Szary, Marek L.**, Associate Professor, Ph.D., Technical University of Wroclaw, Poland, 1977; 1985. Acoustics, sound propagation and control, vibroacoustics and vibration, experimental methods, simulation and modeling, fluidic control system. Adding sound and vibration control using smart materials.

**Tempelmeyer, Kenneth E.**, Professor, *Emeritus*, Ph.D., University of Tennessee, 1969; 1979.

**Weston, Alan J.**, Associate Professor, Ph. D., Southern Illinois University, 1991; 1986. Electrodeposition and doping of laser semiconductors, pedagogical uses of commercial game engines for engineering 3D visualization, electrochemical STM patterning of organic masks for UV VLSI applications.

**Wiltowski, Tomasz**, Professor, Ph.D., Institute of Catalysis and Surface Chemistry, Cracow, Poland, 1982; 2003. Coal transformation and characterization, coal gasification, alternative energy sources, hydrogen production from coal, catalytic conversion of hydrocarbons and alcohols to hydrogen, fuel cells, nanomaterials synthesis and characterization.

**Wittmer, Dale E.**, Professor and *Chair*, Ph.D., University of Illinois, 1980; 1986. Continuous sintering and advanced materials processing, high temperature resistant materials and testing, ceramics whisker synthesis, ceramic composites, carbon fiber production and composites.

**Wright, Maurice**, Professor, *Emeritus*, Ph.D., University of Wales, United Kingdom, 1962; 1984

### **Master of Science in Mechanical Engineering**

Graduate work leading to the Master of Science degree in mechanical engineering is offered by the College of Engineering. The program is designed to provide advanced study in air pollution control, mass and heat transfer, coal conversion, electrochemical processes, thermal science, thermal systems design, solar systems design, chemical and biochemical processes, mechanical systems, computer-aided design, composite materials and ceramics and tribology.

#### **Admission**

Students seeking admission to the graduate program in mechanical engineering must meet the admission standards set by the Graduate School and have a bachelor's degree in engineering or its equivalent. A student whose undergraduate training is deficient may be required to take coursework without graduate credit.

This program requires a nonrefundable \$45.00 application fee that must be submitted with the application for Admissions to Graduate Study in Mechanical Engineering. Applicants may pay this fee by credit card if applying electronically. Applicants submitting a paper application must pay by personal check, cashier's check, or money order made out to SIU, and payable to a U.S. Bank. The application form can be obtained from the Department.

#### **Accelerated Master's Program**

Mechanical Engineering students with senior standing and a GPA of 3.5 will be permitted to take up to six hours of graduate credit in Fall and Spring semesters. Outstanding junior students will be allowed to take one course for graduate credit. By doing so, students then pursuing their MSME degrees after completing their BSME degrees will have these graduate credits transferred toward their MSME degree so that they may be able to finish the degree requirements in a year or so. Students must complete a no fee Graduate School application and submit it to the department chair for approval. Students will be allowed to complete up to 12 hours of graduate credit before receiving their BSME.

#### **Requirements**

Each student majoring in mechanical engineering will develop a program of study with a graduate adviser and establish a graduate committee of at least three members at the earliest possible date. A student may with the approval of a graduate faculty committee and the department chair also take courses in other branches of engineering, or in areas of science and business, such as physics, geology, chemistry, mathematics, life science, administrative sciences, or computer science. A thesis committee of at least three members will approve the thesis and the comprehensive oral exam.

For a student who wishes to complete the requirements of the master's degree with a thesis, a minimum of thirty semester hours of acceptable graduate credit is required. Of this total, eighteen semester hours must be earned in the Department of Mechanical Engineering and Energy Processes. A minimum of 15 hours of coursework at the 500-level (excluding thesis) is required. Each candidate is also required to pass a comprehensive oral examination covering all of the student's graduate work including thesis.

If a student prefers the non-thesis option, a minimum of thirty-six semester hours of acceptable graduate credit is required. The student is expected to take at least twenty-one semester hours within the Department of Mechanical Engineering and Energy Processes including no more than three semester hours of the appropriate 592 course to be devoted to the preparation of a research paper. A minimum of 15 hours of coursework at the 500-level (excluding thesis) is required. In addition, each candidate is required to pass a written comprehensive examination. An oral presentation of the paper may be required.

Each non-thesis student will select a minimum of three engineering graduate faculty members to serve as a graduate committee, subject to the approval of the chair of the department. The committee must include at least one member from one of the other engineering departments and will:

1. approve the student's program of study,
2. approve the student's research paper topic,
3. approve the completed research paper, and
4. administer and approve the written comprehensive examination.

Teaching or research assistantships and fellowships are available for qualified applicants. Additional information about the program, courses, assistantships, and fellowships may be obtained from the College of Engineering or the Department of Mechanical Engineering and Energy Processes.

#### **Courses (ME)**

Graduate work in the Department of Mechanical Engineering and Energy Processes is offered toward a concentration for the Master of Science degree in engineering. Safety glasses are required for some of the courses in this department. Four-hundred level courses in this department may be taken for graduate credit unless otherwise indicated in the course description.

**400-3 Power and Refrigeration Cycles.** Use of engineering thermodynamics in analysis of power and refrigeration cycles. Detailed treatment of various gas and vapor power cycles including combined gas and steam cycles. Thermodynamics of combustion. Gas and vapor refrigeration cycles. First and Second Law analysis and turbo-machinery. Prerequisite: Engineering 300.

**401-1 Thermal Measurements Laboratory.** Study of basic measurements used in the thermal sciences. Calibration techniques for temperature and pressure sensors. Thermal measurements under transient and steady-state conditions. Applications include conduction, convection and radiation experiments. Uncertainty analysis. The handling and reduction of data. Prerequisite: 302.

**405-3 Internal Combustion Engines and Gas Turbines.** Operation and performance characteristics of Otto, Diesel, Wankel engines and gas turbines. Methods of engine testing, types of fuels and their characteristics, fuel metering systems, engine combustion analysis as related to engine performance, fuel characteristics and air pollution, exhaust gas analysis and air pollution control. Prerequisite: Engineering 300.

**406-3 Thermal Systems Design.** Applications of the principles of engineering analysis to the design of thermal systems. Consideration of such systems as refrigeration, air conditioning, spacecraft thermal control and cogeneration. Numerical analysis and solution of an open-ended design problem. Prerequisite: 302, Engineering 351.

**408-3 Energy Conversion Systems.** Principles of advanced energy conversion systems; nuclear power plants, combined cycles, magnetohydrodynamics, cogeneration (electricity and process steam) and heat pumps. Constraints on design and use of energy conversion systems; energy resources, environmental effects and economics. Prerequisite: 301 or 400.

**410-3 Applied Chemical Thermodynamics and Kinetics.** Designed for students interested in chemical and environmental processes and materials science. Topics covered include applications of the Second and Third Laws of Thermodynamics, solution theory, phase equilibria, sources and uses of thermodynamic data, classical reaction rate theory, kinetic mechanisms and the determination of rate-determining steps in chemical reactions. Prerequisite: Chemistry 200, 201, Engineering 300 or consent of instructor.

**415-3 Engineering Acoustics,** Principles of engineering acoustics and their applications to passive and active noise control techniques. Laboratory experience demonstrates techniques for control and reduction of noise.

**416-3 Air Pollution Control.** Engineering control theory, procedure, equipment, and economics related to control of particulate, gaseous, and toxic air emissions. The environmental impacts due both to controlling and not controlling emissions are considered. Understanding of the basics is evaluated as students design control equipment, specify and troubleshoot control systems and predict the impacts for each major type of control system. Prerequisite: senior standing.

**422-3 Applied Fluid Mechanics for Mechanical Engineers.** Applications of fluid mechanics in internal and external flows. The mathematical basis for inviscid and viscous flows calculations is developed with application to pipe and duct flows; external flow about bodies; drag determination; turbomachinery; and reaction propulsion systems. Semester design project of a fluid mechanical system. Prerequisite: Engineering 300, Civil Engineering 370a and Mathematics 305.

**423-3 Compressible Flows.** Foundation of high speed fluid mechanics and thermodynamics. One-dimensional flow, isentropic flow, shock waves and nozzle and diffuser flows. Flow in ducts with friction and heat transfer. Prandtl-Meyer flow. Compressibility effects in reaction propulsion systems. Semester design project. Prerequisite: Engineering 300, Civil Engineering 370a.

**435-3 Design of Mass Transfer Processes.** Design principles of mass transfer processes. The rate mechanism of molecular, convective and interphase mass diffusion. The design of selected industrial mass transport process operations such as absorption, humidification, water cooling, drying and distillation. Prerequisite: 302.

**436-3 Mechanical Engineering Controls.** Analysis and design of controls for mechanical engineering systems: mechanical, electrical, thermal, fluid and combinations of these. Prerequisite: 261, Engineering 300, 335, 351.

**440-3 Heating, Ventilating and Air Conditioning Systems Design.** Principles of human thermal comfort. Heating and cooling load analysis. HVAC system design. Air conditioning processes. Prerequisite: 302.

**446-3 Energy Management.** Fundamentals and various levels of analysis for energy management of commercial buildings and industrial processes and buildings. Use of energy management systems and economic evaluations are required in course projects. Prerequisite: 302.

**463-3 Introduction to Ceramics.** Structure and physical properties, mechanical properties, processing and design of ceramics. Prerequisite: Engineering 312 or equivalent.

**465-3 Introduction to Nanotechnology.** Survey of the rapidly developing fields of nanometer science and engineering. Impact on society; principles of self-assembly; production and properties of nano-materials; cell mechanism as a model for assemblers; nano-tools; and nano-systems are explored. Prerequisite: Chemistry 210.

**468-3 Friction Science and Applications.** Study of systems and materials used for friction applications with a focus on aerospace and ground transportation vehicles. Course covers theories and experimental methods regarding friction and wear, contact mechanics, friction materials vibration and noise, thermal transport and thermo-elastic phenomena. The course approach uses a materials emphasis. Lectures are complemented by exposure to laboratory methods and equipment. Design of a friction component, system or testing device. Prerequisite: Engineering 312 and senior standing or consent of instructor.

**470-3 Mechanical System Vibrations.** Linear vibration analysis of mechanical systems. Design of mechanical systems to include effects of vibration. Prerequisite: 261, Engineering 351, Mathematics 305.

**472-3 Materials Selection for Design.** Interaction of material design process with material selection criteria. Comparison of materials properties, processes and fabrication. Project work includes design models, material selection rationale, oral presentation of projects, construction of mock-up models, and theoretical design problems in the area of the student's specialization. Prerequisite: Engineering 222b, 312.

**475-3 Machine Design I.** Design of machines using bearings, belts, clutches, chains and brakes. Develops application of the theory of fatigue, power transmission and lubrication to the analysis and design of machine elements. Prerequisite: Engineering 351 and Civil Engineering 350a.

**477-3 Fundamentals of Computer-Aided Design and Manufacturing.** Introduction to the concepts of computer-aided design and manufacturing (CAD/CAM). Subjects include computer graphics, geometric modeling, engineering analysis with FEM, design optimization, computer numerical controls, project planning and computer integrated manufacturing. (CIM). Students are required to use computer packages for projects. Prerequisite: 475 or consent of instructor.

**478-3 Finite Element Analysis in CAD.** Course to cover a multitude of topics in CAD/CAE with emphasis on finite element modeling and analysis. Overview of CAD/CAM/CAE; FEA software; FEA problems including trusses, beams, frames, thermal analysis, and fluid mechanics; design optimization; rapid prototyping. Students are required to use FEA software for homework assignments and a design project. Prerequisite: 475 or consent of instructor.

**480-3 Computational Fluid Dynamics.** Application of computational fluid dynamics techniques to the solution of problems in engineering heat transfer and fluid flow. Discretization techniques; stability analysis. Introduction to grid generation. Prerequisite: Engineering 351, Civil and Environmental Engineering 370, Mechanical Engineering 302 or consent of instructor.

**500-3 Advanced Engineering Thermodynamics.** Principles of kinetic theory and classical statistical mechanics applied to thermodynamic systems. Statistical interpretation of the equilibrium state and thermodynamic properties of engineering systems. Introduction to irreversible thermodynamics with engineering examples. Prerequisite: Engineering 300.

**501-3 Transport Phenomena.** Mechanism of heat, mass and momentum transport on both molecular and continuum basis. Estimation of transport properties. Generalized transport equations in one- or three-dimensional systems. Analogy of mass, heat and momentum transfer. Macroscopic balances, simultaneous mass and heat transfer. Prerequisite: 302.

**502-3 Conduction Heat Transfer.** Engineering considerations involving the construction of mathematical and numerical models of conduction heat transfer and the interpretation of results of analyses. Prerequisite: 302.

**503-3 Convective Heat Transfer.** Laminar and turbulent forced convection heat transfer over surfaces and inside tubes, including non-circular cross sections. Developing flows. Laminar free convection. Emphasis throughout is on the analytical approach. Prerequisite: 302.

**504-3 X-Ray Diffraction and Electron Microscopy.** (Same as Physics 571.) X-ray physics. Geometry of crystals. Scattering of X-ray by atoms, crystals and noncrystalline matter. Kinematical theory of diffraction. Powder method, Laue method. Electron optics. Formation and analysis of diffraction patterns. Imaging techniques. Image contrast theories. Analysis of crystal defects. Advanced analytical electron microscopes.

**505-3 Vehicle Dynamics,** To provide an introductory coverage of dynamics of vehicle systems. The topics include mainly automotive systems but others such as aircraft and train systems may be discussed. Students will become familiar with issues related to tire behavior, vehicle suspension design, steering, vehicle and load transfer.

**507-3 Combustion Phenomena.** Basic combustion phenomena-chemical rate processes-flame temperature, burning velocity, ignition energy, quenching distance and inflammability limits-laminar and turbulent flame propagation-aerodynamics of flame-gaseous detonations-two phase combustion phenomena-fluidized bed combustion. Prerequisite: Engineering 300.

**509-3 Thermal Radiation Heat Transfer.** Review of radiation fundamentals. Prediction of radiative properties using classical electromagnetic theory. Properties of real materials. Governing equations between blackbody and graybody surfaces. Exchange of radiation between nondiffuse, nongray surfaces. Radiation in the presence of other energy transfer modes. Approximate and computer solution techniques. Prerequisite: 302.

**525-3 Small Particle Phenomena.** Small particle formation, behavior, properties, emission, collection, analysis and sampling. Includes atomization, combustion, transport of suspension and sols, filtration, light scattering and movement patterns of mono and polydisperse particles and use of a device to measure size, size distribution and one other physical property of an aerosol. Prerequisite: graduate standing.

**531-3 Reaction Engineering and Rate Processes.** Chemical kinetics of homogeneous and heterogeneous reactions, kinetic theories, mechanism and mathematical modeling. Reactor design. Design of multiple reactions; temperature and pressure effects. Nonisothermal and nonadiabatic processes. Non-ideal reactors. Prerequisite: 435.

**535-3 Computer Aided Analysis of Mechanical Systems I.** Computer aided kinematic and dynamic analysis of planar mechanism: topics will include formulation of kinematic and dynamic equations of motion for planar systems. Automatic generations of kinematic constraint such as revolute joint, translation joint, etc. Numerical techniques for solution of nonlinear, differential, and algebraic equations, application of these techniques to planar mechanism and robotic systems. Prerequisite: 309.

**537-3 Nonlinear Vibrations.** Dynamic response and stability of nonlinear systems. Examples and sources of nonlinearity. Various techniques for studying dynamic behavior or nonlinear systems. Prerequisite: 470 or consent of instructor.

**538-3 Applied Optimal Design and Control of Dynamic Systems.** Unconstrained and Constrained Mechanical-System Optimization Problems; Variational Calculus; Continuous Optimal Control; The Maximum Principle and Hamilton-Jacobi Theory; Dynamic-Systems Optimum-Control Examples; Design Sensitivity Analysis; Numerical Methods for Dynamic-System Design and Control Problems; Application of the above techniques to Large Scale Dynamic Systems. Prerequisite: 470 or equivalent.

**540-3 Introduction to Continuum Mechanics.** Tensor analysis applied to continuum mechanics: stress and strain and their invariance, equations of compatibility, constitutive equations - including linear stress-strain relations. Prerequisite: Civil and Environmental Engineering 350a, Mathematics 305, graduate standing in engineering.

**545-3 Intelligent Control.** Techniques to design and develop intelligent controllers for complex engineering systems. Specific techniques covered are fuzzy logic, expert systems, genetic algorithms, simulated annealing and any combinations of these. Prerequisite: 436 or consent of instructor.

**549-3 Wave Propagation, Impact and Explosions.** This course will deal with the dynamic response of materials and structures to dynamic events with particular emphasis on crashes, impacts and explosions.

**550-3 Contact Mechanics.** Course covers fundamentals of mechanics of elastic and inelastic solids in contact. Although the primary focus is on elastic contact, topics involving plastic flow, thermo-elastic effects and contact of rough surfaces are included in the content.

**555-3 Materials Processing.** Course to cover a multitude of topics in the processing of metals, ceramics and, to a lesser extent, polymers. Example are: materials beneficiation, extraction, solidification, sintering and thin film deposition; topics for which the scientific basis for the processes is well established. Prerequisite: 410 and Engineering 312 or consent of instructor.

**562-3 Environmental Degradation of Materials.** Course designed for majors in engineering and the physical sciences. Topics covered include general corrosion, oxidation, hydrogen embrittlement, stress corrosion cracking and fine particle erosion. Approach will draw on principles of chemistry and materials science. Prerequisite: Chemistry 200 and 210, Engineering 312, or consent of instructor.

**564-3 Ceramic Materials for Electronics.** Ceramic materials contribute essential passive functions as components for a wide range of electronic applications related to sensors and energy converters. Ceramic material's electronic properties, electronic and ionic conduction in ceramic oxides; processing, properties and applications of ceramic materials for electronics, solid-oxide fuel cells, properties, fabrication and performance will be covered in this course. Prerequisite: Engineering 312, Mechanical Engineering 463 or consent of instructor.

**565-3 Finite Element Analysis.** (Same as Civil and Environmental Engineering 551). Finite element analysis as a stress analysis or structural analysis tool. Derivation of element stiffness matrices by various means. Application to trusses, plane stress/strain and 3-D problems. Dynamic and material nonlinearity problems. Prerequisite: Civil and Environmental Engineering 350, Engineering 222a or b, and Mathematics 305.

**566-3 Advanced Mechanics of Materials.** (Same as Civil and Environmental Engineering 557) Advanced topics in mechanics of materials including: elasticity equations; torsion of non-circular sections; generalized bending including curved beams and elastic foundations; shear centers; failure criteria including yielding, fracture and fatigue; axisymmetric problems including both thick and thin walled bodies; contact stresses; and stress concentrations. Prerequisite: Civil and Environmental Engineering 350a, and Engineering 222.

**567-3 Tribology.** Analysis and design of tribological components particularly bearings. A number of modern developments in the field and advanced topics will be presented. Prerequisite: graduate standing or consent of instructor.

**568-3 Alternative Energy and Fuel Resources,** The course covers the alternatives for energy resources and the impact of the human growth on the energy usage and its environmental consequences. The course describes the fossil fuel era, renewable energy resources, and hydrogen fuel era. The fundamentals of each of these fuel types, their conversion to usable energy and the potential of each of these fuels for the future is discussed. Prerequisite: ENG 300 and ME 410, or instructor's consent.

**569-3 Non-Destructive Evaluation,** Course to cover a multitude of topics in non-destructive evaluation (NDE) techniques with emphasis on recent advancements in the field. Introduction to the field of NDE. Overview of common NDE techniques, such as visual inspection, eddy current, X-ray and ultrasonics. Recent development and research areas in NDE.

**580-1 to 2 Seminar.** Presentations of topics in the broad areas of mechanical engineering such as thermal, mechanics, materials and acoustics. Prerequisite: enrollment in program leading to Master of Science of Mechanical Engineering.

**582-1 Experimental Research Tools.** Topics important to engineering graduate students engaging in research. These topics include: laboratory safety, statistical data analysis, experimental design, library research and chemical hygiene. Prerequisite: graduate enrollment in Engineering.

**583-1 Technical Research Reporting.** Analysis of technical and scientific writing: journal article, thesis, research paper. Guidelines and principles for writing engineering research literature and proposals. Term project involving thesis or research paper proposal to meet department requirements. Prerequisite: 582, consent of instructor.

**592-1 to 4 Special Investigations in Engineering.** Advanced topics in thermal and environmental engineering. Topics are selected by mutual agreement of the student and instructor. Four hours maximum course credit. Prerequisite: consent of instructor and department chair.

**593-3 Special Topics in Mechanical Engineering.** Studies of special topics in various areas in mechanical engineering. Such topics as coal refining, energy conversion, thermal systems, mechanics, robotics, CAD/CAM, TOM and engineering materials. Prerequisite: consent of instructor.

**595-3 Research Paper.** Research paper on a topic approved by a faculty advisor and committee in Mechanical Engineering. This course is restricted to graduate students in the non-thesis option. Prerequisite: consent of instructor or department and graduate standing in Mechanical Engineering.

**599-1 to 6 Thesis.** Six hours maximum course credit.

**601-1 per semester Continuing Enrollment.** For those graduate students who have not finished their degree programs and who are in the process of working on their dissertation, thesis, or research paper. The student must have completed a minimum of 24 hours of dissertation research, or the minimum thesis, or research hours before being eligible to register for this course. Concurrent enrollment in any other course is not permitted. Graded *S/U* or *DEF* only.