X School of Engineering

Russell A. Primrose, Dean
Jay D. Pinson, Associate Dean for Graduate Studies and Research

The School of Engineering offers programs leading to master's and doctor's degrees in various areas of engineering. These graduate programs permit both departmental and interdisciplinary study to meet the specialized and continuing educational needs of the engineer. Sufficient flexibility allows the student to specialize or to pursue a broad field of study. Current graduate programs in the School of engineering lead to the following degrees:

Master of Science in Aerospace Engineering
Master of Science in Chemical Engineering
Master of Science in Civil Engineering
Master of Science in Electrical Engineering
Master of Science in Engineering
Master of Science in Engineering Management
Master of Science in Materials Engineering
Master of Science in Mechanical Engineering

Doctor of Engineering
- Major in Aerospace Engineering
- Major in Electrical Engineering
- Major in Materials Engineering
- Major in Mechanical Engineering

Doctor of Philosophy in Engineering
- Major in Aerospace Engineering
- Major in Electrical Engineering
- Major in Materials Engineering
- Major in Mechanical Engineering

Programs and the courses appropriate to each of these degrees are described later in this chapter under subject designations, which are alphabetical.

FINANCIAL AID

Assistantships and industrial fellowships are available at the University of Dayton for the encouragement of graduate work and the promotion of research. These are administered by the academic departments. Detailed information relative to application may be secured from the director of graduate engineering.

MASTER'S DEGREE REGULATIONS

Admission

To be considered for admission to graduate study in the School of Engineering. a student must have received an undergraduate degree with emphasis in engineering, physics, chemistry, or applied mathemathics. The normal qualification for admission is graduation from an accredited engineering curriculum with 2.7 or better cumulative grade point average based on a 4.0 grading system. Those with lower grade point averages will be considered for acceptance on a probationary status, in which case particular attention will be given to the last 60 semester hours of their undergraduate programs, to recommendations, and to engineering experience. They may also be required to take a limited amount of undergraduate work. Students who have degrees in physics, chemistry, applied mathematics, or related sciences are encouraged to apply, but they too may be required to take a limited amount of undergraduate work to complete their preparation for graduate study in the School of Engineering. The minimum mathematics requirement for admission is three semester hours in differential equations. Undergraduate courses are available through the Bachelor of Engineering program.

Unclassified Status

Students may also be accepted in unclassified graduate status. They will be considered as students of the School of Engineering who have not been admitted in a graduate degree program. A student can transfer a maximum of only two courses taken in this status to a program of study for a degree without pre-enrollment approval from the director of graduate engineering. An unclassified student planning to seek a degree should complete an application for graduate studies to assure that the courses he takes are acceptable and compatible with degree requirements.

Advisor

Each candidate for the master's degree shall be assigned to an advisor by the departmental chairman or the program director. The advisor shall be agreed upon by the student and approved by the director of graduate engineering. The duties of the advisor are to assist the student in the preparation of his plan of study and to advise him during his period of graduate work. An advisor should be appointed prior to initial registration for graduate studies but no later than the end of the first semester. A change of advisor at a later date is permissible upon the request of the student and approval of the departmental chairperson or program director and the director of graduate engineering.

Plan of Study

The individual plan of study for the degree shall include the specific courses the student is expected to complete and reflect all other requirements of the particular master's degree he is seeking. The plan of study must be filed with the director of graduate engineering prior to the pre-enrollment date for the 16th graduate semester hour. All copies must be approved by the advisor, the program director, and the director of graduate engineering.

Thesis

Each student whose plan of study requires a thesis must prepare the thesis in accordance with the general format outlines in the Guide for Preparation of Thesis, copies of which are available in the departmental offices. Students who have completed registration in all courses but who have not completed the thesis must request approval for continuance in the graduate program by means of a Graduate Student Program Approval form each term until graduation. In general, the thesis will be based on work accomplished in research in the primary area of study. Joint authorship is not permitted. A regular grade will be assigned upon satisfactory completion of the thesis and will be included in the final cumulative grade point average.

Oral and Written Examinations

A final examination is required at the completion of the thesis. The examination may be oral or written or both. It must be given by a committee of no fewer than three. A student who fails to pass it cannot be given another examination in the same semester. No student shall be allowed to take the examination more than three times.

FIVE-YEAR MASTER'S PROGRAM

Undergraduate students who have shown above average scholastic performance during their first three years of undergraduate work are eligible to pursue the five-year master's program. This program allows the senior engineering student the opportunity of taking selected graduate courses, making it possible to complete the requirements for a master's degree with only two semesters of additional work beyond the bachelor's degree. Undergraduate students who are interested in this program should contact their department chairperson during the last semester of their junior year.

DOCTORAL DEGREE REGULATIONS

The School of Engineering offers programs leading to two degrees at the doctoral level, the Doctor of Philosophy in Engineering and the Doctor of Engineering. The programs are restricted to those who have demonstrated superior abilties in scholarship and research. The Doctor of Philosophy in Engineering (PhD) is granted in recognition of high achievement in scholarship and independent research. Graduate programs leading to it currently encompass major fields of study in Aerospace, Electrical, Materials, and Mechanical Engineering. The Doctor of Engineering (DE), granted in recognition of high achievement in scholarship and superior ability to apply the fundamentals of engineering to the solution of technical problems, is comparable in rigor to the PhD. It requires a broad program of course work, a year of internship in engineering, and a practice-oriented dissertation. (These last two can be accomplished at the same time.) The areas of concentration for the DE are Aerospace, Electrical, Materials,

and Mechanical Engineering with major support from Chemical Engineering, Civil Engineering, and Engineering Management. Interdisciplinary study and applied research activities are required.

For either degree, the student must satisfactorily complete a specified number of semester hours of course work with a 3.0 or better cumulative grade point average (based on a 4.0 grading system). The student must also (1) pass the candidacy examination, (2) meet the period of concentrated study requirements, (3) complete an acceptable dissertation, (4) complete the tools of research requirement, (5) demonstrate the ability to accomplish independent study, (6) pass a final examination, and (7) complete other requirements as specified by his advisory committee and the Graduate School of Engineering.

Semester-Hour Requirements

The minimum time required for the PhD or DE degree is six semesters of full-time graduate study (a minimum of 90 semester hours) beyond the bachelor's degree, or four semesters of full-time graduate study (a minimum of 60 semester hours) beyond the master's degree. This includes the credit for the doctoral dissertation *with either degree* (a minimum of 30 semester hours). Registration for the dissertation hours is the same as for other courses; however, only those students who have passed the candidacy examination are eligible. A minimum of 48 semester hours must be taken at this University. Also, a minimum of 12 semester hours in graduate mathematics beyond the bachelor's degree is required for both doctoral degrees.

For the PhD, a student must complete a minimum of 30 semester hours, excluding his dissertation credit, in his major area of study beyond his bachelor's degree.

For the DE, a student is required to have a major and minor area of study. The minor must be in an area outside the major field. A minimum of 21 semester hours in the major and 12 semester hours in the minior is required beyond the bachelor's degree.

Admission

Admission means only that the student will be permitted to enroll for graduate courses. It does not necessarily imply that he will be admitted to a program leading to a doctor's degree or that he will be able to achieve the PhD or the DE.

Normally, a student must earn a master's degree in engineering or science before being granted permission to continue graduate study work for the doctorate. Outstanding students, however, may be permitted to work for either doctoral degree directly without the master's degree.

Notice of Intention

Before taking additional courses after completing the requirements for a master's degree or equivalent graduate hours, a student who expects to work for the PhD or DE is required to file a "Notice of Intention" in the Graduate School of Engineering. Unless this is accomplished, the courses taken beyond the

master's degree requirement may not be accepted toward a doctoral degree. The Notice of Intention must be filed prior to mid-term of the first semester of enrollment. The proper form may be obtained in the Graduate School of Engineering.

Temporary Advisor

After receipt of the notice of intention of a student to become a candidate for either the PhD or the DE, and upon recommendation of the program director, the director of graduate engineering will designate a member of the graduate faculty to serve as temporary advisor to the student and assist in the initial selection of courses for the first semester of enrollment.

Qualifying Examination

After the completion of the master's degree or 30 semester hours of graduate study, the student will take a qualifying examination (which may be waived for the exceptional student). The purpose of the examination is to determine the student's qualifications to continue graduate study and to assist the advisory committee in planning the program of study. The examination shall be written and oral and shall cover the subject matter of graduate courses taken and the student's ability to conduct research, to reason, and to integrate and express knowledge. The student is required to provide evidence of personal research accomplishments (e.g., thesis, research projects, science and engineering technical reports) as part of the examination. The temporary advisor will be responsible for administering the qualifying examination.

Advisory Committee

Before the end of the first semester, the student should consult with the program director and select a major professor to serve as the chairperson of the advisory committee and to direct the research. The chairperson will be a member of the School of Engineering graduate faculty. An advisory committee of at least three graduate faculty members from the School of Engineering will then be recommended for approval to the director of graduate engineering. The composition of the committee will generally reflect the student's area of course study and research interest. At least one person having graduate faculty status will be appointed by the director of graduate engineering. The duties of the advisory committee shall consist of (1) advising the student, (2) assisting the student in preparing the complete program of study, (3) preparing and administering the candidacy examination, (4) assisting in the planning and conducting of the research, (5) approving the dissertation, and (6) conducting and reporting the results of the final examination. Appointment of additional members of the committee from outside the School of Engineering (i.e., other University faculty, adjunct professors, prominent researchers in industry or government) is encouraged. The majority of the committee, however, must be members of the School of Engineering graduate faculty. A dissertation advisor other than the chairperson may be appointed by the Advisory Committee.

Plan of Study

The plan of study shall include all the graduate work the student is expected to complete as determined by his advisory committee. The plan of study is to be submitted to the School of Engineering before the end of the first semester or prior to the pre-enrollment date for the 16th graduate hour beyond the master's degree or its equivalent. The plan shall include the specific courses and all other requirements (seminars, tools of research, research, etc.) which the student is expected to complete, indicating the time and manner in which these requirements are to be met.

Tools of Research

The needs of the student may differ with the educational objectives chosen. Therefore, the tools of research requirement will be determined by the advisory committee and approved by the department chairman or the program director. One from the following will be selected:

1. Command of one approved language, as evidenced by a satisfactory score on the Graduate Foreign Language Tests (GSFLT) in French, German or Russian.
2. Completion of 6 semester hours of selected and approved 400-level or higher courses in computer science and / or instrumentation measuring techniques with at least a B average.
3. Completion of 6 semester hours of graduate courses in a defined area of humanities and / or social sciences, related to his program of study objectives, with the grade of B or higher.

Courses taken in completing the tools of research requirement will not carry credit toward the degree. The method selected in satisfying this requirement is to be listed in the plan of study. This requirement must be satisfied prior to the candidacy examinations.

Period of Concentrated Study

After a student has filed a notice of intention, he must complete a period of concentrated study in order to be considered for the candidacy examination. This requirement can be met in either of two ways:

1. During three consecutive semesters, the student completes a minimum of 21 semester hours of graduate course work.
2. In any two of three consecutive semesters, the student completes a minimum of 18 semester hours of graduate course work.

Internship for DE

The DE internship is a minimum of one year of high level practicing engineering experience, and is normally conducted after the student has passed his candidacy examination. The internship phase of the program must be fully described in the proposal submitted as part of the candidacy examination. The candidate's internship advisor (generally his supervisor at his interning organization) will be added as a member of his advisory committee. The internship, as

part of the DE program of study, must be approved by the candidate's advisory committee, program director, and the director of graduate engineering. From 15 to 21 semester hours can be credited for the internship as part of the dissertation requirement for the Doctor of Engineering.

Candidacy Examination

The candidacy examination for either the PhD or the DE is generally to be taken when most of the course work, as outlined on the approved plan of study, has been completed. Its purpose is to determine the student's eligibility to become a candidate for the doctoral degree. The examination is comprehensive, covering the entire area of the student's graduate study. It will be both written and oral. The oral portion must follow the written portion by a minimum of two weeks. At least three members of the School of Engineering graduate faculty must participate in the preparation and the administering of the examination under the direction of the advisory committee. The director of graduate engineering has the right to appoint additional members to the examining committee. He must be informed of the date and place of the examinations and the membership of the committee at least two weeks before the examinations are given.

As part of the examination, the student must have completed a proposal outlining in detail the proposed area of dissertation study and research (for the PhD) or of the applied research dissertation project (for the DE). The proposal should clearly show the review of the literature in the area, the need for and the uniqueness of the research and / or investigation, the general approach to accomplishing the effort, results expected, detailed costs, the laboratories and / or other facilities needed, and a schedule of completion. In addition, the proposal by the candidate for the DE will explain the interdisciplinary role of the investigation. The student in either degree program must make a copy of this proposal available to each committee member prior to the written examination. (Note: the University of Dayton is not obligated to provide financial support for the research or investigation).

The student must pass all parts of the examination (proposal, written examination, and oral examination) to be admitted to candidacy. He is considered to have passed only when the decision of the examining committee is unanimous. All members must sign the examination report form with an indication of their decision noted prior to its being submitted to the director of graduate engineering. If the student fails any part of the examination, he will be notified in writing of the conditions for another examination. No student will be permitted to take any part of the examination more than twice. A second examination may not be given earlier than four months after failure. Examinations will be retained by the chairperson of the advisory committee.

A student must be admitted to candidacy at least six months prior to receiving his doctor's degree.

Dissertation

A dissertation is required of each doctoral candidate (student who has passed the candidacy examination). The dissertation topic will be determined by the student in consultation with the advisor and approved by the advisory committee, the program director, and the director of graduate engineering. *The PhD dissertation* presents the results of the student's research investigation. It is expected to make an original contribution to technical knowledge, of sufficient importance to merit publication. Also, an abstract not to exceed 600 words will be prepared for submittal to sources for possible acceptance of a publication. A list of technical journals should be attached as possible sources of publication. *The DE dissertation* presents the results of an original investigation as applied to engineering practice. Normally, this will be related directly to the candidate's internship or problems relating to his engineering experience or work. It must be a significant contribution of independent engineering work to merit a doctoral level publication. The student will also prepare an abstract.

The dissertation will be prepared in accordance with instructions outlined in the Guide for Preparation of Dissertation, copies of which are available in the Graduate Engineering Office.

The first draft of the dissertation should be in the hands of the advisor a minimum of six weeks before the end of the semester the degree is sought. Four copies of the dissertation in final form and ten copies of the abstract must be submitted to the Graduate School of Engineering at least four weeks before the end of the semester in which the degree is sought. These copies must bear the written approval of the advisor. The original copy of the dissertation and two copies of the abstract shall be filed in the Library one week prior to the end of the semester.

All doctoral dissertations are microfilmed by the University Microfilm, Inc., Ann Arbor, Michigan. The candidate must sign an agreement with the University Microfilm, Inc., which authorizes this firm to sell copies of his dissertation. Microfilmed dissertations may be copyrighted by the candidate. Fees will be assessed for the cost of mircrofilming and / or copyrights.

The student must obtain approval from his advisory committee to undertake all or part of his dissertation in absentia. A report requesting this permission must be submitted to the director of graduate engineering outlining in detail the relationship between the advisor and the candidate and the name and background of the person who will directly advise the candidate during the accomplishment of this independent research. This person will be added to his advisory committee.

Candidates must be registered for a minimum of two semester hours every semester during their candidacy including the semester the final examination is taken.

Final Examination

After the dissertation has been accepted by the Graduate Engineering Office but no earlier than six months after the successful candidacy examination, the candidate shall take a final oral examination to demonstrate to the examining

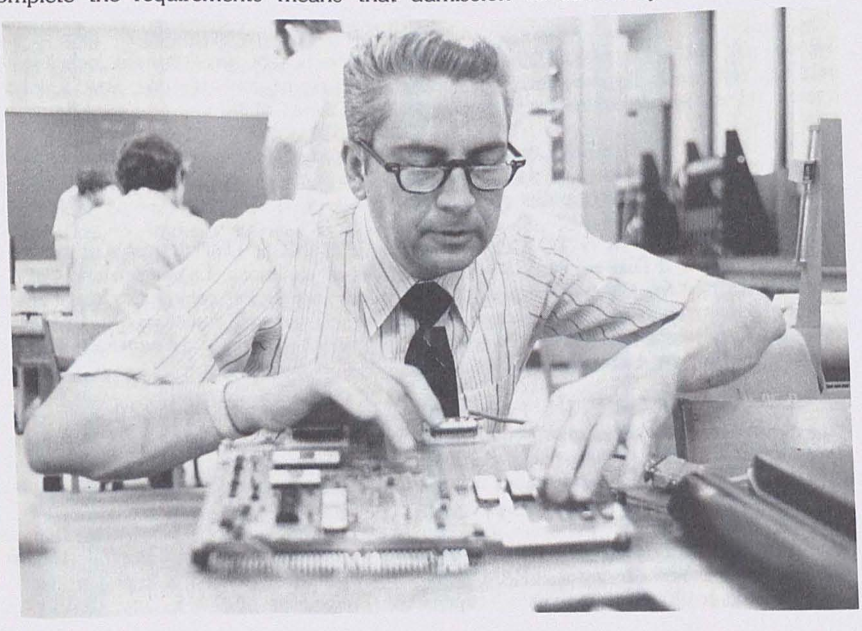
committee that he has all the capabilities for which the doctor's degree is awarded. This is primarily the defense of the dissertation, though it need not be confined exclusively to it. The examination is open to all members of the University of Dayton Faculty and student body. At least ten days prior to the date of the examination, the candidate must have provided the committee with copies of the dissertation in final form and must have disseminated an announcement of the final examination to interested organizations.

The final examining committee normally includes the members of the candidate's advisory committee, with his advisor acting as chairman. The final examining committee shall consist of at least four members of the graduate faculty, at least one of whom is not directly involved in the program concerned and is appointed by the director of graduate engineering. The director of graduate engineering reserves the right to appoint additional committee members and must be informed of the place and time of the final examination at least ten days in advance.

After the examination, the committee will report its decision to the director of graduate engineering. In order to be satisfactory, the report of the examining committee must be unanimous and must be signed by all members. If the candidate fails by only one vote, the case will be referred to the Graduate Study Committee for appropriate action.

Time Limit

Students are expected to complete the requirements for the doctor's degree within five years after the candidacy examination has been passed. Failure to complete the requirements means that admission to candidacy will be cancelled.



AEROSPACE ENGINEERING (AEE)

Jay D. Pinson, Director of the Program

Aerospace Engineering is a major concentration for both the Doctor of Engineering and the Doctor of Philosophy in Engineering. See Doctoral Degree Regulations in the introductory section of this chapter and consult with the director of the program.

The program of study leading to the Master of Science in Aerospace Engineering must include a minimum of 30 semester hours of credit consisting of the following:

1. Twelve semester hours in the major area. Major areas of study include Flight Mechanics, Stability and Control, Fluid Mechanics, Design and Performance, Simulation, Materials and Structures, Energy Conversion, Heat and Mass Transfer.
2. Twelve semester hours of electives. Electives will be selected from current course offerings which best satisfy the student's requirements and meet with the advisor's approval.
3. Six semester hours of research on an approved project. Research projects may be replaced by 6 semester hours of additional course work with the approval of the advisor and the program director.

See also Master's Degree Regulations in the introductory section of this chapter and consult with the director of the program.

COURSES OF INSTRUCTION

AEE 501 ADVANCED AERODYNAMICS I: Fundamentals of aerodynamics including viscosity and compressibility phenomena for subsonic, supersonic, and transonic flow. Emphasis on force and moment determination for bodies, including theory of lift. *3 sem. hrs.*

AEE 502. ADVANCED AERODYNAMICS II: Advanced analytical development of viscous and compressible fluid theory as applied to vehicle performance in steady flight, accelerated flight, analysis of vehicle flight paths and trajectories. *3 sem. hrs.*

AEE 503. INTRODUCTION TO CONTINUUM MECHANICS: Unified treatment of topics common to solid and fluid continua. Tensors, calculus of variations. Lagrangian and Eulerian discriptions of motion. General equations of continuum mechanics, constitutive equations of mechanics, thermodynamics of continua. Reduction of general equations to specialized forms used in follow-on courses in solid and fluid mechanics. Classical and numerical methods for solving continuum mechanics equations. *3 sem. hrs.*

AEE 511. AIRCRAFT DESIGN: Preliminary design of aircraft, including layout, weight and size estimates, wing section and planform selection, determination of configuration aerodynamics, engine and inlet sizing, corrections to propulsion data, refined fuel estimates, weight and balance, stability and control, and performance determination. *3 sem. hrs.*

AEE 513. PROPULSION: Principles of propulsive devices, aerothermodynamics, diffuser and nozzle flow, energy transfer in turbo-machinery, turbojet, turbo-fan, prop-fan engines, turbo-prop and turboshaft engines. RAM and SCRAM jet analysis and a brief introduction to related materials and air frame-propulsion interaction. Prerequisite: MEE 418. *3 sem. hrs.*

AEE 515. CONDUCTION HEAT TRANSFER: Steady state and transient state conduction. Evaluation of temperature fields by formal mathematics, numerical analysis, and analogic experiments. *3 sem. hrs.*

AEE 516. CONVECTION HEAT AND MASS TRANSFER: Development of governing differential equations for convection. Methods of solution including similarity methods, integral methods, superposition of solutions, eigen-value problems. Turbulent flow convection; integral methods, eddy diffusivities for heat and momentum. Extensions to mass transfer. Prerequisite: MEE 410. *3 sem. hrs.*

AEE 517. RADIATION HEAT TRANSFER: Fundamental relationships of radiation heat transfer. Radiation characteristics of surfaces. Geometric considerations in radiation exchange between surfaces. Emissivity and absorptivity of gases. Introduction to radiative exchange in gases. Prerequisite: MTH 403. *3 sem. hrs.*

AEE 521. VEHICLE DYNAMICS: Dynamics of flight vehicles that emphasize the fundamental theory of flight and its application to aerospace systems. Static and dynamic stability including the characteristic longitudinal and lateral perturbation motions about the equilibrium state. *3 sem. hrs.*

AEE 523. AUTOMATIC CONTROL: Basic feedback control theory, transfer functions, stability analysis, Bode plots, Nyquist, root-loci, Routh's criteria. State space methods. Nonlinear systems, phase plane analysis, describing functions, Lyapunov stability analysis. Autopilots, stability augmentation, and flight control system. *3 sem. hrs.*

AEE 525. SIMULATION THEORY AND PREDICTION: Simulation of modern flight vehicles using hybrid computers; prediction and evaluation of flying qualities; vehicle equations of motion and manual control theory. Flight regimes include low-speed-high angle-of-attack, STOL, transonic and others. Flying qualities. Prediction methods. Mathematical model of human pilot. Experimental prediction using hybrid computer. *3 sem. hrs.*

AEE 535. MECHANICAL VIBRATIONS: Multi-degree of freedom systems. Lagrange's equations, transient vibrations, vibrations of continuous systems. Matrix and numerical methods. Introduction to finite element method; to nonlinear vibrations. Prerequisite: MEE 319. *3 sem. hrs.*

AEE 538. INTRODUCTION TO AEROELASTICITY: Static method of stability prediction for elastic systems subjected to conservative forces. Dynamic methods when forces are nonconservative. Follower forces. Stability of flexible shafts, rotors, centrifuges. Aeroelasticity and wing flutter. Panel and membrane flutter in supersonic flow. Galerkin's method. (Registration restricted to students enrolled in Master of Science in Engineering. Aerospace Engineering option, Program.) *3 sem. hrs.*

AEE 543. FUNDAMENTALS OF ADVANCED STRUCTURAL MATERIALS: Introduction of anisotropic material and its complex behavior, comparison with isotropic material. Tools for analysis and design of aerospace structures with laminated composites. Classical laminated plate theory as a special case of the more general and complex anisotropic plate theory for practical application. *3 sem. hrs.*

AEE 544. DESIGN OF ADVANCED STRUCTURES: Structural design of aerospace subsystems and components. Analysis of composites and other advance structures for static and dynamic loads. Methods of optimization for performance and cost. Design criteria prediction for stresses, displacements, instabilities, fatigue fracture. *3 sem. hrs.*

AEE 551. VISCOUS FLOW: Fundamentals of viscous flow. Navier-Stokes and boundary layer equations. Exact and approximate solutions of these equations using modern computational procedures for both laminar and turbulent flows: Prerequisite: MTH 403. *3 sem. hrs.*

AEE 553. COMPRESSIBLE FLOW: Fundamental equations of compressible flow. Introduction to flow in two and three dimensions. Two-dimensional supersonic flow, small perturbation theory, method of characteristics, oblique shock theory. Introduction to unsteady one-dimensional motion and shock tube theory. Method of surface singularities. Prerequisite: MEE 418. *3 sem. hrs.*

AEE 554. TRANSONIC AERODYNAMICS: Inviscid theory related to planer flows, axisymmetric flow and shock free solutions. Viscous consideration for compressible boundary layers and flow separation and reattachment. Numerical methods of relaxation, time dependent, gradient dependent and integral solutions. Consideration, limitation and correlation of wind tunnel and flight testing. Design of supercritical wings. *3 sem. hrs.*

AEE 555. TURBULENCE: Random variable theory, Fourier transforms, power spectral density methods. Description of atmospheric turbulence, discrete gusts, homogeneous isotropic turbulence; gusts in several dimensions; power spectrum of atmospheric turbulence; turbulence due to trailing vortices. Air vehicle response to turbulence, output power spectrum, gust alleviations. Clear air turbulence. Unsteady aerodynamics. *3 sem. hrs.*

AEE 556. HYPERSONIC AERODYNAMICS: Hypersonic prediction techniques, similarity rules, Newtonian impact theory, high temperature equilibrium properties of gases; wake characteristics; heat transfer, chemical kinetics and reacting gas flows, simulation and testing techniques. *3 sem. hrs.*

AEE 561. AIRCRAFT ENVIRONMENTAL CONTROL: Performance analysis of aircraft environmental control systems. Development of steady state and transient equations for system components such as heat exchangers. Psychometrics as it applies to aircraft air conditioning; turbo-machinery used in reverse Brayton refrigeration cycle; application of heat pipes; overall systems and mission analysis; controls and numerical modeling. *3 sem. hrs.*

AEE 565. FUNDAMENTALS OF COMBUSTION: Heat of combustion and flame temperature calculations; rate of chemical reaction and Arrhenius relationship; theory of thermal explosions and concept of ignition delay and critical mass; phenomena associated with hydrocarbon-air combustion; specific applications of combustion. *3 sem. hrs.*

AEE 566. COMBUSTION THEORY OF DETONATION (Rankine-Hugoniot relationships) and flame propagation rate in pre-mixed gas systems; turbulent flames and the well-stirred reactor; theory of diffusion flames; fuel droplet combustion; steady burning of solid materials; ignition and flame spreading across solid materials. *3 sem. hrs.*

AEE 571. ENVIRONMENTAL ACOUSTICS AND VIBRACOUSTICS: Physics of sound propagation. Physiological and legal aspects of sound. Measurement and analysis of sound and vibrations. Vibration and sound control techniques, source modifications, path modifications, receiver modifications. Acoustic considerations in machine design. Prerequisite: MTH 219. *3 sem. hrs.*

AEE 580. AEROSPACE ENGINEERING PROJECT: Student participation in an aerospace research, design or development project under the direction of a project advisor. The student must show satisfactory progress as determined by the project advisor and must present a written report at the conclusion of the project. *3-6 sem. hrs.*

AEE 590. SELECTED READINGS IN AEROSPACE ENGINEERING: Directed readings in the designated area to be arranged and approved by the student's advisor and the program director. May be repeated. *1-3 sem. hrs.*

AEE 595. SPECIAL PROBLEMS IN AEROSPACE ENGINEERING: Special assignments in aerospace engineering subject matter to be arranged and approved by the student's faculty advisor and the program director. *1-6 sem. hrs.*

AEE 612. ADVANCED APPLIED AERODYNAMICS: Optimization of performance and controls, design trade studies, advanced methods for performance predictions, wind tunnel testing, flight testing, computer system design and simulation; analysis and validation of models and results, including design to cost consideration. *3 sem. hrs.*

AEE 622. ADVANCED VEHICLE DYNAMICS: Advanced topics in vehicle dynamics including the coupling of the elastic degrees of freedom with the rigid body motions. Response to controls, flight in a turbulent atmosphere, human pilots and handling qualities as well as inverse problems. *3 sem. hrs.*

AEE 624. OPTIMAL CONTROL: Feedback control, frequency and time domain, stability, controllability, and observability; Bode plots, root-loci, Nyquist methods; variational calculus optimization; dynamic programming; Pontryagin's principles; numerical methods for optimal paths; optimal control in presence of noise; aerospace application. *3 sem. hrs.*

AEE 690. SELECTED READINGS IN AEROSPACE ENGINEERING: Directed readings in aerospace engineering to. be arranged and approved by the student's advisory committee and the program director. May be repeated. *1-3 sem. hrs.*

AEE 695. SPECIAL PROBLEMS IN AEROSPACE ENGINEERING: Special assignments in aerospace engineering. Subject matter to be arranged and approved by the student's advisory committee and the program director. May be repeated. *1-3 sem. hrs.*

AEE 698. DE DISSERTATION: An original investigation as applied to aerospace engineering practice. Results must be of sufficient importance to merit publication. *1-15 sem. hrs.*

AEE 699. PhD DISSERTATION: Research in aerospace engineering. Results must be of sufficient importance to merit publication. *1-15 sem. hrs.*

CHEMICAL ENGINEERING (CME)

Ronald A. Servais, Chairperson of the Department

The program of study leading to the Master of Science in Chemical Engineering must include a minimum of 30 semester hours of credit consisting of the following:
1. Six semester hours in the basic sciences or mathematics.
2. Twelve semester hours of Chemical Engineering courses. All of these must be graduate-level courses. They must include CME 507, 521, and 581 or 582.
3. Six semester hours of electives as approved by the advisor and the chairman of the department.
4. Six semester hours on an approved thesis project. Upon the request of the student and with the approval of the advisor and the chairman of the department, the thesis may be replaced by nine semester hours of additional course work.

A final examination is required at the completion of the thesis or course work. See also Master's Degree Regulations in the introductory section of this chapter and consult with the advisor.

COURSES OF INSTRUCTION

CME 505. THERMODYNAMICS OF SOLIDS: Thermodynamic properties of solutions and intermediate phases. Equilibrium behavior of phase mixtures. Representation of multicomponent phase diagram. Experimental determination and prediction of phase diagrams. Prerequisite: MAT 502 or consent of instructor. *3 sem. hrs.*

CME 507. ADVANCED THERMODYNAMICS: Applications of the laws of thermodynamics-phase equilibria in ideal and nonideal systems-chemical equilibrium. *3 sem. hrs.*

CME 508. ADVANCED TOPICS IN CHEMICAL ENGINEERING: Study and discussion of current problems in chemical engineering research. Prerequisites: CME 521, 581, or consent of instructor. *3 sem. hrs.*

CME 509. INTRODUCTION TO POLYMER SCIENCE: Introduction to polymers. A largely nonmathematical survey of the field. Prerequisites: college chemistry and calculus. *3 sem. hrs.*

CME 510. PHYSICAL PROPERTIES OF POLYMERS: Intensive discussion of the interrelations between molecular and gross physical properties of polymers. Prerequisites: CME 509 or equivalent, background in differential equations. *3 sem. hrs.*

CME 511. PRINCIPLES OF CORROSION: Application of electrochemical principles, corrosion reactions, passivation, cathodic and anodic protection, stress corrosion, and high temperature oxidation. *3 sem. hrs.*

CME 515. STATISTICAL THERMODYNAMICS: Microscopic thermodynamics; kinetic theory; virial theorem of Clausius; transport phenomena; Gibbs, Boltzman, Bose-Einstein, Fermi-Dirac statistics. Connection between statistical and thermodynamic quantities. Applications to perfect and real gases, liquids, crystalline solids, and thermal radiation. Information theory, irreversible thermodynamics. Prerequisites: CME 305, MTH 219. *3 sem. hrs.*

CME 521. ADVANCED TRANSPORT PHENOMENA: Applications of the principles of momentum and heat transfer to steady state and transient problems. Potential flow, boundary layer theory. Prerequisite: CME 581 or equivalent. *3 sem. hrs.*

CME 522. SEPARATION PROCESSES: A study of mass transfer in binary and multi-component systems. Absorption. Distillation. Extraction. *3 sem. hrs.*

CME 541. PROCESS DYNAMICS: Mathematical modeling and computer simulation of process dynamics and control for chemical engineering processes. *3 sem. hrs.*

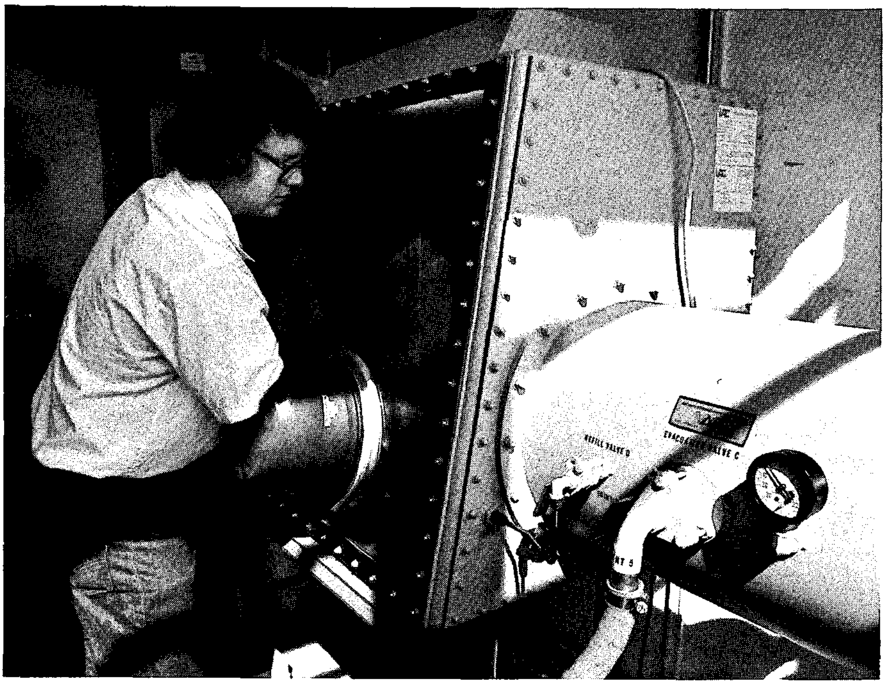
CME 542. CHEMICAL ENGINEERING KINETICS: Ideal and non-ideal reactor behavior. Fluid mixing. Fluid-particle reactions. Fluid-fluid reactions. Catalysis. *3 sem. hrs.*

CME 581. ADVANCED CHEMICAL ENGINEERING CALCULATIONS I: Applications of ordinary and partial differential equations to engineering problems. Classical methods of solution. *3 sem. hrs.*

CME 582. ADVANCED CHEMICAL ENGINEERING CALCULATIONS II: Analysis and design of processes and the solutions of the resulting differential equations by computer techniques. *3 sem. hrs.*

CME 595. SPECIAL PROBLEMS IN CHEMICAL ENGINEERING: Particular assignments to be arranged and approved by the chairman of the department. *1-6 sem. hrs.*

CME 599. THESIS *3-6 sem. hrs.*



CIVIL ENGINEERING (CIE)

Seymour J. Ryckman, Chairperson of the Department

The program of study for the Master of Science in Engineering must include a minimum of 30 semester hours consisting of the following:

1. Three to six semester hours in basic sciences.
2. Eighteen to 21 semester hours in Civil Engineering, Engineering Mechanics, and / or thesis-related courses approved by the student's advisor.
3. Six semester hours on an approved thesis project. Students engaged in thesis research enroll in CIE 599.

A final examination is required at the completion of the thesis.

See also Master's Degree Regulations in the introductory section of this chapter and consult with the advisor.

COURSES OF INSTRUCTION

CIE 500. ADVANCED STRUCTURAL ANALYSIS: Frames of variable cross section, arches; flat and folded plates; elastic stability of columns, frames, and plates; cylindrical, spherical, and barrel shells; structures dynamics of beam and frames. Prerequisites: CIE 405, EGM 304. *3 sem. hrs.*

CIE 501. STRUCTURAL ANALYSIS BY COMPUTER: Review of force and displacement methods. Introduction to direct element and substructure methods. Students write and execute, using computer terminals, their own programs to analyze plane and space trusses, grids, and plane and space frames. Prerequisite: CIE 406. *3 sem. hrs.*

CIE 502. PRESTRESSED CONCRETE: Discussion of the properties of concrete and prestressing steel. Theory and design of prestressed concrete beams, slabs, columns, frames, ties, and circular tanks. Prerequisite: CIE 407. *3 sem. hrs.*

CIE 503. PLASTIC DESIGN IN STEEL: Analysis and design procedures based on ultimate load capacity applied to steel beams, frames, and their connections. Concept of plastic hinge, necessary conditions for the existence of plastic moment, instability, deformations, repeated and reversed loading, and minimum weight design. Prerequisite: CIE 415. *3 sem. hrs.*

CIE 520. ADVANCED SOIL MECHANICS: Treatment of the theories of conventional soil mechanics. Detailed study and analysis of the static and dynamic properties of soils, with applications to foundation behavior. Prerequisite: CIE 312. *3 sem. hrs.*

CIE 524. FOUNDATION DESIGN: Analysis of earth pressure, stability of natural slopes, and bearing capacity of soil; design of spread foundations, pile foundations, beams on elastic foundations, anchored bulkheads, caissons, and cofferdams. Prerequisite: CIE 312. *3 sem. hrs.*

CIE 535. SANITARY CHEMISTRY: Principles, techniques, and interpretations of physical, chemical and biological tests related to water, sewage, and industrial wastes. Prerequisite: CHM 124. *3 sem. hrs.*

CIE 540. HIGHWAY GEOMETRIC DESIGN: Design controls and criteria, vehicle capacity, sight distance, intersection and interchange design. Prerequisite: CIE 405. *3 sem. hrs.*

CIE 544. TRAFFIC ENGINEERING: Characteristics of traffic, including the road user, the vehicle, origin, and destination surveys; traffic regulation, control devices and aids, design, administration, and planning. Prerequisite: CIE 405. *3 sem. hrs.*

CIE 558. TRAFFIC ENGINEERING RESEARCH: Problems in control or capacity restraints based on studies of local situations. *3 sem. hrs.*

CIE 560. ADVANCED SANITARY ENGINEERING: Stream polution control and design of water and waste treatment plants and sewers. Prerequisites: CIE 333, 434. *3 sem. hrs.*

CIE 562. INDUSTRIAL WASTE TREATMENT: Nature and quality of specific industrial wastes and water supplies, treatment and disposal of industrial wastes. Prerequisites: CIE 333, 434. *3 sem. hrs.*

CIE 580. HYDROLOGY AND SEEPAGE: The deposition, movement, and infiltration of water as related to the hydrologic cycle and groundwater hydraulics; a study of the theory of flow in porous media with application to dams, excavations, and other foundation problems. Prerequisites: CIE 313, 312. *3 sem. hrs.*

CIE 582. ADVANCED HYDRAULICS: Problems and study involving open channel flow, draw down curves, hydraulics of dams, spillway, models, and water distribution systems. Prerequisite: CIE 313. *3 sem. hrs.*

CIE 595. SPECIAL PROBLEMS IN CIVIL ENGINEERING: Special assignments in civil engineering subject matter to be arranged and approved by the student's advisor and the department chairman. *2-6 sem. hrs.*

CIE 599. THESIS *3-6 sem. hrs.*

ENGINEERING MECHANICS (EGM)

SUPPORTING COURSES OF INSTRUCTION

EGM 501. EXPERIMENTAL STRESS ANALYSIS: A study of the experimental analysis of stress as an aid to design for strength and economy with emphasis on electrical strain gauges. Also photoelasticity, brittle coatings, photoelastic coatings, analogies, structural similitude. Two hours lecture and one three-hour laboratory period per week. Prerequisite: EGM 304. *3 sem. hrs.*

EGM 519. ANALYTIC DYNAMICS: Kinematics, relative motion, constraints and generalized coordinates, Hamilton's principle, Lagrange's equations, variational principles. Applications to particle dynamics and rigid body motion. Prerequisites: EGM 301, MTH 219 or equivalent. *3 sem. hrs.*

EGM 530. APPLIED ELASTICITY: Equations of equilibrium and continuity; solution of two-dimensional problems in rectangular and curvilinear coordinates by means of stress functions; St. Venant's principle; energy methods; stress concentrations; introduction to three-dimensional and thermal stress problems; application of finite difference equations. Prerequisite: EGM 304. *3 sem. hrs.*

EGM 531. THEORY OF LINEAR VISCOELASTICITY: The principles of viscoelasticity; Kelvin and Maxwell models of viscoelastic materials; creep and relazation phenomena; application of hereditary integral and complex compliance; the correspondence principle with applications to beams and columns,. wave propagation and vibrational response. *3 sem. hrs.*

EGM 539. THEORY OF PLASTICITY: Fundamentals of elasticity and plasticity, yield criteria, plastic stress-strain relations, theories of work hardening. Extremum principles. Application to problems of bending, torsion, plane stress, and plane strain. Slip line and limit analysis. Prerequisite: MEE 533. *3 sem. hrs.*

EGM 595. SPECIAL PROBLEMS IN ENGINEERING MECHANICS: Particular assignments to be arranged and approved by the chairman of the Department of Civil or Mechanical Engineering. *2-6 sem. hrs.*

ELECTRICAL ENGINEERING (ELE)

Bernhard M. Schmidt, Chairperson of the Department

Electrical Engineering is a major concentration for both the Doctor of Engineering and the Doctor of Philosophy in Engineering. See Doctoral Degree Regulations in the introductory section of this chapter and consult with the department chairman and the director of the programs.

The program of study leading to the Master of Science in Electrical Engineering must include a minimum of 30 semester hours of credit consisting of the following:

1. Six semester hours in basic and engineering sciences. It is possible to combine six semester hours from separate areas. Selected courses must meet with the approval of the advisor.
2. Twelve semester hours in Electrical Engineering at the graduate level.
3. Six semester hours in thesis-supporting courses approved by the advisor.
4. Six semester hours on an approved thesis project. Students engaged in thesis research enroll in ELE 599.

A final examination is required at the completion of the thesis.

See also Master's Degree Regulations in the introductory section of this chapter, and consult with the advisor.

COURSES OF INSTRUCTION

ELE 502. NETWORK SYNTHESIS: Synthesis of linear passive networks using classical pole-zero techniques; conditions for physical realizability approximating network functions and design to meet specific requirements; analysis and synthesis of linear active networks. Prerequisites: ELE 332, 413. *3 sem. hrs.*

ELE 505. QUANTUM ELECTRONICS — PRINCIPLES: Principles of quantum theory; classical and quantum statistics; many-particle systems; electromagnetic interactions with materials. Applications to lasers and Q.M. communication theory. Prerequisite: ELE 440 or equivalent. *3 sem. hrs.*

ELE 506. SOLID STATE DEVICES: Introduction to the theory of solid state electron devices. Bulk devices, junction devices, devices involving electric, magnetic, optical, and acoustical interactions. *3 sem. hrs.*

ELE 507. ELECTROMAGNETIC FIELDS I: Fundamental concepts; introduction to waves; theorems of electromagnetics; plane wave function; cylindrical wave functions. Applications to extremely low frequency through optical frequency systems. Prerequisite: ELE 334. *3 sem. hrs.*

ELE 508. ELECTROMAGNETIC FIELDS II: Spherical wave functions; perturbational and variational techniques; radiative systems; microwave networks. Prerequisite: ELE 334. *3 sem. hrs.*

ELE 509. ANALYSIS OF LINEAR SYSTEMS: A study of Fourier series, finite trigonometric series, Fourier transforms, and their applications in the analysis of linear systems. *3 sem. hrs.*

ELE 513. COMMUNICATION THEORY: The application of Fourier series and integrals to the analysis of communication problems; theory of random signals, autocorrelation, power density spectra, and optimum filters. Prerequisite: ELE 413. *3 sem. hrs.*

ELE 514. ANALYSIS OF NONLINEAR SYSTEMS: An advanced study of methods of analysis of nonlinear systems with applications in the fields of electric circuit theory and control systems. Prerequisite: ELE 509. *3 sem. hrs.*

ELE 515. AUTOMATIC CONTROL THEORY: Analysis and synthesis of feedback control systems; graphical frequency-response techniques; establishing performance criteria; state-space techniques. Prerequisite: ELE 432. *3 sem. hrs.*

ELE 517. RANDOM PROCESSES IN SYSTEM THEORY I: A coherent, semiformal introduction to the theory of probability and random processes as applied to system theory. The axioms of probability; the concept of random variable, distributions, density; function of random variables; stochastic processes; stationary processes; linear mean square estimation; Markov processes. Prerequisite: ELE 331 or consent of instructor. *3 sem. hrs.*

ELE 518. ESTIMATION THEORY AND ITS APPLICATIONS: A unified approach to the theory of estimation as applied to engineering problems of communication and control. Review of probability and linear dynamical systems, analysis of discrete and continuous linear stochastic systems; frequency and time domain solution of the linear estimation problem; applications to current engineering problems of communication and control. Prerequisite: ELE 517. *3 sem. hrs.*

ELE 521. CONDUCTORS AND DIELECTRICS: Ionic and metallic conduction; thermoelectric phenomena; conductors for various engineering application; physics of "nonconductors"; ferro-electricity; electrets; piezoelectricity; optical properties; specialty materials. Prerequisite: ELE 505. *3 sem. hrs.*

ELE 522. MAGNETIC MEASUREMENTS AND INSTRUMENTS: Magnetic material properties; quantities and units. Field generation; measurement of field strength, magnetic moment and induction. A.C. permeability, iron losses, waveforms. Permanent magnet properties. Static and dynamic hysteresis loops. Magnetic domain observation. Thermomagnetic analysis. Two weekly lecture hours and five laboratory sessions of 4 hours each. Prerequisite: ELE 524 or consent of instructor. *3 sem. hrs.*

ELE 523. PERMANENT MAGNETS: Basic properties and description. Magnetic circuit design. Magnet materials types and properties. Physics and metallurgy of permanent magnets. Property measurement. Engineering applications. Present research activities. Three weekly lecture hours and five laboratory sessions of 4 hours each. Field trip to magnet manufacturer. Prerequisite: ELE 524 or consent of instructor. *4 sem. hrs.*

ELE 524. MAGNETIC MATERIALS — PHYSICAL PRINCIPLES: Description of magnetic material properties. The magnetic circuit. Atomic magnetism. Types of magnetic order and spin structures. Intrinsic magnetization. Molecular field concept. Anisotropy. Magnetostriction. Magnetic resonances. Prerequisite: ELE 333 or consent of instructor. *3 sem. hrs.*

ELE 531. DIGITAL SYSTEMS THEORY I: Switching circuit theory: number systems, truth functions, Boolean algebra, switching devices, codes, relay circuits, and an introduction to sequential circuits. Prerequisite: ELE 313 or consent of instructor. *3 sem. hrs.*

ELE 532. DIGITAL SYSTEMS THEORY II: Sequential circuit theory; clocked sequential circuits, incompletely specified sequential circuits, pulse-mode circuits, fundamental mode circuits. Prerequisite: ELE 531. *3 sem. hrs.*

ELE 533. DIGITAL SYSTEMS THEORY III: Digital computer design: digital arithmetic, switching matrices, digital computer elements, arithmetic and control units, the logic design of a simple digital computer. Prerequisite: ELE 532. *3 sem. hrs.*

ELE 534. DIGITAL SYSTEMS THEORY IV: Advanced sequential machine theory; finite state machines, regular expressions, lossless machines, bilateral analysis and synthesis procedures, sequential iterative systems. Prerequisite: ELE 532. *3 sem. hrs.*

ELE 535. CODING THEORY: The theory of error-correcting, error-detecting codes as applied to the design of reliable digital data systems. Prerequisite: ELE 532. *3 sem. hrs.*

ELE 536. MICROCOMPUTERS I: Basic computer architecture, arithmetic logic units, calculator chips, micro-processors, timing and instruction cycles, system architecture, programming, cross assembly. Prerequisite: ELE 533 or digital design experience. *3 sem. hrs.*

ELE 537. MICROCOMPUTERS II: Advanced microcomputer design, teletype I/O, asynchronous receiver-transmitters, interface design, control topics, cross assembly, high order languages, system considerations. Prerequisite: ELE 536 or equivalent design experience. *3 sem. hrs.*

ELE 541. POWER ELECTRONICS: Applications of power semiconductors to power control amplification, and regulation, in the light of an integrated, quantitative treatment of mechanical, thermal, and electrical characteristics and ratings; modeling for linear, nonlinear and switching modes; and thermal and electric circuit interactions. Prerequisite: ELE 313 or equivalent. *3 sem. hrs.*

ELE 551. ELECTRICAL POWER SYSTEM DYNAMICS: Basic structure of the electrical power transmission system; criteria for system stability; symmetrical components; synchronous machine equations of motion, transients and dynamics; transmission line surges, short circuit calculations. Prerequisites: ELE 334, 431. *3 sem. hrs.*

ELE 555. SYSTEM DYNAMICS I: The methodology for modeling the dynamics of complex social-economic systems. Use of these models to study organizational policies and design for higher order multiple-loop, nonlinear feedback structures. *3 sem. hrs.*

ELE 595. SPECIAL PROBLEMS IN ELECTRICAL ENGINEERING: Particular assignments to be arranged and approved by the chairman of the department. *2-6 sem. hrs.*

ELE 599. THESIS *3-6 sem. hrs.*

ELE 602. MAGNETIC EXCHANGE INTERACTION THEORIES: Molecular field theory of ferro-, ferri-, and antiferromagnets. Direct, indirect, and super-exchange interactions. Localized-ion vs. band-model theories. Complex magnetic spin structures. Emphasis on physical concepts rather than detailed mathematical development. Prerequisite: ELE 524 or consent of instructor. *2 sem. hrs.*

ELE 603. MAGNETIC ANISOTROPY AND MAGNETOSTRICTION: Mathematical description of magnetic anisotropy and magneto-elastic phenomena. Physical causes of magnetocrystalline anisotropy and magnetostriction. Relationship to theory of magnetic exchange. Prerequisite: ELE 524 or consent of instructor. *2 sem. hrs.*

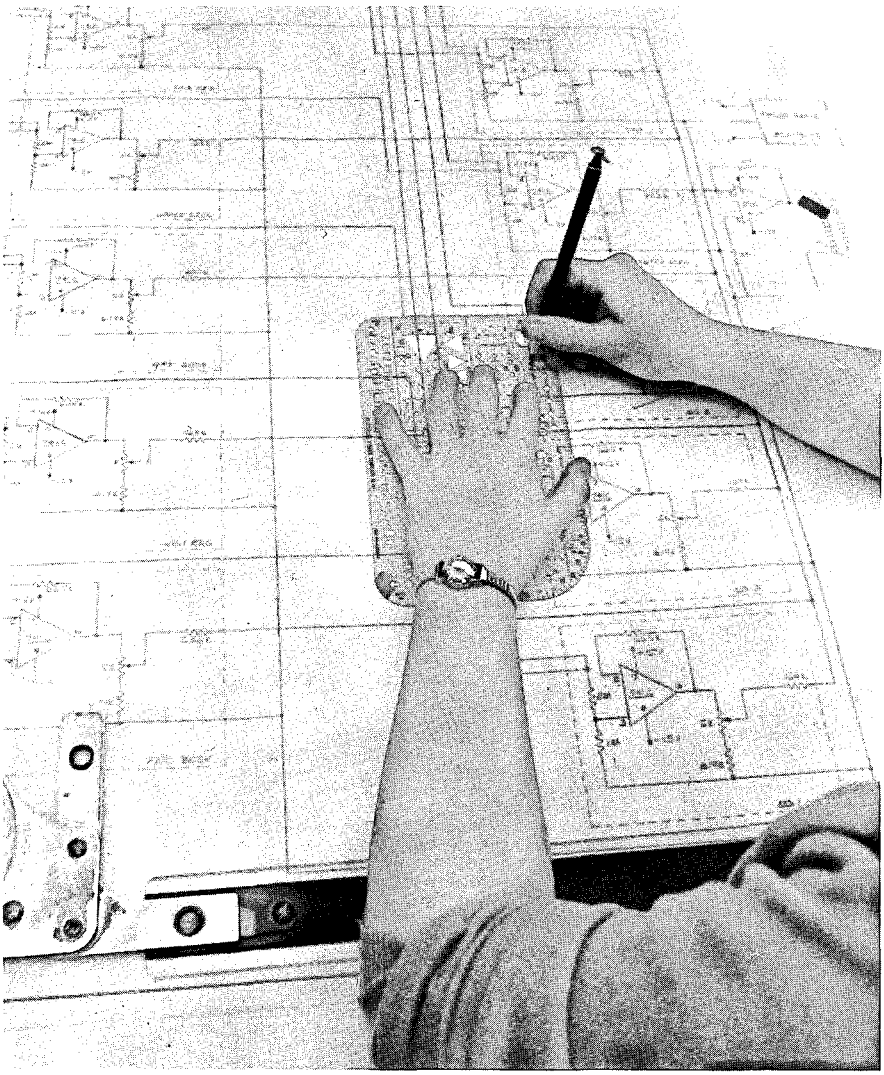
ELE 626. SYSTEM DYNAMICS II: The continuation of System Dynamics I with special emphasis on the study of large scale corporate, urban, educational, and ecological systems. Prerequisite: ELE 555. *3 sem. hrs.*

ELE 690. SELECTED READINGS IN ELECTRICAL ENGINEERING: Directed readings in electrical engineering areas to be arranged and approved by the chairman of the student's advisory committee and the department chairman. May be taken more than once. *1-3 sem. hrs.*

ELE 695. SPECIAL PROBLEMS IN ELECTRICAL ENGINEERING: Special electrical engineering topics not covered in regular courses. Course sections arranged and approved by chairman of the student's advisory committee and the department chairman. May be taken more than once. *1-3 sem. hrs.*

ELE 698. DE DISSERTATION: An original investigation as applied to engineering practice. Results must be of sufficient importance to merit publication. *1-15 hrs.*

ELE 699. PhD DISSERTATION: An original research effort in electrical engineering which makes a definite contribution to technical knowledge. Results must be of sufficient importance to merit publication. *1-15 sem. hrs.*



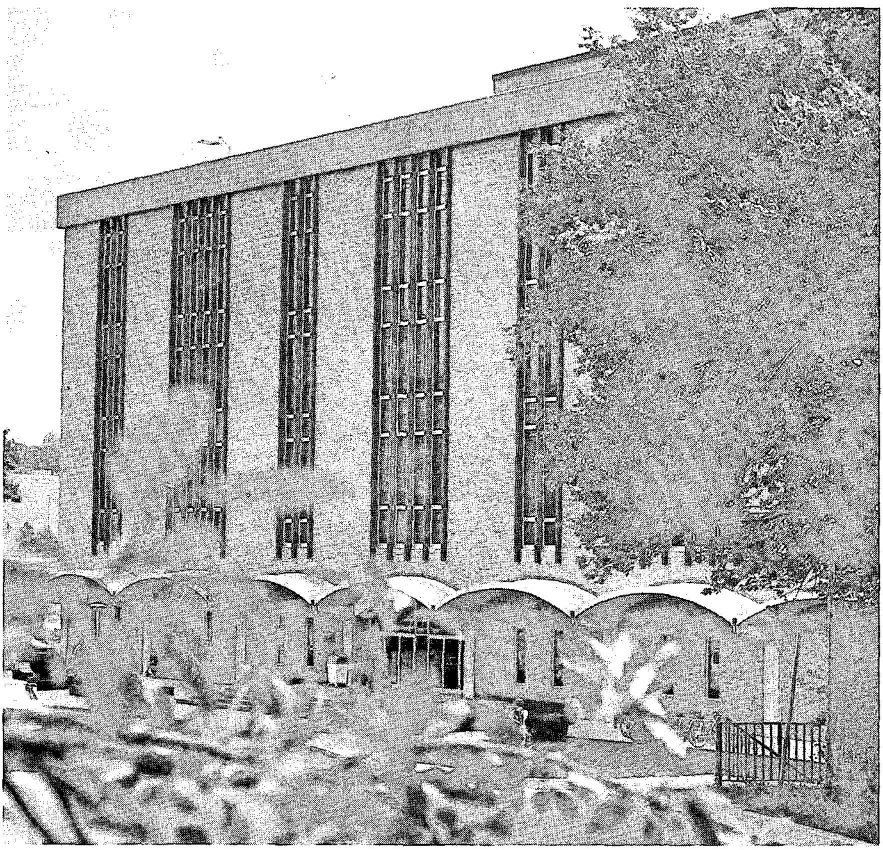
ENGINEERING (EGR)

Jay D. Pinson, Director of the Program

The Master of Science in Engineering allows flexibility for general or specialized program construction according to the needs of the individual student in conformance with the requirements of the School of Engineering and the University of Dayton. The program of study leading to the Master of Science in Engineering must include a minimum of 30 semester hours of the following:

1. Twelve semester hours in a major area.
2. Twelve semester hours of electives.
3. Six semester hours of research on an approved project.

See also Master's Degree Regulations in the introductory section of this chapter, and consult with the director of the Master of Engineering program.



ENGINEERING MANAGEMENT (ENM)

John R. Fraker, Director of the Program

The program of study leading to the Master of Science in Engineering Management is designed to prepare the practicing engineer for the management of engineering activities in any environment — industry, government, business, the military. It must include a minimum of 36 semester hours consisting of the following:

1. Eighteen to 21 semester hours of core courses in Engineering Management. These are ENM 505, 530, 535, 582, 585, 590, and MBA 587. (ENM 590 is a variable credit course requiring an engineering report of a project in engineering management.)
2. Nine semester hours of engineering electives. This requirement will normally be satisfied by nine semester hours of courses in the student's own field of engineering.
3. Six to nine hours of electives as approved by the advisor and the program director.

See also Master's Degree Regulations in the introductory section of this chapter, and consult with the advisor.

COURSES OF INSTRUCTION

ENM 505. MANAGEMENT OF ENGINEERING SYSTEMS: Introduction to the functions and tools of engineering management, the specific roles and relationships of engineering activities in the total enterprise; the techniques of systems analysis, engineering system design, and system optimization. *3 sem. hrs.*

ENM 506. ENGINEERING MANAGEMENT AND SOCIETY: Important governmental and societal dimensions affecting the design, fabrication, and production of engineering systems. *3 sem. hrs.*

ENM 530. COST AND ECONOMIC ANALYSIS FOR ENGINEERS: Principles and methods of economic analysis of engineering activities. The time value of money, short-and-long-term investments, comparison of alternatives, replacement analysis, and minimum cost models. *3 sem. hrs.*

ENM 535. ENGINEERING DECISION-MAKING: Introduction to rational decision-making with applications in the analysis and design of engineering systems. Decision-making under uncertainty and risk as well as under certainty. Corequisite: MTH 368 or equivalent. *3 sem. hrs.*

ENM 541. PRODUCTION ENGINEERING: The design of systems of men and machines for the production process: forecasting, scheduling, production and inventory control, staffing, plant layout, and equipment replacement. Prerequisite: MTH 368 or equivalent. *3 sem. hrs.*

ENM 551. POLICY ANALYSIS AND PLANNING IN PUBLIC SYSTEMS I: General introduction to qualitative and quantitative methodologies of policy analysis and planning in the public sector with special emphasis on project and program planning. *3 sem. hrs.*

ENM 552. POLICY ANALYSIS AND PLANNING IN PUBLIC SYSTEMS II: Continuation of ENM 551 with emphasis on complete analysis of large scale public systems. Prerequisite: ENM 551 or equivalent. *3 sem. hrs.*

ENM 553. PUBLIC SYSTEMS ENGINEERING: Guided study of the application of policy analysis and planning techniques for public systems. Emphasis on urban-regional improvement and world systems of energy and food. Prerequisite: ENM 551 or equivalent.
2-6 sem. hrs.

ENM 555. SYSTEM DYNAMICS I: The methodology for modeling the dynamics of complex social-economic systems. The use of these models to study organizational policies and design for higher order, multiple-loop, nonlinear feedback structures. *3 sem. hrs.*

ENM 556. SYSTEM DYNAMICS II: Continuation of ENM 555 with emphasis on the study of large scale corporate, urban, educational, and ecological systems. Prerequisite: ENM 555 or equivalent. *3 sem. hrs.*

ENM 560. ENGINEERING APPLICATIONS OF STATISTICS: Application of statistical principles of analysis and control to production processes, studies of process capabilities, quality control, work sampling, and engineering experimentation. Prerequisite: MTH 368 or equivalent. *3 sem. hrs.*

ENM 561. DESIGN AND ANALYSIS OF ENGINEERING EXPERIMENTS: Advanced topics in experimental design and analysis, including experimental designs, response surface analysis, evolutionary operations, multiple and partial regression and correlation. Prerequisite: MTH 368 or equivalent. *3 sem. hrs.*

ENM 565. RELIABILITY ENGINEERING I: Introduction to the concepts and methodology of reliability engineering. The reliability of components and multi-component systems, analysis and design of systems, and design and evaluation of processes for assuring the reliability, maintainability, and availability of systems. Prerequisite: MTH 368 or equivalent.
3 sem. hrs.

ENM 566. RELIABILITY ENGINEERINGII: Continuation of ENM 565. Advanced topics in reliability engineering, with emphasis on the design of systems to meet specified reliability, availability, and maintainability requirements. Prerequisite: ENM 565 or equivalent.
3 sem. hrs.

ENM 570. ENGINEERING OPTIMIZATION I: Introduction to the methodology of optimization with emphasis on application to engineering systems. Classical optimization, constrained optima, search techniques, steepest ascent techniques. The use of the digital computer is emphasized. 3 sem. hrs.

ENM 571. ENGINEERING OPTIMIZATION II: Introduction to the methodology of optimization with emphasis on application to engineering systems. Mathematical programming techniques, including linear, nonlinear, separable, quadratic, and dynamic programming. The use of the digital computer is emphasized. Note: ENM 570 is not a prerequisite. *3 sem. hrs.*

ENM 575. PROBABILISTIC PROCESSES: Introduction to the analysis and design of probabilistic systems. Queueing theory, Markov processes, simulation. Prerequisite: MTH 368 or equivalent. *3 sem. hrs.*

ENM 582. ORGANIZATIONAL DEVELOPMENT IN AN ENGINEERING ENVIRONMENT: The inter-personal and group skills needed by the engineering manager. Emphasis on establishing work environments which allow for communication, trust, high morale, satisfaction, and productive group activity. *3 sem. hrs.*

ENM 585. ORGANIZATIONAL SYSTEMS: Systems theory is used to integrate behavioral science knowledge of organizations. Special emphasis on research, engineering, and development activities. *3 sem. hrs.*

ENM 586. DESIGN OF ORGANIZATIONAL SYSTEMS: Guided study of the design of organizations. Emphasis on the implementation of actual design studies. Prerequisite: ENM 585. *3 sem. hrs.*

ENM 590. CASE STUDIES IN ENGINEERING MANAGEMENT: Student participation in an engineering management project or study under the direction of a project advisor. A satisfactory written engineering report, as determined by the project advisor, is required at the completion of the project. Prerequisite: permission of the advisor. *3-6 sem. hrs.*

ENM 595. SPECIAL PROBLEMS IN ENGINEERING MANAGEMENT: Special assignments in engineering management to be arranged and approved by the advisor and the program director. *2-6 sem. hrs.*

MATERIALS ENGINEERING (MAT)

Ronald A. Servais, Acting Director of the Program

Materials Engineering is a major concentration for both the Doctor of Engineering and the Doctor of Philosophy in Engineering. See Doctoral Degree Regulations in the introductory section of this chapter and consult with the director of the programs.

The program of study leading to the Master of Science in Materials Engineering must include a minimum of 30 semester hours consisting of the following:

1. Twelve semester hours in the major field.
2. Twelve semester hours of approved electives from current course offerings which best suit the student's requirements.
3. Six semester hours of research on a Materials Engineering project or thesis. Upon the request of the student and with the approval of the advisor and the program director, this may be replaced by six semester hours of additional course work.

See also Master's Degree Regulations in the introductory section of this chapter, and consult with the advisor.

COURSES OF INSTRUCTION

MAT 501. PRINCIPLES OF MATERIALS I: The electronic, atomic, submicroscopic, microscopic, and macroscopic structures of crystalline solids, including bonding, electron theory of metals, crystals, dislocations, phase diagrams, phase transformations, and diffusion. Prerequisite: MTH 219. *3 sem. hrs.*

MAT 502. PRINCIPLES OF MATERIALS II: A general introduction to the mechanical and electronic properties of materials. Elasticity; plasticity creep; fracture; electrical and thermal processes; magnetic, dielectric and optical properties. Prerequisite: MAT 501. *3 sem. hrs.*

MAT 503. X-RAY CRYSTALLOGRAPHY: Introduction to the fundamentals of crystallography and x-ray diffraction techniques with application to the study of materials. Two hours lecture and one three-hour laboratory per week. Prerequisite: MAT 501 or consent of instructor. *3 sem. hrs.*

MAT 504, TECHNIQUES IN MATERIALS ANALYSIS: Fundamentals and applications of the traditional analytical methods such as metallography, x-ray analysis, electron microprobe, transmission and scanning electron microscopy. Recent techniques: NMR, EPR, atomic absorption, Raman and Mossbauer spectroscopy, holography, ESCA and Anger spectroscopy. Emphasis on applicability. Prerequisite: MAT 501 or consent of instructor. *3 sem. hrs.*

MAT 505. THERMODYNAMICS OF SOLIDS: Thermodynamic properties of solutions and intermediate phases. Equilibrium behavior of phase mixtures. Representation of multicomponent phase diagram. Experimental determination and prediction of phase diagrams. Prerequisite: MAT 502 or consent of instructor. *3 sem. hrs.*

MAT 506. MECHANICAL BEHAVIOR OF MATERIALS: Description of the state of stress and strain in materials, plastic deformation, fatigue, fracture, creep, and rupture. Prerequisite: MAT 502 or consent of instructor. *3 sem. hrs.*

MAT 507. INTRODUCTION TO CERAMIC MATERIALS: Ceramic raw materials, manufacturing processes, and unique properties of ceramic products: glasses, porcelain enamels, ceramic-metal seals, electrical and magnetic ceramics, refractories, and ceramics for special applications. Prerequisite: MAT 501. *3 sem. hrs.*

MAT 508. PRINCIPLES OF MATERIALS SELECTION: Basic scientific and practical consideration involved in the intelligent selection of materials for specific applications. Impact of new developments in materials technology and analytical techniques. Prerequisite: MAT 501 or consent of instructor. *3 sem. hrs.*

MAT 509. INTRODUCTION TO POLYMER SCIENCE: Introduction to polymers. A largely nonmathematical survey of the field. Prerequisites: college chemistry and calculus. *3 sem. hrs.*

MAT 510. PHYSICAL PROPERTIES OF POLYMERS: Intensive discussion of the interrelations between molecular and gross physical properties of polymers. Prerequisites: MAT 509 or equivalent, background in differential equations. *3 sem. hrs.*

MAT 511. PRINCIPLES OF CORROSION: Application of electrochemical principles, corrosion reactions, passivation, cathodic and anodic protection, stress corrosion, and high temperature oxidation. *3 sem. hrs.*

MAT 512. MAGNETIC MATERIALS — PHYSICAL PRINCIPLES: Description of magnetic material properties. The magnetic circuit. Atomic magnetism. Types of magnetic order and spin structure. Intrinsic magnetization. Molecular field concept. Anisotropy. Magnetostriction. Magnetic resonances. Prerequisite: ELE 333 or consent of instructor. *3 sem. hrs.*

MAT 513. MAGNETIC MATERIALS FOR ENGINEERING APPLICATIONS: Magnetic domains. Technical magnetization and domain structure. A.C. properties, losses, eddy currents. Causes of coercivity. Metallic and ceramic materials for transformers, electrical machinery, permanent magnets, HF devices, data recording, computer memories. Metallurgy and crystallography of magnetic materials. Prerequisite: MAT 512 or consent of instructor. Note: Simultaneous attendance in MAT 513S is recommended. *3 sem. hrs.*

MAT 513S. MAGNETIC MATERIALS PROSEMINAR *1 sem. hr.*

MAT 514. APPLIED SUPERCONDICTIVITY — AN INTRODUCTION: Basic phenomena. Theorectical concepts. Superconductive materials — types, properties, physics, mettalurgy. Superconducting magnets. Other present and future engineering applications. Prerequisite: consent of instructor. *2 sem. hrs.*

MAT 515. STATISTICAL THERMODYNAMICS: Microscopic thermodynamics; kinetic theroy; viral theorem of Clausius; transport phenomena; Gibbs, Boltzman, Bose-Einstein, Fermi-Dirac statistics. Connection between statistical and thermodynamic qualities. Applications to perfect and real gases, liquids, crystalline solids, and thermal radiation. Information theory, irreversible thermodynamics. Prerequisites: MEE 301, MTH 219. *3 sem. hrs.*

MAT 550. MATERIALS ENGINEERING PROJECT: Student participation in a materials engineering project under the direction of a project advisor. The student prepares a satisfactory written report, as determined by the project advisor, and presents an open seminar on the subject of the project. *1-6 sem. hrs.*

MAT 590. SELECTED READINGS IN MATERIALS ENGINEERING: Directed readings in selected area of materials engineering arranged and approved by the student's advisor and the program director. *1-3 sem. hrs.*

MAT 595. SPECIAL PROBLEMS IN MATERIALS ENGINEERING: Special assignments arranged by the materials engineering faculty. *1-3 sem. hrs.*

MAT 599. THESIS *3-6 sem. hrs.*

MAT 601. SURFACE CHEMISTRY OF SOLIDS: The nature of solid surfaces and their importance to chemical and physical reactions at solid-gas, solid-liquid, and solid-solid interfaces. Prerequisites: MAT 501 and 502 or consent of instructor. *3 sem. hrs.*

MAT 602. MAGNETIC EXCHANGE INTERACTION THEORIES: Molecular field theory of ferro-, ferri-, and antiferromagnets. Direct, indirect, and super-exchange interactions. Localized-ion vs. band-model theories. Complex magnetic spin structures. Emphasis on physical concepts rather than detailed mathematical developments. Prerequisite: MAT 513 (ELE 524) or consent of instructor. *2 sem. hrs.*

MAT 603. MAGNETIC ANISOTROPY AND MAGNETOSTRICTION: Mathematical description of magnetic anisotropy and magneto-elastic phenomena. Physical causes of magneto-crystalline anisotropy and magnetostriction. Relationship to theory of magnetic exchange. Prerequisite: MAT 513 (ELE 524) or consent of instructor. *2 sem. hrs.*

MAT 690. SELECTED READINGS IN MATERIALS ENGINEERING: Directed readings in materials engineering area arranged and approved by the chairman of the student's advisory committee and the program director. May be repeated. *1-3 sem. hrs.*

MAT 695. SPECIAL PROBLEMS IN MATERIALS ENGINEERING: Special assignments in materials engineering subject matter arranged and approved by the student's doctoral advisory committee and the program director. May be repeated. *1-3 sem. hrs.*

MAT 698. DE DISSERTATION: An original investigation as applied to materials engineering practice. Results must be of sufficient importance to merit publication. *1-15 sem. hrs.*

MAT 699. PhD DISSERTATION: An original research effort which makes a definite contribution to technical knowledge. Results must be of sufficient importance to merit publication. *1-15 sem. hrs.*

MECHANICAL ENGINEERING (MEE)

Howard E. Smith, Chairperson of the Department

Mechanical Engineering is a major concentration for both the Doctor of Engineering and the Doctor of Philosophy in Engineering. See Doctoral Degree Regulations in the introductory section of this chapter and consult with the departmental chairman and the director of the programs.

For the Master of Science in Mechanical Engineering, major areas of concentration are Materials Engineering, Thermal Engineering, Energy Conversion, Fluid Mechanics, Solid Mechanics, and Mechanical Design. Each program of study leading to this master's degree must include a minimum of 30 semester hours consisting of the following:

1. Twelve to 15 semester hours in Mechanical Engineering courses to be selected from the following:
Materials Engineering — MEE 501, 502, 505, 506, 508, 509A.
Thermal Engineering — MEE 500, 511, 512, 513, 514, 515, 516, 517, 565, 566, 567, 590B, 595.
Energy Conversion — MEE 500, 511, 513, 514, 565, 567, 590B.
Fluid Mechanics — MEE 500, 503, 516, 551, 553, 590C, 595.
Solid Mechanics — MEE 500, 503, 533, 534, 535, 538, 539, 543, 544, 545, 546, 547, 548, 549, 590D, 595.
Mechanical Design — MEE 500, 503, 531, 532, 533, 534, 535, 536, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 590E, 595.
2. Six semester hours of MEE 550, Mechanical Engineering Project. Upon the request of the student and with the approval of the faculty advisor and the department chairman, the project may be replaced by six semester hours of additional course work.
3. Nine to 12 semester hours of electives, to be chosen from current course offerings which best suit the student's requirements. For the major area of Energy Conversion, 15 semester hours must be selected from paragraphs 1 and 2 above, and one of the following two courses must be selected: MEE 568, MEE 569.

See also Master's Degree Regulations in the introductory section of this chapter and consult with the advisor.

COURSES OF INSTRUCTION

Students who have completed work equivalent to the stated prerequisite courses may be enrolled in these courses with the consent of the instructor.

MEE 500. ADVANCED ENGINEERING ANALYSIS: Utilization of fundamental principles from mechanics and thermodynamics along with auxiliary laws from the various engineering disciplines for the analysis of practical problems from industry. Emphasis on the professional engineering approach which includes formulation of problem, assumptions, plan or method of attack, solving the problem, checking, and generalizing the results. *3 sem. hrs.*

MEE 501. PRINCIPLES OF MATERIAL I: The electronic, atomic, submicroscopic, microscopic, and macroscopic structures of crystalline solids. Bonding, electron theory of metals, crystals, dislocations, phase diagrams, phase transformations, and diffusion. Prerequisite: MTH 219. *3 sem. hrs.*

MEE 502. PRINCIPLES OF MATERIALS II: General introduction to the mechanical and electronic properties of materials. Elasticity; plasticity; creep; fracture; electrical and thermal processes; magnetic, dielectric, and optical properties. Prerequisite: MEE 501. *3 sem. hrs.*

MEE 503. INTRODUCTION TO CONTINUUM MECHANICS: Unified treatment of topics common to solid and fluid continua. Tensors, calculus of variations. Lagrangian and Eulerian descriptions of motion. General equations of continuum mechanics, constitutive equations of mechanics, thermodynamics of continua. Reduction of general equations to specialized forms used in follow-on courses in solid and fluid mechanics. Classical and numerical methods for solving continuum mechanics equations. *3 sem. hrs.*

MEE 505. THERMODYNAMICS OF SOLIDS: Thermodynamic properties of solutions and intermediate phases. Equilibrium behavior of phase mixtures. Representation of multi-component phase diagrams. Experimental determination and prediction of phase diagrams. Prerequisites: MEE 302, 502, or consent of instructor. *3 sem. hrs.*

MEE 506. MECHANICAL BEHAVIOR OF MATERIALS: Description of the state of stress and strain in materials, plastic deformation, fatigue, fracture, creep, and rupture. Prerequisite: MEE 502 or consent of instructor. *3 sem. hrs.*

MEE 508. PRINCIPLES OF MATERIALS SELECTION: Basic scientific and practical consideration involved in the intelligent selection of materials for specific applications. Impact of new developments in materials technology and analytical techniques. Prerequisite: MEE 501 or consent of instructor. 3 sem. hrs.

MEE 511. CLASSICAL THERMODYNAMICS: Equilibrium, first law, second law, state principle, and zeroth law; development of entropy and temperature from availability concepts; chemical potential, chemical equilibrium, and phase equilibrium. Thermodynamics of irreversible processes; Onsager reciprocal relations; application of these concepts to diffusion, electronic phenomena in solids, direct energy conversion, and biological problems. *3 sem. hrs.*

MEE 512. STATISTICAL THERMODYNAMICS: Microscopic thermodynamics; kinetic theory; virial theorem of Clausius; transport phenomena; Gibbs, Boltzmann, Bose-Einstein, Fermo-Dirac statistics. Connection between statistical and thermodynamic quantities. Applications to perfect and real gases, liquids, crystalline solids, and thermal radiation. Information theory, irreversible thermodynamics. Prerequisites: MEE 301, MTH 219. *3 sem. hrs.*

MEE 513. PROPULSION: Principles of propulsive devices, aerothermodynamics, diffuser and nozzle flow, energy transfer in turbo-machinery, turbojet, turbo-fan, prop-fan engines, turbo-prop and turboshaft engines, RAM and SCRAM jet analysis and a brief introduction to related materials and air frame-propulsion interaction. Prerequisite: MEE 418. *3 sem. hrs.*

MEE 514. DIRECT ENERGY CONVERSION: Introduction to the principles of direct energy conversion. Irreversible thermodynamics; semiconductors; thermoelectric and photo-voltaic devices; magnetohydrodynamics; electrofluid-dynamic energy conversion; fuel cells. Prerequisites: MEE 302, 303. *3 sem. hrs.*

MEE 515. CONDUCTION HEAT TRANSFER: Steady state and transient state conduction. Evaluation of temperature fields by formal mathematics, numerical analysis, and analogic experiments. *3 sem. hrs.*

MEE 516. CONVECTION HEAT AND MASS TRANSFER: Development of governing differential equations for convection. Methods of solution including similarity methods, integral methods, superposition of solutions, eigenvalue problems. Turbulent flow convection; integral methods, eddy diffusivities for heat and momentum. Extensions to mass transfer. Prerequisite: MEE 410. *3 sem. hrs.*

MEE 517. RADIATION HEAT TRANSFER: Fundamental relationships of radiation heat transfer. Radiation characteristics of surfaces. Geometric considerations in radiation exchange between surfaces. Emissivity and absorptivity of gases. Introduction to radiative exchange in gases. *3 sem. hrs.*

MEE 531. KINEMATIC SYNTHESIS OF MECHANISMS: Synthesis of mechanisms generating a predetermined motion. Introduction to spatial mechanisms. *3 sem. hrs.*

MEE 532. NOISE CONTROL: Physics of sound propagation. Physiological and legal aspects of sound. Measurement and analysis of sound and vibrations. Vibration and sound control techniques, source modifications, path modifications, receiver modifications. Acoustic considerations in machine design. *3 sem. hrs.*

MEE 533. THEORY OF ELASTICITY: Analysis of three-dimensional stress and strain at a point; equations of elasticity in orthogonal curvilinear coordinates and cartesian coordinates, including strain-displacement relations, force balance equations, stress-strain relations, and mechanical and imposed displacement boundary conditions; methods of formulation of equations for solution; plane stress and plane strain; torsion; energy formulations of elasticity problems; numerical solution procedures. Prerequisites: EGM 303, MTH 219. *3 sem. hrs.*

MEE 534. THEORY OF PLATES AND SHELLS: Theory of plates: small displacement-no shear deformation; small displacements-shear deformation; large displacement-small strains; buckling; sandwich plate theory. Thin shell theory: topics from the theory of surfaces; thin shell equations in orthogonal curvilinear coordinates; bending, membrane, and shallow shell theories; cylindrical, toroidal, and general shells of revolution; numerical integration applied to stress and vibration problems of shells of revolution. Prerequisite: MEE 533. *3 sem. hrs.*

MEE 535. MECHANICAL VIBRATIONS: Topics from dynamic theory; undamped free vibration of discrete and continuous systems; approximation of continuous eigenvalue problems with discrete eignevalue problems; modal analysis of damped and undamped, discrete and continuous systems; structural response to shock loading. Prerequisite: MEE 319. *3 sem. hrs.*

MEE 536. FEEDBACK CONTROL SYSTEMS: Study of automatic controls involving hydraulic, pneumatic, and mechanical systems; linear state space techniques; stability analysis; nonlinear system analysis and stability, describing functions, and the direct method of Liapunov. Prerequisite: MEE 435. *3 sem. hrs.*

MEE 538. STABILITY OF ELASTIC SYSTEMS: Static methods of stability prediction for elastic systems subjected to conservative forces. Dynamic methods when forces are nonconservative. Follower forces. Stability of flexible shafts, rotors, centrifuges. Aeroelasticity and wing flutter. Panel and membrane flutter in supersonic flow. *3 sem. hrs.*

MEE 539. THEORY OF PLASTICITY: Fundamentals of elasticity and plasticity, yield criteria, plastic stress-strain relations, theories of work hardening. Extremum principles. Application to problems of bending, torsion, plane stress, and plane strain. Slip line and limit analysis. Prerequisite: MEE 533. *3 sem. hrs.*

MEE 540. BEARINGS AND BEARING LUBRICATION: Theoretical aspects of lubrication; determination of pressure distribution in bearings from viscous flow theory; application of hydrodynamic and hydrostatic bearing theories to the design of bearings; high-speed bearing design problems; properties of lubricants; methods of testing. *3 sem. hrs.*

MEE 541. ELASTO-HYDRODYNAMIC LUBRICATION: Application of theory of elasticity to contact stresses; elasto-hydrodynamic theory with applications involving various contact geometry including bearings and gears. Experimental apparatus for measurements of film thickness, shape, and pressure distribution. Prerequisite: MEE 540. *3 sem. hrs.*

MEE 542. BOUNDARY LUBRICATION: Physical chemistry of lubricants and surfaces; mechanisms of wear; material requirements for sliding and rolling contact; solid lubricants; experimental analysis and techniques. *3 sem. hrs.*

MEE 543. FUNDAMENTALS OF ADVANCED STRUCTURAL MATERIALS: Introduction of anisotropic material and its complex behavior, comparison with isotropic material. Tools for analysis and design of aerospace structures with laminated composites. Classical laminated plate theory as a special case of the more general and complex anisotropic plate theory for practical application. *3 sem. hrs.*

MEE 544. DESIGN OF ADVANCED STRUCTURES: Structural design of aerospace subsystems and components. Analysis of composites and other advance structures for static and dynamic loads. Methods of optimization for performance and cost. Design criteria prediction for stresses, displacements, instabilities, fatigue fracture. *3 sem. hrs.*

MEE 545. COMPUTER AIDED DESIGN: Modeling of mechanical systems and structures, analysis by analytical and numerical methods, development of mechanical design criteria and principles of optimum design, selected topics in mechanical design and analysis, utilization of the digital computer as an aid in the design of mechanical elements. *3 sem. hrs.*

MEE 546. FINITE ELEMENT ANALYSIS I: The Ritz method; the generalized Ritz (Finite Element) method; fundamentals of the Finite Element Method; interpolation functions; derivation of finite elements for bars, beams, plates, shells; isoparametric solid finite elements; isoparametric shell finite elements; natural vibration; elastic stability. *3 sem. hrs.*

MEE 547. FINITE ELEMENT ANALYSIS II: Advanced topics in Finite Element Analysis such as: familiarization with large general purpose computer codes such as NASTRAN, SAPIV, and MARC-CDC; elastic-plastic analysis; large deflection; time-dependent dynamics; heat conduction; coding large finite element programs. Prerequisite: MEE 546. *3 sem. hrs.*

MEE 548. ENERGY METHODS IN SOLID MECHANICS: Development of fundamental energy principles; virtual displacements, strain energy, Castigliano's theorems, minimum potential energy principles. Applications to engineering problems; redundant structures, buckling, static and dynamic analysis. *3 sem. hrs.*

MEE 549. THEORY OF ELASTIC STABILITY: Introduction to stability theory; buckling of plates and shells; influence of initial imperfections; nonlinear analysis; numerical solutions methods. Prerequisite: MEE 534. *3 sem. hrs.*

MEE 550. MECHANICAL ENGINEERING PROJECT: Student participation in a departmental research, design, or development project under the direction of a project advisor. The student must show satisfactory progress as determined by the project advisor and present a written report at the conclusion of the project. *1-6 sem. hrs.*

MEE 551. VISCOUS FLOW: Fundamentals of viscous flow. Navier-Stokes and boundary layer equations. Exact and approximate solutions of these equations using modern computational procedures for both laminar and turbulent flows. Prerequisite: MEE 503. *3 sem. hrs.*

MEE 553. COMPRESSIBLE FLOW: Fundamental equations of compressible flow, introduction to flow in two and three dimensions. Two-dimensional supersonic flow, small perturbation theory, method of characteristics, oblique shock theory. Introduction to unsteady one-dimensional motion and shock tube theory. Method of surface singularities. Prerequisite: MEE 418. *3 sem. hrs.*

MEE 565. FUNDAMENTALS OF COMBUSTION: Heat of combustion and flame temperature calculations; rate of chemical reaction and Arrhenius relationship; theory of thermal explosions and the concept of ignition delay and critical mass; phenomena associated with hydrocarbon-air combustion; specific applications of combustion. *3 sem. hrs.*

MEE 566. COMBUSTION THEORY: Theory of detonation (Rankine-Hugoniot relationships) and flame propagation rates in pre-mixed gas systems; turbulent flames and the well-stirred reactor; theory of diffusion flames; fuel droplet combustion; steady burning of solid materials; ignition and flame spreading across solid materials. *3 sem. hrs.*

MEE 567. SOLAR HEATING ANALYSIS: Topics dealing with energy usage patterns; thermal insulation studies and energy conversion schemes; building heating load calculations; characteristics and measurement of solar radiation; analysis and testing of solar collectors; solar heating systems; economic trends of solar heating; heat pumps. Prerequisite: MEE 302. *3 sem. hrs.*

MEE 568. INTERNAL COMBUSTION ENGINES: A study of combustion and energy release processes. Applications to spark and compression ignition, thermal jet, rocket, and gas turbine engines. Special emphasis given to understanding of air pollution problems caused by internal combustion engines. Idealized and actual cycles are studied in preparation for laboratory testing of internal combustion engines. Prerequisite: MEE 301. *3 sem. hrs.*

MEE 569. HEATING AND AIR CONDITIONING: Topics dealing with thermal environments and methods of control. Included are psychometrics, solar radiation, heat transmission through solid boundaries, industrial and residential environments, air conditioning load calculations, systems design, refirgeration principles. Prerequisite: MEE 301. *3 sem. hrs.*

MEE 590. SELECTED READINGS: Directed readings in a designated area arranged and approved by the student's faculty advisor and the departmental chairman. May be repeated. (A) Materials Engineering, (B) Thermal Engineering, (C) Fluid Mechanics, (D) Solid Mechanics, (E) Mechanical Design. *1-3 sem. hrs. each*

MEE 595. SPECIAL PROBLEMS IN MECHANICAL ENGINEERING: Special assignments in mechanical engineering subject matter arranged and approved by the student's faculty advisor and the departmental chairman. *1-6 sem. hrs.*

MEE 690. SELECTED READINGS: Directed readings in a designated area arranged and approved by the student's doctoral advisory committee and the departmental chairman. May be repeated. (A) Materials Engineering, (B) Thermal Engineering, (C) Fluid Mechanics, (D) Solid Mechanics, (E) Mechanical Design. *1-3 sem. hrs. each*

MEE 695. SPECIAL PROBLEMS IN MECHANICAL ENGINEERING: Special assignments in mechanical engineering subject matter arranged and approved by the student's doctoral advisory committee and the department chairman. May be repeated. *1-6 sem. hrs.*

MEE 698. DE DISSERTATION: An original investigation as applied to mechanical engineering practice. Results must be of sufficient importance to merit publication. *1-15 sem. hrs.*

MEE 699. PhD DISSERTATION: An original research effort which makes a definite contribution to technical knowledge. Results must be of sufficient importance to merit publication. *1-15 sem. hrs.*