

College of Engineering

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Modern technological developments in engineering have brought about considerable change in the College of Engineering's curriculum at Wichita State University. The curriculum provides a vigorous, challenging experience through a broad spectrum of fundamental technical knowledge as well as courses in humanities, social sciences, communications, mathematics and physical sciences. This balance in the curriculum prepares students for professional positions in the scientific-industrial community after the bachelor's degree or allows them to continue in graduate studies for a more active participation in research and advanced study.

The College of Engineering is organized into four degree-granting departments: aerospace, electrical and computer, industrial and manufacturing, and mechanical.

The programs in engineering are offered in daytime and evening classes, and the courses are the same whether they are taught in the day or at night.

Degrees Offered Undergraduate

The Bachelor of Science degree programs in aerospace, computer, electrical, industrial, manufacturing and mechanical engineering are accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET).

Graduate

A Master of Science (MS) is offered in aerospace, electrical, industrial, and mechanical engineering. A Master of Engineering Management program is offered in the industrial and manufacturing engineering department. A Doctor of Philosophy (PhD) also is offered by each of the four departments of engineering.

Typical fields of specialization include aerodynamics, fluid mechanics, propulsion, structures, solid mechanics, composites, dynamics, and control; communication theory, signal processing, control theory, digital systems, energy, and power systems; thermodynamics, heat transfer, engineering materials, engineering design, kinematics; and operations research, management science, manufacturing processes, and human factors.

See the *Wichita State University Graduate Bulletin* for more information about the graduate programs.

Policies Admission

All entering students with a declared interest in engi-

neering will be admitted to the College of Engineering in program status. Engineering students must complete the following courses, each with a grade of C or better, within the first 24 hours: (a) English 101/100, English 102, and Communications 111, and (b) Mathematics 242, or their equivalents.

Transfer students must present an earned GPA of 2.000 or higher on a 4.000 scale for all prior college work in order to be fully admitted into the College of Engineering. Transfer students with a GPA of less than 2.000 may petition for probationary admission.

Probation

Students are placed on academic probation if any of the following grade point averages is less than 2.000 and if they have attempted at least 6 hours in that grade point average at Wichita State University: (1) cumulative grade point average of all college/university work, (2) WSU grade point average and (3) engineering major grade point average. Attempted hours are defined as all hours appearing on the transcript with a grade of A, B, C, D, F, W, Cr, NCr, I, S, or U. Academic probation is not removed until all grade point averages are at least 2.000. Transfer students admitted on probation must complete at least 12 semester hours of credit work at Wichita State before probation may be removed.

Students on academic probation may not enroll for more than 12 semester hours in a 16-week term, 6 semester hours in an eight-week term, or 3 hours in a four-week term. Exceptions to these limitations may be made on the recommendation of the student's department advisor with the approval of the student's department chairperson.

Academic Dismissal

Students on academic probation are subject to academic dismissal from the College of Engineering if they fail to attain a cumulative WSU grade point average of 2.000 in the next 12 hours attempted, or a cumulative major grade point average of 2.000 in the next 9 hours attempted in their major field, and the grade point average for the most recent semester or Summer Session is below 2.000.

Academic Advising and Enrollment

Students in the College of Engineering are invited to seek academic advice from their advisors or the department chairs any time during the school year. Engineering students are strongly urged to register early for courses during published registration dates to avoid closed classes. Late registration or adding engineering courses will be allowed only during the first week of a regular semester or the first three days of a Summer Session.

Students in the College of Engineering may not enroll in more than 20 hours per semester during the academic year. Summer Session enrollments are lim-

ited to a maximum of 5 hours for each four-week session or 10 hours during the eight-week session. Students who have completed at least 24 hours at WSU with a WSU grade point average of 3.000 or higher may petition their department chairperson for permission to enroll in excess hours.

Students who are employed full or part time should, in consultation with their academic advisor, reduce their enrollments to a level appropriate to their work load.

Only students admitted to the College of Engineering or the Graduate School will be allowed to enroll in engineering courses at the 300 level or above. Because there are legitimate reasons for qualified non engineering students to enroll in an engineering course at the 300 level or above, the academic dean will consider petitions for exceptions to the preceding statement.

Transfer Credit

Students wishing to receive transfer credits for engineering courses taken at other institutions prior to admission to WSU must submit transcripts and course descriptions and syllabi to the College of Engineering for evaluation. Courses considered for transfer credit must have a grade of C or better.

Degree-bound WSU students should speak with an advisor before enrolling in courses at another institution.

Graduation Requirements

All engineering students who are pursuing bachelor's degrees must meet three sets of course requirements for graduation: (A) WSU General Education requirements, (B) College of Engineering requirements, and (C) the Accreditation Board for Engineering and Technology (ABET) requirements. Guidelines for these are given below:

WSU General Education Requirements

(1) Communications skills courses: All WSU students must complete three courses in communication skills: English 101 or 100 (for non-native speakers), English 102, and Communication 111, each with a grade of C or better.

(2) Four Introductory courses in the disciplines, to include one course each in the divisions of Fine Arts, Humanities, and Social and Behavioral Sciences, and an additional course in a different discipline in either Humanities or Social and Behavioral Sciences

(3) Two additional courses that are not Introductory. One is to be a Further Study course in one of the disciplines in the division in which two Introductory courses are taken. The second additional course is to be an Issues and Perspectives course in a different division.

All WSU students also must complete courses in the division of Natural Science and Mathematics; however, because the engineering curriculum

requires 32-34 hours of mathematics and natural sciences, engineering students automatically satisfy the requirements in this division.

Refer to the section on the General Education Program in this *Catalog* for a description of the Introductory courses, Further Study courses, and Issues and Perspectives courses.

College of Engineering Requirements

(1) Effective fall 2001, PHIL385, Engineering Ethics, is a required course in Humanities under the General Education requirements described above.

(2) Mathematics and Natural Sciences: 32-34 hours of mathematics and natural sciences must be completed, as prescribed by each department.

(3) Core requirements (13 hours): AE 223, Statics (3 hrs.); ECE 282, Circuits I (4 hrs.); IEN 255, Engineering Economy (3 hrs.); and ME 398, Thermodynamics (3 hrs.). These are courses that all engineering students must complete, regardless of major.

(4) Department requirements: Each department has specific courses that must be completed. These courses and their prerequisites are in the departmental sections of the *Catalog* and are listed on the department check sheets.

(5) Technical electives: Additional courses required, but not specified, by the department. Each should be chosen in consultation with a department advisor.

ABET Requirements

ABET expects the curricular content of an engineering program to include the equivalent of at least three years of study in the areas of mathematics, basic sciences, humanities and social sciences, and engineering topics. The course work must include at least (1) one year of an appropriate combination of mathematics beyond trigonometry and basic sciences, (2) one-half year (17 hours) of humanities and social sciences, and (3) one and one-half years (51 hours) of engineering topics.

Studies in basic sciences must include both general chemistry and calculus-based general physics at appropriate levels, with at least a two-semester sequence of study in either area. The courses in humanities and social sciences must provide both breadth and depth and not be limited to a selection of unrelated introductory courses. Engineering topics include subjects in the engineering sciences and engineering design.

All engineering students follow about the same general curriculum for the first two years. All engineering programs of study are designed to meet ABET criteria as well as satisfy WSU general education requirements, and all courses should be selected with the assistance of a College of Engineering advisor. The recommended sequence of courses for engineering students in all departments is outlined later in this section. Each sequence has been planned so

that students can complete the program to meet all requirements in the minimum time.

As part of the institutional effort required to ensure continuous accreditation by ABET, students taking longer than five years to complete an undergraduate degree will be required to meet ABET engineering curricular criteria in effect at the time of their graduation.

Students must file an application for degree card in the engineering dean's office two semesters preceding their final semester.

Graduation grade point average requirements: The candidate for a degree must attain a 2.000 grade point average in each of the following categories:

(1) All college and university work attempted (cumulative grade point average)

(2) All work attempted at WSU (WSU grade point average)

(3) All work in the student's major.

Students are not allowed credit toward graduation for D grade work in excess of one-quarter of their total hours.

Cooperative Education Program

The College of Engineering offers a cooperative education program in conjunction with the University Cooperative Education Internship Program described in this *Catalog*.

The Co-op plan is a voluntary program in which the student works part-time (parallel program) or alternates paid preprofessional work periods with classroom periods during the junior and senior years. The two most typical plans are illustrated in the following table.

Year	3			4			5		
Semester	F	S	Su	F	S	Su	F	S	
Plan A	W	C	W	C	W	C	C	C	
Plan B	C	W	C	W	C	W	C	C	

C Indicates in college W Indicates at work

These plans make it possible for each industrial position to be filled by two students, one from Plan A and one from Plan B. Other plans can be developed in cooperation with the coordinator.

To be eligible for the Co-op program, a student must demonstrate by academic performance during the freshman year the potential to complete the degree program satisfactorily. Generally this means the earning of a grade point average of 2.500 or higher. Also the student's character and personality must be acceptable to the cooperating employer. Transfer students with the above qualifications should contact the cooperative education coordinator at the beginning of their first semester at WSU. To continue in the program, a student must maintain a satisfactory academic standing.

Students interested in participating in the program should contact the College of Engineering Co-op

coordinator who will provide the necessary application information. Upon acceptance into the program, the coordinator will assist the student in arranging interviews with cooperating industries.

Engineering—General Engineering (ENGR)

The following course explores general engineering topics.

Lower-Division Course

Engr. 101. An Introduction to Engineering (3). Assists engineering students in exploring engineering careers and opportunities. Provides information on academic and life skills essential to become a successful engineering student. Promotes connections to specific engineering majors and provides activities to assist and reinforce the decision to major in engineering. Recommended for all new engineering students. Offered fall and spring.

Aerospace Engineering (AE)

The educational objectives of the aerospace engineering program are to provide (a) an undergraduate education that will allow successful graduates to become engineers who are sufficiently trained in the principles of aerospace engineering to meet the needs of potential employers and to provide (b) the foundation for capable students to pursue graduate studies in aerospace engineering and related fields.

Aerospace engineering students participate in an academic program of study in technical areas such as aerodynamics, performance, propulsion, flight mechanics, and structures. After developing a background of skills in these technical areas, senior students complete a two course sequence in aerospace design.

The aerospace engineering curriculum also gives students the opportunity to develop a comprehensive foundation in mathematics, physics, general engineering, digital computations, written and oral communications, and humanities and social sciences.

Students have access to an excellent array of laboratory facilities including six wind tunnels, a water tunnel, a computer lab, a structural testing lab, and a composite structures lab. These facilities are among the finest found in academic institutions.

The aircraft industries in Wichita include The Boeing Company, Cessna Aircraft Company, Bombardier Learjet Corporation, and Raytheon Aircraft. The presence of these companies has a strong positive influence on WSU's aerospace engineering program.

Bachelor of Science Degree in Aerospace Engineering

Sequence of Courses

The undergraduate program requires the completion of 135 semester hours for graduation, minus advanced

placement credit. The suggested course of study for aerospace engineering students is given in the following table.

Model Program

Freshman

Course	Hrs.
ENGL 101 or 100 and 102, College English I and II...	6
CHEM 111, General Chemistry.....	5
MATH 242 and 243, Calculus I and II.....	10
PHYS 313 and 315, University Physics I and Lab.....	5
IEN 222, Engineering Graphics.....	3
AE 227, Engineering Digital Computation.....	3

Sophomore

Course	Hrs.
COMM 111, Public Speaking.....	3
MATH 344, Calculus III.....	3
MATH 555, Ordinary Differential Equations.....	3
PHYS 314, University Physics II.....	4
AE 223, Statics.....	3
AE 324, Fundamentals of Atmospheric Flight.....	3
AE 333, Mechanics of Materials.....	3
AE 373, Dynamics.....	3
ME 250, Materials Engineering.....	3
ME 398, Thermodynamics I.....	3
Humanities and fine arts or social and behavioral sciences electives**.....	3

Junior

Course	Hrs.
ME 521, Fluid Mechanics.....	3
AE 415, Introduction to Space Dynamics.....	3
AE 424, Aerodynamic Theory.....	4
AE 502, Aerospace Propulsion I.....	3
AE 514, Flight Mechanics and Controls.....	3
AE 525 and 625, Flight Structures I and II.....	6
IEN 255, Engineering Economy.....	3
Humanities and fine arts or social and behavioral sciences electives**.....	6
PHIL385, Engineering Ethics.....	3

Senior

Course	Hrs.
AE 512, Experimental Methods in Aerodynamics....	2
AE 607, Flight Control Systems.....	3
ECE 282, Circuits I.....	4
AE 528 and 628, Airspace Design I and II.....	8
Natural sciences elective*.....	3
Humanities and fine arts or social and behavioral sciences electives**.....	6
Technical electives.....	9

*To be chosen from a list of approved courses available from the college student records office.

**Refer to graduation requirements at the beginning of this section for details.

Lower-Division Courses

AE 115. Introduction to Astronautics (1). An introduction and overview of astronautics. Historical, technical, and

practical aspects of rocketry, space dynamics, spacecraft design, and the space environment. Intended for freshman and sophomore AE students who have not taken AE 324, however, it may be taken by students at any level in other engineering departments or colleges.

AE 124. Introduction to Aeronautics (2). An introduction and overview of aeronautics. Historical and modern case studies are used to survey the aerodynamic, structural, stability, and propulsive aspects of atmospheric flight vehicles. Intended for freshman and sophomore AE students who have not taken AE 324, however, it may be taken by students at any level in other engineering departments or colleges.

AE 223. Statics (3). The study of the condition of equilibrium of rigid bodies under the action of forces. Rigid bodies include beams, trusses, frames, and machines. Considers both two- and three-dimensional bodies. Also includes the study of centroids, centers of gravity, and moments of inertia. Co-requisites: MATH 243 and PHYS 313.

AE 227. Engineering Digital Computation (3). FORTRAN programming and utilization of Digital Computing Center facilities; introduction to linear algebra and matrix methods for engineers, selected numerical methods for approximating functions, solution of systems of equations, numerical integration, and numerical determination of the roots of polynomials. Co-requisite: MATH 243.

AE 281A. Co-op Education (1). Introduces the student to engineering practice by working in industry in an engineering-related job and provides a planned professional experience designed to complement and enhance the student's academic program. Individualized programs must be formulated in consultation with, and approved by, appropriate faculty sponsors and cooperative education coordinators. Intended for students who will be working full time on their Co-op assignment and need not be enrolled in any other course. May be repeated. Offered Cr/Ncr only. Prerequisites: 30 hours toward a Bachelor of Science degree in aerospace engineering and approval by appropriate faculty sponsor.

AE 281P. Co-op Education (1). Introduces the student to engineering practice by working in industry in an engineering-related job and provides a planned professional experience designed to complement and enhance the student's academic program. Individualized programs must be formulated in consultation with, and approved by, appropriate faculty sponsors and cooperative education coordinators. Students must enroll concurrently in a minimum of 6 hours of course work including this course in addition to a minimum of 20 hours per week at their Co-op assignment. Prerequisites: successful completion of 20 hours toward an engineering degree and approval by appropriate faculty sponsor. May be repeated. Graded Cr/Ncr.

Upper-Division Courses

AE 324. Fundamentals of Atmospheric Flight (3). The study of the atmosphere, aircraft, and aerodynamic nomenclature. Introduction to aerodynamic theory, airfoils, wings,

aircraft performance, stability and control, and propulsion. Prerequisite: AE 223. Co-requisite: AE 227.

AE 333. Mechanics of Materials (3). The study of mechanical properties of materials, transformation of stresses and strains, stresses and deformations in structural elements of various shapes and loading, statically indeterminate structures, and buckling. Prerequisite: AE 223. Co-requisite: MATH 344.

AE 373. Dynamics (3). A study of the kinematics and kinetics of particles and rigid bodies. Includes force-mass-acceleration, work-energy, and impulse-momentum methods. Prerequisites: AE 223 and MATH 344.

AE 415. Introduction to Space Dynamics (3). Fundamentals of orbital mechanics and rigid body dynamics; two-body problems; orbital maneuvers and orbital determination; rigid body kinematics and kinetics. Prerequisites: AE 227 and 373; co-requisite: MATH 555.

AE 424. Aerodynamic Theory (4). A study of the dynamics of compressible and incompressible flow, two- and three-dimensional airfoil theory, viscous flow, and drag; an introduction to performance. Prerequisites: MATH 555, AE 324 and 373. Co-requisite: ME 521.

AE 460. Selected Topics (1-3). New or special topics presented on sufficient demand. Repeatable for credit when subject material warrants. Prerequisite: instructor's consent.

AE 481A. Co-op Education (1). See AE 281A. Graded Cr/Ncr unless student has received permission before enrolling for course to be used as a technical elective. Prerequisites: junior standing and approval by the appropriate faculty sponsor. May be repeated.

AE 481P. Co-op Education (1). See AE 281P. Graded Cr/Ncr unless student has received permission before enrolling for course to be used as a technical elective. Prerequisites: junior standing and approval by the appropriate faculty sponsor. May be repeated.

Courses for Graduate/Undergraduate Credit

AE 502. Aerospace Propulsion I (3). Survey of aerospace propulsion methods. Production of thrust and consumption of fuel. Rocket performance analysis; liquid chemical and solid propellant rocket engines. Jet engine cycle analysis; turbojet, ramjet, turbofan, and turboprop engines. Analysis of piston engines and propellers. Prerequisites: AE 227 and 373, ME 398. Co-requisite: AE 424 or ME 521.

AE 508. Systems Dynamics (3). Lumped parameter modeling; classical, numerical, transform, and state model methods of solution; introduction to systems with feedback; analogies of various physical systems. Prerequisites: AE 373 and MATH 555.

AE 512. Experimental Methods in Aerodynamics (2). A study of experimental methods and test planning,

error analysis and propagation, model design, instrumentation and flow visualization. Uses subsonic and supersonic wind tunnels. Prerequisite: AE 424.

AE 514. Flight Dynamics and Control (3). Static stability and control of conventional aircraft and implications in aircraft design, six degrees of freedom time dependent equations of motion and their linearized solutions. Consideration of stability versus maneuverability and the dynamic modes of motion of the aircraft. Prerequisite: AE 415. Co-requisite: AE 424.

AE 525. Flight Structures I (3). Stress analysis of flight vehicle components. Prerequisite: AE 333. Co-requisite: MATH 555.

AE 527. Numerical Methods in Engineering (3). Error analysis. Includes polynomial approximations and power series, iterative solutions of equations, matrices and systems of linear equations, numerical differentiation and integration, approximate solution of differential equations by finite differences. Prerequisites: AE 227. Co-requisite: MATH 555.

AE 528. Aerospace Design I (4). 2R; 2L. Methodology of flight vehicle design; mission objectives, regulations, and standards; use of hand and computer methods for configuration development and component sizing; ethics; and liability in design. Prerequisites: AE 502, 514, and 525.

AE 607. Flight Control Systems (3). Classical design methods for stability and control augmentation and guidance systems, specifically for aerospace vehicles, including block diagrams, root locus, and frequency response. Sensors used in aerospace systems. Flying qualities and performance specifications for closed loop systems. Includes a review of the aircraft and spacecraft dynamic model derivation. Prerequisite: AE 514.

AE 625. Flight Structures II (3). Strength analysis and design of flight vehicle components. Introduction to energy methods and variational principles. Application of finite element method to the analysis of flight vehicle structures. Special projects in structural analysis and design. Prerequisite: AE 525.

AE 628. Aerospace Design II (4). 2R; 2L. Preliminary design of flight vehicles, design iteration, sensitivity studies, optimization, economic considerations, and introduction to project management. Prerequisite: AE 528.

AE 653. Basic Composite Material Technologies (3). Introduces basic composite material technologies including mechanical behavior, material classification, testing for mechanical properties, manufacturing methods, nondestructive inspection, and design. Prerequisite: AE 333.

AE 654. Manufacturing Composite Structures (1-2). Manufacturing methods and tooling for fiber-reinforced polymer structures and structural components. Prerequisites: both ME 250 and AE 653 are recommended.

AE 660. Selected Topics (1-3). New or special topics presented on sufficient demand. Repeatable for credit when subject material warrants. Prerequisite: instructor's consent.

AE 690. Independent Study (1-3). Arranged individual independent study in specialized areas of aerospace engineering under the supervision of a faculty member. Repeatable for credit. Prerequisite: consent of supervising faculty member.

AE 702. Aerospace Propulsion II (3). In-depth study of rocket and jet propulsion. Turbojet and rocket engine components. Effect of operating variables on turbojet cycles and rocket performance. Prerequisite: AE 502 or instructor's consent.

AE 703. Rotor Aerodynamics (3). Aerodynamics of rotors, including propellers, wind turbines and helicopters; momentum, blade element, and potential flow analysis methods; helicopter dynamics, control, and performance. Prerequisite: AE 424.

AE 707. Modern Flight Control System Design I (3). Modern multi-loop design methods for stability and control augmentation and guidance systems, specifically for aerospace vehicles. State variable model. Optimal state feedback gains and Riccati's equation, tracking systems, sensors and actuators, discretization of continuous dynamic systems, optimal design for digital controls, and effect of non-linearities and trim conditions on design considerations. Prerequisite: AE 514 or AE 714, and AE 607 or ECE 684 or ME 659.

AE 711. Intermediate Aerodynamics (3). A study of potential flow equations of motion, singularity solutions, principle of superposition, conformal mapping, thin airfoil theory, finite wing theory, effects of fluid inertia, three-dimensional singularities, swept wing theory, delta wing theory, introduction to panel methods, and an introduction to automobile aerodynamics. Prerequisite: AE 424 or ME 521.

AE 712. Advanced Aerodynamics Laboratory (3). 1R; 3L. Advanced topics in wind tunnel testing including analysis and sensitivity, modeling techniques, flexure design and calibration, control surface loads and moments, laser velocimetry, hot film anemometry, dynamic signal processing, flow measurement probes, flow visualization using smoke tunnels and water tunnel. Prerequisite: AE 512 or instructor's consent.

AE 713. Introduction to Aeroelasticity (3). Studies phenomena involving interactions among aerodynamic, inertial, and elastic forces. Explores influence of these interactions on aircraft design. Includes such specific cases as divergence, control effectiveness, control reversal, flutter, buffeting, dynamic response to rapidly applied periodic forces, aeroelastic effects on load distribution, and static and dynamic stability. Prerequisites: AE 333, 424 or equivalent.

AE 714. Advanced Flight Dynamics I (3). Review of the equations of motion for aircraft. Nonlinear effects and aircraft response. Stability and control of elastic aircraft. Response to turbulence. Prerequisite: AE 514 or instructor's consent.

AE 715. Intermediate Space Dynamics (3). Advanced topics in orbital mechanics—vector mechanics perspective of the two-body problem, interplanetary missions including gravity assist maneuver, rocket performance, ballistic trajectories, atmospheric entry, and space environment. Prerequisite: AE 373.

AE 716. Compressible Fluid Flow (3). Analysis of compressible fluid flow for one- and two-dimensional cases, moving shock waves, one-dimensional flow with friction and heat addition, linearized potential equation, method of characteristics, conical shocks, and subsonic similarity laws. Prerequisites: AE 424, ME 521 or equivalent.

AE 719. Introduction to Computational Fluid Dynamics (3). Classification of partial differential equations, numerical solution of parabolic, elliptic, and hyperbolic differential equations, stability analysis, boundary conditions, scalar representation of the Navier-Stokes equations, incompressible Navier-Stokes equations. Prerequisite: AE 424 or ME 521.

AE 722. Finite Element Analysis of Structures I (3). Advanced treatment of the theoretical concepts and principles necessary for the application of the finite element method in the solution of differential equations in engineering. Prerequisite: AE 625 or equivalent or instructor's consent.

AE 731. Theory of Elasticity (3). Develops the equations of the theory of elasticity and uses them to determine stress and displacement fields in linear elastic isotropic bodies; uses Airy stress functions to obtain solutions; and introduces energy principles and variational methods. Prerequisite: instructor's consent.

AE 733. Advanced Mechanics of Materials (3). An extension of AE 333. Includes transformation of stress and strain in three dimensions, non-circular torsional members, curved beams, beams with un-symmetric cross sections, energy methods and the finite element method of analysis, stress concentration, theories of failure and fracture mechanics. Prerequisite: AE 333.

AE 737. Mechanics of Damage Tolerance (3). An introduction to the mechanics of damage tolerance emphasizing stress analysis-oriented fracture mechanics. Includes stress intensity, fracture toughness, residual strength, fatigue crack growth rate, fatigue crack propagation, and damage tolerance concepts. Prerequisite: AE 525 or instructor's consent.

AE 759. Neural Networks for System Modeling and Control (3). Introduces specific Neural Network architectures used for dynamic system modeling and intelligent control. Includes theory of feed-forward, recurrent, and Hop-

field networks; applications in robotics, aircraft and vehicle guidance, chemical processes, and optimal control. Prerequisites: AE 607 or ME 659 or ECE 684 or instructor's consent.

AE 760. Selected Topics (1-3). Prerequisite: instructor's consent.

AE 773. Intermediate Dynamics (3). An extension of AE 373. Studies the kinematics and kinetics of particles and rigid bodies for two- and three-dimensional motion. Includes an introduction to vibratory motion, dynamic stability of linear systems, and Lagrange's equations. Prerequisite: AE 373.

AE 777. Vibration Analysis (3). A study of free, forced, damped, and undamped vibrations for one and two degrees of freedom, as well as classical, numerical, and energy solutions of multi-degree freedom systems. Introduces continuous systems. Prerequisites: MATH 555, AE 373 and 333.

Courses for Graduate Students Only

AE 801. Structural Dynamics (3). A study of the dynamic response of multiple degree of freedom systems and continuous systems subjected to external dynamic forcing functions. Classical, numerical, and energy solutions. Prerequisite: AE 777.

AE 807. Modern Flight Control Systems Design II (3). Continuation of AE 707, emphasizing the effects of atmospheric turbulence and corrupted measurements; state estimation using the Kalman filter; output feedback design methods for flight controls; robustness requirements in the design; and extension to digital systems. Prerequisites: AE 707 and 714.

AE 811. Panel Methods in Aerodynamics (3). An introduction to panel method theory and application for inviscid incompressible attached flows. Utilization of some two- and three-dimensional computer codes. Prerequisites: AE 711 and MATH 757 or equivalent.

AE 812. Aerodynamics of Viscous Fluids (3). Viscous fluids flow theory and boundary layers. Prerequisite: AE 424 or ME 521.

AE 814. Advanced Flight Dynamics II (3). Sensitivity analyses of flight parameters, control surface sizing, handling qualities; pilot in-the-loop analysis; trajectory optimization. Prerequisite: AE 714.

AE 817. Transonic Aerodynamics (3). Experimental and analytical difficulties in flow and flight near Mach one; basic equations and solution methods: linearized potential equation; shock occurrence criteria on wings; Transonic Area Rule; nozzle throat design; detached shock wave computations; computational methods. Prerequisites: AE 424 or equivalent; and AE 711 or 716.

AE 818. Hypersonic Aerodynamics (3). Classical hypersonic theory and approximations; Newtonian flow; flight

corridors and trajectories; hot gas effects; experimental difficulties; short time test facilities; computational techniques; propulsion methods; airframe-engine integration; SCRam jets. Prerequisites: AE 711 and 716 or equivalent.

AE 822. Finite Element Analysis of Structures II (3). Formulation of the finite element equations by variational methods; the use of isoparametric and higher order elements for analyzing two- and three-dimensional problems in solid mechanics; introduction to solutions of nonlinear problems. Prerequisites: AE 722 and 731.

AE 831. Continuum Mechanics (3). Introductory treatment of the fundamental, unifying concepts of the mechanics of continua with applications to classical solid and fluid mechanics. Prerequisite: consent of the instructor.

AE 832. Theory of Plates and Shells (3). Small deflections of thin elastic plates; classical solutions for rectangular and circular plates; approximate solutions for plates of various shapes; introduction to the analysis of thin shells. Prerequisite: AE 731.

AE 833. Theory of Elastic Stability (3). Buckling of columns, frames, beams, plates, and shells. Prerequisite: AE 731.

AE 837. Advanced Mechanics of Damage Tolerance (3). An extension of AE 737. Includes mathematical foundations of linear elastic and non-linear fracture mechanics, computational fracture mechanics, and mechanics of distributed cracking. Prerequisite: AE 731, 737, or instructor's consent.

AE 853. Advanced Mechanics of Laminated Composites (3). An extension of AE 653. Includes anisotropic elasticity, classical laminate theory, failure theories, lateral deflections, elastic stability, large deformation theory, and energy methods. Prerequisites: AE 653 and 731.

AE 860. Selected Topics (1-3). Prerequisite: instructor's consent.

AE 876. MS Thesis (1-6). Graded *S/U* only.

AE 878. MS Directed Project (1-3). A project conducted under the supervision of an academic advisor for the directed project option. Requires a written report and an oral presentation on the project. Graded *S/U* only. Prerequisite: consent of academic advisor.

AE 890. Independent Study (1-3). Arranged individual independent study in specialized areas of aerospace engineering under the supervision of a faculty member. Repeatable for credit. Prerequisite: consent of supervising faculty member.

AE 911. Airfoil Design (3). Historical development of airfoils, underlying theories and experiments; modern airfoil design philosophies and techniques; theories used in modern airfoil computation methods; application of computer programs for practical airfoil design problems including high lift and control devices. Prerequisites: AE 711, MATH 757.

AE 913. Aerodynamics of Aeroelasticity (3). A study of thin airfoils and finite wings in steady flow and thin airfoils oscillating in incompressible flow. Includes extension to compressible and three-dimensional airfoils and modern methods for low aspect ratio lining surfaces. Prerequisites: AE 711 and 777 or instructor's consent.

AE 919. Advanced Computational Fluid Dynamics (3). A study of structured grid generation schemes, transformation of the governing equations of fluid motion, numerical algorithms for the solution of Euler equations, parabolized Navier-Stokes equations, and Navier-Stokes equations. Explore the fundamentals of unstructured grids and finite volume schemes. Prerequisite: AE 719 or ME 858.

AE 936. Theory of Plasticity (3). Includes criteria of yielding, plastic stress-strain relationships, and stress and deformation in thick-walled shells, rotating discs and cylinders, bending and torsion of prismatic bars for ideally plastic and strain-hardening materials. Includes two-dimension and axially symmetric problems of finite deformation and variational and extremum principles. Prerequisite: AE 731.

AE 960. Advanced Selected Topics (1-3). Prerequisite: instructor's consent.

AE 976. PhD Dissertation (1-16). Graded *S/U* only. Repeatable for credit. Prerequisite: admission to doctoral aspirant status.

AE 990. Advanced Independent Studies (1-3). Prerequisite: instructor's consent.

Electrical and Computer Engineering (ECE)

Students in the electrical and computer engineering (ECE) department have two degree programs from which to choose, electrical engineering or computer engineering.

The objectives of the electrical engineering program are 1) to enable students to enter the electrical engineering field by providing them with the fundamental knowledge necessary for the practice of electrical engineering, including scientific principles, rigorous analysis, and creative design to meet the requirements of employer constituents; and 2) to provide an undergraduate education that will enable qualified students to pursue graduate studies in electrical engineering and related fields.

The objectives of the computer engineering program are 1) to enable students to enter the computer engineering field by providing them with the fundamental knowledge for the practice of computer engineering in the areas of computer system design and computer networking, including scientific principles, rigorous analysis, and creative design to meet the requirements of employer constituents; and 2) to provide an undergraduate education that will enable qualified students to pursue graduate studies in computer engineering and related fields.

Both programs require a total of 128 credit hours minus hours from advanced placement credit. The

programs have a minimum of 93 credit hours in common. The common hours are made up of communications skills (9 hours), math and science courses (29 hours), general education courses (18 hours), and the courses covering the fundamentals common to each of the degree programs at WSU (13 hours). The remaining common courses are computer software and digital design courses and courses stressing the laws governing the individual behavior of electrical systems as well as their behavior when included as parts of more complex electrical systems (24 hours). The programs are structured to assure that electrical engineering students are familiar with computers and computer hardware and computer engineers have a strong background in electrical engineering principles.

Electrical and computer engineering students should have a strong interest in mathematics and science. As part of the curriculum, senior-level students are required to take a two-semester senior project sequence. This project gives the students the opportunity to apply skills acquired during their course work to "real world" problems.

The electrical engineering degree has a sufficient number of technical electives to allow the student to develop skills in specialized areas such as communications and signal processing, control systems, electric power systems, electronics, and digital systems.

The computer engineering degree is a more specialized degree with more required courses and fewer electives.

Specific requirements and a suggested academic year breakdown for the electrical and computer engineering programs are given below.

Model Program—Electrical Engineering

Freshman	
Course	Hrs.
ENGL101/100 and 102, College English I and II.....	6
MATH 242 and 243, Calculus I and II.....	10
ECE 194, Introduction to Digital Design.....	4
COMM 111, Public Speaking.....	3
ECE 282, Circuits I.....	4
ECE 229, Engineering Computing in C.....	3
General education courses*.....	3

Sophomore	
Course	Hrs.
MATH 555, Differential Equations I.....	3
PHYS 313 and 314, University Physics I and II.....	8
ECE 284, Circuits II.....	3
ECE 383, Signals and Systems.....	3
ME 398, Thermodynamics I.....	3
AE 223, Statics.....	3
IEN 254, Engineering Probability and Statistics I.....	3
PHIL385, Engineering Ethics.....	3

Junior	
Course	Hrs.
ECE 684, Introductory Control System Concepts.....	7
ECE 492, Electronic Circuits I.....	3
ECE 493, Electronic Circuits II or ECE 688, Power Electronics.....	4

IEN 255, Engineering Economy.....	3
MATH 344, Calculus III.....	3
General education courses*.....	6
CHEM 111, General Chemistry.....	5
Technical electives**.....	6

Senior	
Course	Hrs.
ECE 585 and 595, Electrical Design Project I and II	4
ECE 363, Electromagnetic Field Theory.....	3
ECE 410, Distributed Parameter Circuits.....	3
ECE 488, Electric Machines and Transformers.....	4
ECE 586, Introduction to Communication Systems	3
Technical electives**.....	16
General education courses*.....	6

* Refer to graduation requirements at the beginning of this section for details.

** Must be chosen with advisor's approval from a departmentally approved list.

Model Program—Computer Engineering

Freshman	
Course	Hrs.
COMM 111, Public Speaking.....	3
ENGL101/100 and 102, College English I and II.....	6
MATH 242 and 243, Calculus I and II.....	10
ECE 194, Introduction to Digital Design.....	4
ECE 282, Circuits I.....	4
ECE 229, Engineering Computing in C.....	3
General education courses*.....	3

Sophomore	
Course	Hrs.
MATH 555, Differential Equations I.....	3
ECE 284, Circuits II.....	3
ECE 238, Assembly Language Programming for Engineers.....	3
ECE 294, Digital Design Techniques.....	3
PHYS 313 and 314, University Physics I and II.....	8
General education courses*.....	6
ECE 394, Introduction to Computer Architecture.....	3
AE 223, Statics.....	3

Junior	
Course	Hrs.
IEN 254, Engineering Probability and Statistics I.....	3
ECE 383, Signals and Systems.....	3
ME 398, Thermodynamics I.....	3
ECE 492 and 493, Electronic Circuits I and II.....	7
CS 300, Data Structures and Algorithms.....	4
ECE 477I, Unix.....	3
CHEM 111, General Chemistry.....	5
PHIL385, Engineering Ethics.....	3

Senior	
Course	Hrs.
IEN 255, Engineering Economy.....	3
ECE 594, Microprocessor-Based System Design.....	4
ECE 585 and 595, Electrical Design Project I and II	4
CS 540, Operating Systems.....	3

General education courses*.....	6
Technical electives***.....	12

* Refer to graduation requirements at the beginning of this section for details.

** Must be chosen with advisor's approval from a departmentally approved list.

Lower-Division Courses

ECE 101. Introduction to Electrical Engineering (1). Gives those students also enrolled in ENGR 101 the opportunity for a hands-on experience in each of the areas of specialization in electrical engineering: digital design, power, communications, and control.

ECE 194. Introduction to Digital Design (4). 3R; 3L. An introduction to digital design concepts. Includes number systems, Boolean algebra, Karnaugh maps, combinational circuit design, adders, multiplexers, decoders, sequential circuit design, state diagram, flip flops, sequence detectors, and test different combinational and dequential circuits. Uses CAD tools for circuit simulation. Prerequisite: MATH 111 or equivalent.

ECE 229. Engineering Computing in C (3). Introductory course in digital computer programming using C with applications to elementary engineering problems. Stresses both C syntax rules and problem solving approaches. Laboratory exercises given for programming on personal computers. Prerequisite: MATH 111 or 112 or equivalent.

ECE 238. Assembly Language Programming for Engineers (3). An introduction to basic concepts of computer organization and operation. Studies machine and assembly language programming concepts that illustrate basic principles and techniques. Laboratory exercises given for experience using personal computers. Prerequisite: ECE 229.

ECE 282. Circuits I (4). 3R; 3L. Electric circuit principles and methods of analysis. Includes d.c. circuits, network theorems, capacitance and inductance, a.c. circuit analysis, phasor plane techniques, complex power, and balanced three-phase circuits. Prerequisite: MATH 242.

ECE 284. Circuits II (3). Includes circuits with mutually coupled elements, transfer functions emphasizing frequency response, two-port networks, Laplace transforms and application to transient circuit analysis, and the application of computer-aided analysis software toward circuit analysis and design. Prerequisites: ECE 282 and MATH 243.

ECE 294. Digital Design Techniques (3). Digital design techniques include registers and register transfer language, RTL state design; memory, memory interfacing, and micro-programming; programmable logic devices, different types of PLDs, combinational and sequential circuit design using PLDs; ABEL programming; PLD-based design using ABEL; CMOS family; TTL to CMOS and CMOS to TTL interfacing. Uses CAD tools for circuit simulation. Prerequisite: ECE 194.

Upper-Division Courses

ECE 363. Electromagnetic Field Theory (3). A vector development of electric and magnetic fields, including experimental laws, polarization phenomena, and Maxwell's equations. Prerequisites: ECE 282, MATH 344 and 555.

ECE 383. Signals and Systems (3). Properties of signals and systems, convolution and its application to system response, Fourier series representation of periodic signals, Fourier transforms and continuous spectra, filters, time domain sampling, and Z-transforms. Many of these topics involve discrete as well as continuous systems. Prerequisites: MATH 555 and ECE 229. Co requisite: ECE 284.

ECE 394. Introduction to Computer Architecture (3). Introduces memory systems, arithmetic circuits, and computer architecture. A small computer will be designed in class. Studies instruction set selection, bus systems, hardware design, and microprogrammed design. Prerequisite: ECE 294.

ECE 410. Distributed Parameter Circuits (3). 2R; 3L. A study of the theory and applications of distributed parameter circuits with emphasis on transmission lines. Treats telegraphers' equations, transient signals on lossless lines, steady state signals on lossless lines, effects of lumped impedances, and Smith Chart techniques. Prerequisite: ECE 383.

ECE 477. Selected Topics in Electrical Engineering (1-4). New or special courses presented on sufficient demand. Repeatable for credit. Prerequisite: departmental consent.

ECE 481A. Co-op Education (1). Provides the student the opportunity to obtain practice in application of engineering principles by employment in an engineering-related job integrating course work with a planned and supervised professional experience. Individualized programs must be formulated in consultation with, and approved by, appropriate faculty sponsors and cooperative education coordinators. Intended for students who will be working full-time on their Co-op assignment and need not be enrolled in any other course. Offered *Cr/NCr* only. Prerequisites: junior standing and approval by appropriate faculty sponsor.

ECE 481P. Co-op Education (1). Provides the student the opportunity to obtain practice in application of engineering principles by employment in an engineering-related job integrating course work with a planned and supervised professional experience. Individualized programs must be formulated in consultation with, and approved by, appropriate faculty sponsors and cooperative education coordinators. Students must enroll concurrently in a minimum of 6 hours of course work including this course in addition to a minimum of 20 hours per week at their Co-op assignment. Offered *Cr/NCr* only. Prerequisites: junior standing and approval by appropriate faculty sponsor.

ECE 488. Electric Machines and Transformers (4). 3R; 3L. Theory and analysis of transformers, DC machines, and

AC machines. Includes single-phase and three-phase transformers, DC machines, synchronous machines, and induction motors. Prerequisites: ECE 282 and ENGL102.

ECE 492. Electronic Circuits I (3). Introduces semiconductor devices and applications in discrete and integrated circuit design. Applications include, but are not limited to, op-amp circuits, rectification, and transistor amplifiers. Prerequisite: ECE 229. Co requisite: ECE 284.

ECE 493. Electronic Circuits II (4). 3R; 3L. An investigation of the theory and application of discrete and integrated circuits. Includes op-amp construction, frequency response, feedback and stability, power amplifiers, and non-linear integrated circuits. Prerequisites: ECE 492 and ENGL102.

Courses for Graduate/Undergraduate Credit

ECE 510. Optics (4). 3R; 1L. A study of the theory and application of optics. Includes geometrical optics, physical optics, Fourier optics, optical image processing, lasers, and nonlinear optics. Prerequisites: PHYS 314, ECE 383.

ECE 585. Electrical Design Project I (2). 3L. A design project under faculty supervision chosen according to the student's interest. Prerequisites: COMM 111 and departmental consent. May not be counted toward a graduate electrical major.

ECE 586. Introduction to Communication Systems (4). 3R; 3L. Fundamentals of communication systems; models and analysis of source, modulation, channel, and demodulation in both analog and digital form. Reviews Fourier Series, Fourier Transform, DFT, Probability, and Random Variables. Studies in Sampling, Multiplexing, AM and FM analog systems, and additive white Gaussian noise channel. Additional topics such as PSK and FSK digital communication systems covered as time permits. Prerequisites: ECE 383 and either STAT 471 or IEN 254.

ECE 588. Advanced Electric Motors (3). Advanced electric motor applications and theory. Includes single-phase motors, adjustable speed ac drive applications, and stepper motors. Prerequisites: ECE 488 and 492.

ECE 594. Microprocessor Based System Design (4). 3R; 1L. Presents development of microprocessor based systems. Studies interfacing the address bus, data bus, and control bus to the processor chip. Memory systems and I/O devices interfaced to the appropriate busses. Vendor-supplied, special-purpose chips, such as interrupt controllers, programmable I/O devices, and DMA controllers, integrated into systems designed in class. Lab gives hands-on experience. Prerequisites: ECE 394, or 238 and 294.

ECE 595. Electrical Design Project II (2). 3L. A continuation of ECE 585. Prerequisite: ECE 585. Will not count toward a graduate electrical engineering degree.

ECE 598. Electric Power Systems Analysis (3). Analysis of electric utility power systems. Topics include analysis

and modeling of power transmission lines and transformers, power flow analysis and software, and an introduction to symmetrical components. Prerequisite: ECE 282.

ECE 636. Telecommunications (3). Topics in circuit and packet switching, layered communication architectures, state dependent queues, traffic engineering, call processing, software organization, routing, and common channel signaling. Prerequisite: ECE 586 or departmental consent.

ECE 644. Advanced Digital Lab (2). An open laboratory experience for computer engineering students. Gives the student an opportunity to use state-of-the-art devices and equipment in designing complex digital systems. Will not count towards an electrical engineering degree. Prerequisites: ECE 394 and 594.

ECE 684. Introductory Control System Concepts (3). An introduction to system modeling and simulation, dynamic response, feedback theory, stability criteria, and compensation design. Prerequisite: ECE 383.

ECE 688. Power Electronics (4). 3R; 3L. Deals with the applications of solid-state electronics for the control and conversion of electric power. Gives an overview of the role of the thyristor in power electronics application and establishes the theory, characteristics and protection of the thyristor. Presents controlled rectification, static frequency conversion by means of the DC link-converter and the cyclo converter, emphasizing frequency, and voltage control and harmonic reduction techniques. Also presents requirements of forced commutation methods as applied to DC-DC control and firing circuit requirement and methods. Introduces applications of power electronics to control AC and DC motors using new methods such as microprocessor. Prerequisite: ECE 492.

ECE 691. Integrated Electronics (3). A study of BJT and MOS analog and digital integrated circuits. Includes BJT, BiMOS, and MOS fabrication; application specific semi-custom VLSI arrays; device performance and characteristics; and integrated circuit design and applications. Prerequisites: ECE 194 and 493.

ECE 698. Principles of Power Distribution (3). The distribution system is a vital contributor to the overall power system function of providing quality electrical service. Provides an overall view of the engineering fundamentals of distribution system. Discusses distribution system planning and automation, primary and secondary distribution networks. Presents voltage regulation, protection, and reliability. Prerequisite: ECE 598 or departmental consent.

ECE 726. Digital Communication Systems I (3). Presents the theoretical and practical aspects of digital and data communication systems. Includes the modeling and analysis of information sources as discrete processes; basic source and channel coding; multiplexing and framing; spectral and time domain considerations related to ASK, PSK, DPSK, QPSK, FSK, MSK, and other techniques appropriate for communicating digital information in both base-band and band-pass systems; intersymbol interference; effects of

noise on system performance; optimum systems; and general M-ary digital systems in signal-space. Prerequisites: ECE 586 and 754.

ECE 736. Data Communication Networks (3). Presents a quantitative performance evaluation of telecommunication networks and systems. Includes fundamental digital communications system review; packet communications; queuing theory; OSI, s.25, and SNA layered architectures; stop-and-wait protocol, go-back-N protocol, and high-level data link layer; network layer flow and congestion control; routing; polling and random access; local area networks (LAN); integrated services digital networks (ISDN); and broad band networks. Prerequisites: ECE 383 or departmental consent.

ECE 738. Embedded Systems Programming (3). A study of the requirements and design of embedded software systems. Application of the C programming language in the implementation of embedded systems emphasizing real-time operating systems, interfacing to assembly and high-level languages, control of external devices, task control, and interrupt processing. Prerequisite: ECE 594 or equivalent.

ECE 744. Introduction to VHDL (3). An introduction to VHSIC hardware description language. Includes different types of modeling techniques using state-of-the-art CAD tools. Covers extensively behavioral modeling, structural modeling, and data-flow modeling. Design assignments include design and simulation of both combinational and sequential circuits using VHDL. Prerequisites: ECE 229 and 394.

ECE 754. Probabilistic Methods in Systems (3). A course in random processes designed to prepare the student for work in communications controls, computer systems information theory, and signal processing. Covers basic concepts and useful analytical tools for engineering problems involving discrete and continuous-time random processes. Discusses applications to system analysis and identification, analog and digital signal processing, data compression parameter estimation, and related disciplines. Prerequisites: ECE 383 and either STAT 471 or IEN 254.

ECE 764. Routing and Switching I (4). 3R; 3L. An introductory course which studies different hardware technologies, like ethernet and token ring. Discusses VLSM. Introduces different routing protocols. Includes hands-on experience in the ECE department's routing and switching lab. Prerequisite: ECE 736 or departmental consent.

ECE 765. Routing and Switching II (4). 3R; 3L. Discusses different bridging techniques, including SRB, RSRB, and DLSW. Also includes advanced routing protocols, like OSPF and EIGRP, and route redistribution. Includes hands-on experience in the ECE department's routing and switching lab. Prerequisite: ECE 764 or departmental consent.

ECE 777. Selected Topics in Electrical Engineering (1-4). New or special courses presented on sufficient demand. Repeatable for credit. Prerequisite: departmental consent.

ECE 781. Analog Filters (3). A detailed study of analog filter design methods. Includes both passive and active filters. Discusses analog filter approximations; covers sensitivity and noise analyses. Prerequisite: ECE 383 and 492.

ECE 782. Digital Signal Processing (3). Presents the fundamental concepts and techniques of digital signal processing. Time domain operations and techniques include difference equations and convolution summation. Covers Z-transform methods, frequency-domain analysis of discrete-time signals and systems, discrete Fourier transform, and fast Fourier transform. Emphasizes the frequency response of discrete-time systems and the relationship to analog systems. Prerequisite: ECE 383 or departmental consent.

ECE 790. Independent Study in Electrical Engineering (1-3). Arranged individual, independent study in specialized content areas in electrical engineering under the supervision of a faculty member. Repeatable for credit. Prerequisite: departmental consent.

ECE 792. Linear Systems (3). Review of mathematics relevant to state-space concepts. Formulation of state-variable models for continuous-time and discrete-time linear systems. Concepts of controllability, observability, stabilizability, and detectability. Pole placement and observer design. State transformation techniques and their utilization in analysis and design of linear control systems. Prerequisite: ECE 383.

ECE 797. Computer Application to Power System Analysis (3). Describes the use of power system component models and efficient computational techniques in the development of a new generation of computer programs representing the steady and dynamic states of electric power systems and informs of methods currently employed in the electric utility industry. Emphasizes algorithms suitable for computer solution of power systems problems such as power flows and system voltages during normal and emergency conditions and transient behavior of the system resulting from fault conditions and switching operations. Prerequisites: ECE 229 and 598.

ECE 798. Advanced Electric Power Systems Analysis (3). Advanced topics in analysis and operation of electric utility power systems. Topics include faulted system analysis, economic dispatch, generator modeling, power system stability, and system protection. Prerequisite: ECE 598.

Courses for Graduate Students Only

ECE 826. Digital Communication Systems II (3). Studies modern digital communication systems. Discusses topics such as carrier and symbol synchronization techniques; fading multipath channels; frequency-hopped spread spectrum systems; smart antenna array systems; space time codes (STC); space-time block codes (STBC); multi-input multi-output (MIMO); orthogonal frequency division multiplexing (OFDM) systems; and multi carrier code division multiple access (MC-CDMA) communications. Prerequisite: ECE 726.

ECE 844. Advanced Computer Architecture I (3). Covers advanced architectural subjects—microprogramming, economics of chip design, instruction set performance, and pipelining. Prerequisites: ECE 594 or equivalent.

ECE 845. Adaptive Filters (3). Concerned with estimating a signal of interest or the state of a system in the presence of additive noise, but without making use of priori statistical characteristics of the signal nor the noise. Concerned with the design, analysis, and application of recursive filtering algorithms that operate in an environment of unknown statistics. Content includes least mean-square (LMS) filters, recursive least-square (RLS) filters, and recursive least-squares lattice (LSL) filters. All are adaptive and self-designing. Includes concepts of convergence, tracking ability, and robustness. Prerequisite: ECE 754.

ECE 864. Multi-Service Over IP (4). 3R; 1L. Advanced networking course; deals with challenges and solutions associated with sending voice, video, and data (multi-service) over IP. Includes Telephony signaling, call routing and dial plans, measuring voice quality, voice digitization and coding, quality of service issues, and current research. Hands-on lab allows students to design, troubleshoot, and test different VOIP scenarios. Prerequisites: ECE 764 and graduate standing in ECE.

ECE 876. MS Thesis (1-6). Graded *S/U* only. Repeatable for credit toward the MS thesis option up to 6 hours. Prerequisite: prior consent of MS thesis advisor.

ECE 877. Special Topics in Electrical Engineering (3). New or special courses are presented under this listing on sufficient demand. Repeatable for credit. Prerequisite: departmental consent.

ECE 878. MS Directed Project (1-3). A project conducted under the supervision of an academic advisor for the directed project option. Requires a written report and an oral presentation on the project. Graded *S/U* only. Prerequisite: consent of academic advisor.

ECE 882. Speech Digital Signal Processing (3). An introductory study in speech signal generation and digital speech signal processing. Includes speech generation and perception, acoustic phonetics, models of speech signals and speech production, analysis methods of digital speech signals, digital representations of speech signals, short-time Fourier transforms and the application to spectrograms, pitch and formant estimation, parametric and nonparametric methods of signal representation, linear prediction methods, speech data compression, some methods of speech synthesis and recognition, and speech signals in the presence of noise. Prerequisites: ECE 754.

ECE 883. Digital Filters (3). A study of digital filter design methods. Includes both IIR and FIR filters. Discusses software and hardware implementations; introduces two-dimensional digital filters. Prerequisite: ECE 782 or departmental consent.

ECE 886. Error Control Coding (3). Introduces error control codes, including Galois fields, linear block codes, cyclic codes, Hadamard codes, Golay codes, BCH codes, Reed-Solomon codes, convolutional codes, Viterbi decoding algorithm, Turbo codes, and ARQ protocols. Applies to digital 3G and 4G cellular and satellite communications systems. Prerequisite: ECE 726.

ECE 893. Optimal Control (3). Reviews mathematics relevant to optimization, including calculus of variations, dynamic programming, and other norm-based techniques. Formulates various performance measures to define optimality and robustness of control systems. Studies design methods for various classes of systems, including continuous-time, discrete-time, linear, nonlinear, deterministic, and stochastic systems. Prerequisite: ECE 792.

ECE 894. Advanced Computer Architecture II (3). Vector processors, memory-hierarchy design, input, and output. Prerequisite: ECE 844.

ECE 897. Operation and Control of Power Systems (3). Acquaints electric power engineering students with power generation systems, their operation in economic mode, and their control. Introduces mathematical optimization methods and applies them to practical operating problems. Introduces methods used in modern control systems for power generation systems. Prerequisite: ECE 598.

ECE 960. Advanced Selected Topics in Electrical Engineering (1-3). Presents new or specialized advanced topics in engineering. Repeatable for credit. Prerequisite: instructor's consent.

ECE 976. PhD Dissertation (1-16). Graded S/U only. Repeatable for credit. Prerequisite: admission to doctoral aspirant status.

ECE 982. Speech Recognition (3). Reviews topics of speech digital signal processing and analysis as necessary for a study of speech recognition such as speech signal production and perception; acoustic-phonetic characterization of speech signals; representing speech signals in time and frequency; and linear prediction of speech signals. Studies topics such as vector quantization, pattern comparison and template matching methods, dynamic time alignment or warping, stochastic methods such as hidden Markov models, linear prediction or phonetics as two methods of segmenting speech signals, language or context-dependent models, and small vs. large vocabulary models. Prerequisite: ECE 882 or departmental consent.

ECE 986. Wireless Spread Spectrum Communications (3). Explains what spread-spectrum communications is and why direct-sequence code-division multiple access (DS-SS) spread-spectrum is used for wireless communications. Studies the block diagrams of the IS-95 forward and reverse wireless communication links under multipath mobile fading environment using analysis techniques and simulation. Analyzes pseudo-noise (PN) signal generation, the band-limited waveform shaping filter, convolu-

tional coding, interleaver, Walsh code orthogonal modulation, Rake finger receivers, non-coherent Walsh orthogonal sub-optimal demodulation, other simultaneously supportable subscribers, and third generation CDMA. Prerequisite: ECE 726.

ECE 990. Advanced Independent Study (1-3). Arranged individual, independent study in specialized content areas in engineering under the supervision of a faculty advisor. Repeatable toward the PhD degree. Prerequisites: advanced standing and departmental consent.

ECE 993. Large Scale Control Systems (3). Sensitivity analysis of deterministic and stochastic systems; sources of uncertainty in control systems, e.g., plant parameter variation, time delays, small non-linearities, noise disturbances, and model reduction; quantitative study of the effects of uncertainties on system performance; low-sensitivity design strategies, state and output feedback design; sensitivity function approach, singular perturbation, and model education techniques; adaptive systems; and near-optimal control. Prerequisite: ECE 893.

Industrial and Manufacturing Engineering

The industrial and manufacturing engineering (IMfgE) department at WSU takes responsibility for instruction and research in design, analysis, and operation of manufacturing and other integrated systems of people, material, equipment, and capital. The department offers curricula and educational experience designed and continuously improved through the involvement and contribution of its constituents: students and alumni, potential employers of program graduates, and faculty.

The IMFG E department offers two undergraduate degree programs, one in industrial engineering (BSIE) and another in manufacturing engineering (BSMfgE). The BSIE degree program is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (EAC/ABET). The BSMfgE degree program is new and accreditation for it has not yet been sought.

The department also offers three graduate degree programs: Master of Engineering Management (MEM), MS in IE, and PhD in IE. Both the MSIE and PhD programs allow concentrations in engineering systems, ergonomics/human factors engineering, and manufacturing systems engineering. The MEM program is geared toward helping engineers/technologists develop planning, decision making, and managerial skills while receiving advanced technical knowledge.

The department also offers graduate certificate programs in the following five areas: systems engineering and management, computer-aided design and manufacturing, industrial ergonomics and safety, production systems, and quality engineering and management.

Modern, well-equipped laboratories are available to supplement classroom theory in ergonomics, man-

ufacturing engineering, and computer analysis. The department's laboratory facilities include Cessna Manufacturing Processes Lab, Graphics Lab, Metrology Lab, Computer Integrated Manufacturing Lab, Automation and Controls Lab, Ergonomics Lab, and Open Computing Lab. Students in the academic programs offered by the industrial and manufacturing engineering department get ample opportunity to work on real-life problems in local industries as part of course requirements.

Bachelor of Science Degree in Industrial Engineering

Industrial engineers apply scientific knowledge to solve problems in manufacturing and other industries, businesses, and institutions, focusing on productivity improvement through better use of human resources, financial resources, natural resources and man-made structures and equipment. IEs apply a full range of analytical, simulation, and experimentation tools to problems in designing, planning, implementing, and operating systems. These problems are found in a wide variety of service organizations (such as banks, hospitals, social services, and government agencies), project-based firms (such as construction and consulting), and product-based firms (such as processing, manufacturing, and electronics). The focus of industrial engineering is systems integration and improvement.

Program Educational Objectives

Educational objectives of the industrial engineering program are driven by WSU's mission as a metropolitan university. Specifically, our IE program educational objectives are:

1. A majority of our graduates will be employed in jobs related to design, implementation, and improvement of systems in manufacturing and service sectors, including jobs in quality engineering, facilities management, man-machine systems, simulation, project planning, inventory management, ergonomics, and optimization.

2. Some of the graduates will pursue graduate studies in engineering or business.

3. Graduates will enjoy professional success because of the program's emphasis on solving real-world problems in industries and organizations in the metropolitan area.

Sequence of Courses

The BS in industrial engineering program requires the completion of 128 semester hours for graduation, minus hours commensurate with advanced placement credit. Students may select 12 hours of technical electives to emphasize their study of engineering systems, ergonomics, or manufacturing engineering. This allows students to specialize in a specific area of industrial engineering. Students' programs are determined by their own interests in consultation with their faculty advisors. Specific requirements and a suggested schedule for the industrial engineering program are given in the accompanying table.

Model Program**Freshman**

Course	Hrs.
ENGL101/100 and 102, College English I and II.....	6
MATH 242 and 243, Calculus I and II.....	10
PHYS 313, University Physics I.....	4
CHEM 111, General Chemistry.....	5
IEN 222, Engineering Graphics.....	3
MFG E 258, Manufacturing Method I.....	3

Sophomore

Course	Hrs.
COMM 111, Public Speaking.....	3
MATH 511, Linear Algebra.....	3
PHIL385, Engineering Ethics.....	3
PHYS 314, University Physics II.....	4
AE 223, Statics.....	3
ECE 229, Engineering Computing in C.....	3
IEN 254, Engineering Probability and Statistics I.....	3
IEN 255, Engineering Economy.....	3
IEN 452, Work Analysis and Design.....	3
IEN 524, Engineering Probability and Statistics II.....	3
IEN 550, Introduction to Operations Research.....	3

Junior

Course	Hrs.
MATH 344, Calculus III.....	3
ECE 282, Circuits I.....	4
ME 250, Materials Engineering.....	3
IEN 549, Industrial Ergonomics.....	3
IEN 553, Production and Inventory Control.....	3
IEN 554, Statistical Quality Control.....	3
IEN 563, Facilities Planning and Design.....	2
IEN 565, Systems Simulation.....	3
Technical electives**.....	3
Humanities, social science or fine arts electives*.....	6

Senior

Course	Hrs.
ME 398, Thermodynamics I.....	3
IEN 556, Information Systems.....	3
IEN 590, Industrial Engineering Design I.....	3
IEN 690, Industrial Engineering Design II.....	3
Technical electives**.....	9
Humanities, social science or fine arts electives*.....	9

*Refer to the College of Engineering graduation requirements in the WSU *Undergraduate Catalog* for details.

**To be chosen from an approved list (a minimum of 6 hours must be taken within the IMFG E department).

Bachelor of Science Degree in Manufacturing Engineering

Manufacturing engineering is concerned with converting raw materials and intermediate products into final and other intermediate products through the use of various design, processing, assembly, and automation techniques as well as the design and manufacturing of tools, jigs, and machines used in these processes. The strength of the BSMfgE program at Wichita State is its emphasis on the following three manufacturing engineering areas: materials and

processes; product engineering and assembly; and manufacturing quality and productivity. Manufacturing engineers can apply their broad and comprehensive skills in a wide spectrum of industries.

Program Educational Objectives

Educational objectives of the manufacturing engineering program are driven by WSU's mission as a metropolitan university. Specifically, our MFG E program educational objectives are:

1. A majority of our graduates will be employed in jobs related to design, planning and control, implementation, and improvement of manufacturing processes.

2. Some of the graduates will pursue graduate studies in engineering or business.

3. Graduates will enjoy professional success because of the program's emphasis on solving real-world problems in industries and organizations in the metropolitan area.

Sequence of Courses

The BS in manufacturing engineering program requires the completion of 128 semester hours for graduation, minus hours commensurate with advanced placement credit. Students may select 9 hours of technical electives to emphasize their study of advanced manufacturing engineering concepts and related topics in other engineering disciplines. Selection of appropriate courses would allow the students to tailor their study to fit their individual interests and needs. Students' programs of study are determined in consultation with their faculty advisors.

Specific requirements and a suggested schedule for the manufacturing engineering program are given below.

Model Program**Freshman**

Course	Hrs.
ENGL101/100 and 102, College English I and II.....	6
MATH 242 and 243, Calculus I and II.....	10
PHYS 313, University Physics I.....	4
CHEM 111, General Chemistry.....	5
ME 250 and 251, Materials Engineering and lab.....	4
MFG E 258, Manufacturing Methods and Materials I.....	3

Sophomore

Course	Hrs.
COMM 111, Public Speaking.....	3
MATH 344, Calculus III.....	3
PHIL385, Engineering Ethics.....	3
AE 223, Statics.....	3
ECE 229, Engineering Computing in C.....	3
IEN 222, Engineering Graphics.....	3
IEN 254, Engineering Probability and Statistics I.....	3
IEN 255, Engineering Economy.....	3
MFG E 502, Manufacturing Measurement Analysis	3
MFG E 558, Manufacturing Methods and Materials II.....	4

Junior

Course	Hrs.
MATH 555, Ordinary Differential Equations.....	3
PHYS 314, University Physics II.....	4
AE 333, Mechanics of Materials.....	3
ECE 282, Circuits I.....	4
ME 398, Thermodynamics I.....	3
IEN 524, Engineering Probability and Statistics II.....	3
IEN 554, Statistical Quality Control.....	3
MFG E 545, Manufacturing Systems	3
MFG E 554, Manufacturing Tools.....	3
Humanities, social science or fine arts electives*.....	6

Senior

Course	Hrs.
ME 439, Mechanical Engineering Design I.....	3
IEN 664, Engineering Management.....	3
MFG E 590, Manufacturing Engineering Design I.....	3
MFG E 690, Manufacturing Engineering Design II.....	3
Technical electives**.....	9
Humanities, social science or fine arts electives*.....	9

*Refer to the College of Engineering graduation requirements in the WSU *Undergraduate Catalog* for details.

**To be chosen from an approved list (at least 6 hours must be from one of the engineering departments).

Industrial Engineering (IEN)**Lower-Division Courses**

IEN 101. Introduction to Industrial and Manufacturing Engineering (1). Cross-listed as MFG E 101. An introduction and overview of the discipline areas within industrial and manufacturing engineering. Combines design, case study, and hands-on experience with lectures on the different emphasis areas.

IEN 150. Workshop in Industrial Engineering (1-3). Offered from time to time on various topics in industrial engineering.

IEN 222. Engineering Graphics (3). 1R; 3L. Uses computer graphics to produce technical drawings and solve engineering design problems. Studies basic spatial relationships involving orthographic projections, auxiliary views, and pictorial projections. Design implementation includes dimensioning, tolerancing, sectional views, threaded fasteners, blue print reading, and working drawings. Also uses descriptive geometry to find true lengths of lines; spatial relationships between points, lines, and planes; and intersections of solids, surfaces, and conic sections. Prerequisite: MATH 123 or equivalent.

IEN 250. Topics in Engineering Graphics (2). 1R; 3L. The application of engineering graphics to the study of special problems and to methods of conveying information. Prerequisite: IEN 222.

IEN 254. Engineering Probability and Statistics I (3). A study of the concepts of probability theory, random variables, distributions, moments, sample statistics, and confidence intervals. Prerequisite: MATH 243.

IEN 255. Engineering Economy (3). Economic comparisons of engineering alternatives considering the time value of money, taxes, and depreciation; accounting and its relationship to economic analysis; and replacement decisions. Corequisite: MATH 243.

IEN 281P. Co-op Education (1). Introduces the student to engineering practice by working in industry in an engineering-related job and provides a planned professional experience designed to complement and enhance the student's academic program. Individualized programs must be formulated in consultation with, and approved by, appropriate faculty sponsors and cooperative education coordinators. Intended for students who will be working full time on their Co-op assignment and need not be enrolled in any other course. May be repeated. Offered Cr/Ncr only. Prerequisites: 30 hours toward bachelor of science in industrial engineering degree and approval by appropriate faculty sponsor.

Upper-Division Courses

IEN 452. Work Systems (3). The documentation, measurement, and design of work systems. Includes work measurement systems, methods engineering, work sampling, predetermined time systems, and economic justification. Prerequisites: IEN 254 and 255.

IEN 480. Selected Topics in Industrial Engineering (1-4). New or special course material presented upon sufficient student demand. Repeatable for credit. Prerequisite: departmental consent.

IEN 481P. Co-op Education (1). See IEN 281P. Prerequisites: junior standing and approval by appropriate faculty sponsor.

IEN 490. Independent Study (1-3). Arranged individual independent study in specialized areas of industrial engineering under the supervision of a faculty member. May be repeated for credit. Prerequisite: consent of supervising faculty member.

Courses for Graduate/Undergraduate Credit

IEN 524. Engineering Probability and Statistics II (3). A study of hypothesis testing, regression analysis, analysis of variance, correlation analysis, and design of experiments emphasizing applications to engineering. Prerequisite: IEN 254 or STAT 471.

IEN 549. Industrial Ergonomics (3). A systematic approach to the optimization of the human-task-environment system. Includes work space design, manual materials handling, cumulative trauma disorders, and environmental factors. Emphasizes applications in industry. Prerequisite: IEN 452. Co requisite: IEN 524 or departmental consent.

IEN 550. Operations Research (3). Models and methods in operations research. Linear and quadratic programming. Network models and algorithms. Integer, dynamic, and

nonlinear programming. Unconstrained and constrained optimization. Co requisite: IEN 254.

IEN 553. Production Systems (3). Cross-listed as MFG E 545. Quantitative techniques used in the analysis and control of production systems. Includes forecasting, inventory models, operation planning and scheduling. Prerequisite: IEN 550. Co requisite: IEN 255.

IEN 554. Statistical Quality Control (3). A study of the measurement and control of product quality using statistical methods. Includes acceptance sampling, statistical process control, and total quality management. Prerequisite: IEN 524.

IEN 556. Information Systems (3). Provides a basic understanding of information systems in a modern enterprise, including database design, information technology, and ethics using hands-on activities and directed classroom discussion. Prerequisites: IEN 452 and ECE 229.

IEN 557. Safety Engineering (3). Environmental aspects of accident prevention, industrial compensation, and safety legislation. Fundamental concepts of occupational health and hygiene. Prerequisite: IEN 254 or STAT 471.

IEN 563. Facilities Planning and Design (2). Quantitative and qualitative approaches to problems in facilities planning and design, emphasizing activity relationships, space requirements, materials handling and storage, and plant layout. Prerequisites: IEN 550 and MFG E 258. Co requisite: IEN 452.

IEN 565. Systems Simulation (3). The design of simulation models and techniques for use in designing and evaluating discrete systems, including manufacturing systems too complex to be solved analytically. Emphasizes general purpose computer simulation languages. Prerequisites: IEN 553 and ECE 229. Co requisite: IEN 524.

IEN 664. Engineering Management (3). An introduction to the design and control of technologically based projects. Considers both the theoretical and practical aspects of systems models, organizational development, project planning and control, resource allocation, team development, and personal skill assessment. Prerequisites: IEN 254 and 255.

IEN 724. Statistical Methods for Engineers (3). For graduate students majoring in engineering. Students study and model real-life engineering problems and draw reliable conclusions through applications of probability theory and statistical techniques. Cannot be used to fulfill degree requirements for the BS degree in industrial and manufacturing engineering. Prerequisite: MATH 243.

IEN 731. Foundations of Optimization (3). An extensive treatment of the theory and concepts of linear, nonlinear, constrained, and unconstrained optimization techniques. Prerequisite: IEN 550.

IEN 740. Analysis of Decision Processes (3). Decision analysis as it applies to capital equipment selection and

replacement, process design, and policy development. Explicit consideration of risk, uncertainty, and multiple attributes is developed and applied using modern computer-aided analysis techniques. Prerequisites: IEN 254 and 255.

IEN 749. Advanced Ergonomics (3). A continuation of IEN 549. Includes principles and application of human factors to the design of the workplace, displays, control systems, hand tools, and video display terminals. Prerequisite: IEN 549.

IEN 750. Industrial Engineering Workshops (1-4). Various topics in industrial engineering. Prerequisite: departmental consent.

IEN 754. Reliability and Maintainability Engineering (3). Studies problems of quantifying, assessing, and verifying reliability. Presents various factors that determine the capabilities of components emphasizing practical applications. Examples and problems cover a broad range of engineering fields. Prerequisite: IEN 524.

IEN 755. Design of Experiments (3). Application of analysis of variance and experimental design for engineering studies. Includes general design methodology, single-factor designs, randomized blocks, factorial designs, fractional replication, and confounding. Prerequisite: IEN 524 or instructor's consent.

IEN 757. Modern Techniques in Safety Engineering (3). An advanced study of the principles and quantitative measures of industrial safety and the Occupational Safety and Health Act. Prerequisite: IEN 557.

IEN 760. Ergonomics Topics (3). New or special courses on topics in ergonomics and human factors engineering. May be repeated for different topics Prerequisite: departmental consent.

IEN 764. Systems Engineering and Analysis (3). Presentation of system design process from the identification of a need through conceptual design, preliminary design, detail design and development, and system test and evaluation. Studies operational feasibility, reliability, maintainability, supportability, and economic feasibility. Prerequisites: IEN 254 and 255.

IEN 770. Industrial Automation (3). 2R; 3L. Teaches the design and application of manufacturing automated systems. Discusses automation components, such as sensors, actuators, and microprocessors, along with the use of programmable logic controllers. Introduces other areas of automation, such as robotics, machine vision, DNC machine tools, and their integration into automated system. Prerequisite: ECE 229 or knowledge of a programming language.

IEN 775. Computer Integrated Manufacturing (3). A study of the concepts, components, and technologies of CIM systems; enterprise modeling for CIM; local area networks; CAD/CAD interfaces; information flow for CIM;

shop floor control; and justification of CIM systems. Prerequisite: ECE 229 or knowledge of a programming language, MFG E 558.

IEN 780. Topics in Industrial Engineering (3). New or special courses are presented under this listing. Repeatable for credit when subject matter warrants.

IEN 781. Cooperative Education (1-8). A work-related placement with a supervised professional experience to complement and enhance the student's academic program. Intended for master's level or doctoral students in IE. Repeatable for credit. May not be used to satisfy degree requirements. Prerequisite: departmental consent and graduate GPA of 3.00 or above. *Cr/Ncr* only.

IEN 785. Tolerancing in Design and Manufacturing (3). Provides a basic understanding of the theory and application of tolerancing in design, manufacturing, and inspection. Reviews current literature in the area of tolerancing and inspection. Includes detailed discussion of the ASME standards on geometric dimensioning and tolerancing (GD&T), GD&T verification procedures, tolerance analysis and allocation, statistical tolerancing, and Taguchi's approach to tolerancing. Prerequisite: IEN 254 or instructor's consent.

Courses for Graduate Students Only

IEN 835. Applied Forecasting Methods (3). A study of the forecasting methods, including smoothing techniques, time series analysis, and Box-Jenkins models. Prerequisite: IEN 524.

IEN 842. Advanced Simulation (3). A study of advanced techniques and methods for statistically selecting input distributions for and analyzing output from simulation models. Also studies variance reduction and model validation techniques. Prerequisites: IEN 565 and 524.

IEN 854. Quality Engineering (3). A broad view of quality tools and their integration into a comprehensive quality management and improvement system. Covers the theory and approaches of the major quality leaders such as Deming, Juran, and Crosby. Explores off-line and on-line quality engineering techniques, including cost of quality, the seven "old" and seven "new" tools, Quality Function Deployment, and statistical process control methods. Explores design of engineering experiments, including Taguchi's methods. Prerequisite: IEN 524.

IEN 857. Environmental Hygiene Engineering (3). Evaluation and control of mechanical, physical, and chemical environments. Environmental factors considered include heat, cold, noise, vibration, light, pressure, acceleration, radiation, and air contaminants. Prerequisite: IEN 549.

IEN 876. Thesis (1-6). Graded *S/U* only. Repeatable for credit. Prerequisite: consent of thesis advisor.

IEN 877. Foundations of Neural Networks (3). For students from a variety of disciplines. Introduces the theory and practical applications of artificial neural networks. Covers several network paradigms, emphasizing the use of neural networks as a solution tool for industrial problems which require pattern recognition, predictive and interpretive models, pattern classification, optimization, and clustering. Presents examples and discusses them from a variety of areas including quality control, process monitoring and control, robotics control, simulation/metamodeling, economic analysis models, diagnostic models, combinatorial optimization, and machine vision. Prerequisite: instructor's consent.

IEN 878. MS Directed Project (1-3). A project conducted under the supervision of an academic advisor for the directed project option. Requires a written report and an oral presentation on the project. Graded *S/U* only. Prerequisite: consent of academic advisor.

IEN 880. Topics in Industrial Engineering (3). New or special courses are presented under this listing on sufficient demand. Repeatable for credit when subject matter warrants.

IEN 890. Independent Study in Industrial Engineering (3). Analysis, research, and solution of a selected problem. Prerequisite: instructor's consent.

IEN 930. Multiple Criteria Decision-Making (3). An extensive treatment of techniques for decision-making where the multiple criteria nature of the problem must be recognized explicitly. Prerequisite: IEN 550.

IEN 949. Work Physiology (3). The study of cardiovascular, pulmonary, and muscular responses to industrial work including aspects of endurance, strength, fatigue, recovery, and the energy cost of work. Utilization of physical work capacity and job demand for task design, personnel assignment, and assessment of work-rest scheduling. Prerequisite: IEN 549.

IEN 950. Occupational Biomechanics (3). Theoretical fundamentals of the link system of the body and kinetic aspects of body movement. Includes application of biomechanics to work systems. Prerequisites: IEN 549 and AE 223.

IEN 956. Knowledge-Based Systems (3). Introduction to the concepts and techniques in knowledge-based systems or expert systems. Includes design and development of knowledge-based systems using microcomputer-based software. Prerequisite: ECE 229 or AE 227 or departmental consent.

IEN 960. Advanced Selected Topics (1-3). New or special courses on advanced topics presented under this listing on sufficient demand. Prerequisite: instructor's consent.

IEN 976. PhD Dissertation (1-6). Graded *S/U* only. Repeatable for credit. Prerequisite: admission to doctoral aspirant status.

IEN 990. Advanced Independent Study (1-3). Arranged individual, independent study in specialized content areas. Repeatable toward the PhD degree. Prerequisites: advanced standing and departmental consent.

Manufacturing Engineering (MFG E)

Lower-Division Courses

MFG E 101. Introduction to Industrial and Manufacturing Engineering (1). Cross-listed as IEN 101. An introduction and overview of the discipline areas within industrial and manufacturing engineering. Combines design, case study, and hands-on experience with lectures on the different emphasis areas.

MFG E 258. Manufacturing Methods and Materials I (3). 2R; 3L. Provides a basic understanding of materials and processes used to manufacture products. Some of the major manufacturing processes covered include metal machining, metal forming, extrusion, casting, joining, and plastics forming. Emphasizes the use of materials, sciences and mathematics to understand the behavior of materials undergoing the manufacturing process. Includes an introduction to process planning. Students gain an extensive hands-on experience in different manufacturing processes and in teamwork. Prerequisite: MATH 123.

MFG E 490. Independent Study (1-3). Arranged individual independent study in specialized areas of industrial engineering under the supervision of a faculty member. May be repeated for credit. Prerequisite: consent of supervising faculty member.

Courses for Graduate/Undergraduate Credit

MFG E 502. Manufacturing Measurement Analysis (3). 2R; 3L. Covers methods for measurement and analysis of variables in the production of industrial parts. Topics include basic principals of measurement, data acquisition, data analysis, dimensional measurement techniques, basic understanding and evaluation of GD&T, force, temperature, surface finish measurement, principals of gage design, gage capability studies, process capability studies, and sampling techniques. Includes a laboratory component to familiarize students with different kinds of measurement devices such as CMM, non-contact optical measurement devices, surface profilometer, optical flats, and automatic data collection. Prerequisites: IEN 254 and MFG E 258.

MFG E 545. Manufacturing Systems (3). Cross-listed as IEN 553. A study of the design, planning, implementation, and control of manufacturing systems. Discusses types of manufacturing systems, material requirement planning, capacity planning, facilities planning, scheduling, and an introduction to computer-aided process planning. Prerequisite: MFG E 558.

MFG E 554. Manufacturing Tools (3). Introduces the principles behind the design and fabrication of machine tools and production tooling. Discusses tool materials;

machine tool kinematics, accuracy, instrumentation, and control; and designing fixtures and jigs. Includes an introduction to design of inspection tools, machining and press working tools, and modular fixturing. Application of theories to labs and design problems. Prerequisite: MFG E 258. Co-requisite: AE 223.

MFG E 558. Manufacturing Methods and Materials II (4). 3R; 3L. Covers theoretical and practical aspects of manufacturing processes, including material properties and behavior as influenced by the manufacturing process. In-depth study of such manufacturing processes as casting heat treatment, bulk forming, sheet metal forming, metal cutting, non-traditional machining, and process monitoring through measurement of manufacturing process variables. Also includes laboratory experience and plant tours. Prerequisites: MFG E 258 and ME 250.

MFG E 622. Computer-Aided Design and Manufacturing (3). Introduction to 3-D computer graphics. Discusses concepts of CAD/CAM/CIM, design theory, automation, and knowledge-based CAD systems. Examines the basic principles of computer-aided manufacturing, NC programming, and CAD/CAM integration. Describes the design interchange standards and the interface between CAD and CAM. Prerequisites: IEN 222 and ECE 229 or equivalent.

MFG E 654. Nontraditional Machining Processes (3). A study of the role and economics of nontraditional processes; use of laser and electron beams in inspection and measurement; heat treatment; material removal; material joining; and coating. Also covers the fundamentals of electro-discharge machining, electro-chemical machining, chemical milling, and water-jet machining. Prerequisite: MFG E 558.

MFG E 658. Forming Processes (3). Introduction to the fundamentals of deformation and techniques for analysis of forming processes. Application to various bulk forming and sheet metal forming processes. Introduction to applied non-linear finite element analysis and its application for analysis and design of forming processes. Prerequisite: AE 333.

Mechanical Engineering (ME)

Mechanical engineering is one of the broadest engineering fields. Mechanical engineers are found in virtually all productive industries, from aircraft and automotive to consumer products and building equipment. In these jobs, mechanical engineers design products, machines, and processes for manufacturing. They analyze, test, and develop these products, machines and manufacturing processes to attain the best performance and durability within cost and time limits. Examples of specific mechanical engineering jobs include:

- design, development, and manufacturing of automotive engines and vehicle systems;
- design, development, and manufacturing of gas turbine and other aircraft engines;

- design and construction of electrical power plant energy conversion and generating systems;

- design, development, and manufacturing of consumer products, ranging from appliances such as refrigerators, washers, and electric drills, to the manufacturing systems for producing facial tissue and processed foods and packaging of these items;

- design and specification of heating, air-conditioning, and ventilating systems used in aircraft, automobiles, and buildings;

- analysis of the complex flow of gases and fluids such as air flow in aircraft inlet ducts and fluid flow in hydraulic and pumping systems;

- study of heat flow, ranging from boilers and automotive radiators to heat management problems in orbiting spacecraft.

The mechanical engineering program prepares students for these job possibilities, as well as possible entry to graduate school for those so inclined. This is accomplished through a broad course of study that covers not only the technical aspects required, but the ethical, professional, and communications skills needed to be a successful practicing engineer. The program includes components in mathematics and natural science, written and oral communications skills, humanities and social sciences, a core of engineering science subjects, and a specified set of required technical courses covering the basic areas of mechanical engineering. In addition, students select elective courses that allow them to develop specialized knowledge in areas such as robotics, manufacturing, entrepreneurship, biomechanics, materials structure and behavior, heat transfer, and energy conversion. Modern laboratories and a wide variety of computer facilities provide students with hands-on experience in experimental work and computer-aided design and engineering.

Bachelor of Science Degree in Mechanical Engineering

Educational Objectives

1. Prepare students for employment as mechanical engineers
2. Enable interested students to pursue graduate education
3. Utilize the unique opportunities of a metropolitan location to provide graduates with industry-based project experiences.

Sequence of Courses

The program requires the completion of 128 semester hours for graduation, minus hours commensurate with advanced placement credit. Specific requirements and a suggested course of study for the mechanical engineering program follow.

Model Program

Freshman

<i>Course</i>	<i>Hrs.</i>
ENGL101/100 and 102, College English I and II.....	6
CHEM 111, General Chemistry.....	5
MATH 242 and 243, Calculus I and II.....	10
PHYS 313 and 315, University Physics I and lab.....	5
COMM 111, Public Speaking.....	3
Humanities and fine arts or social and behavioral sciences elective*.....	3

Sophomore

<i>Course</i>	<i>Hrs.</i>
MATH 344, Calculus III.....	3
MATH 555, Differential Equations I.....	3
PHYS 314, University Physics II.....	4
AE 223, Statics.....	3
ECE 282, Circuits I.....	4
IEN 222, Engineering Graphics.....	3
IEN 255, Engineering Economy.....	3
ME 250, Materials Engineering.....	3
ME 251, Materials Engineering Lab.....	1
ME 325, Computer Applications.....	2
Humanities and fine arts or social and behavioral sciences elective*.....	3

Junior

<i>Course</i>	<i>Hrs.</i>
AE 333, Mechanics of Materials.....	3
AE 373, Dynamics.....	3
ME 339, Design of Machinery.....	3
ME 398, Thermodynamics I.....	3
ME 403, Mechanical Engineering Laboratory.....	3
ME 439, Mechanical Engineering Design I.....	3
ME 502, Thermodynamics II.....	3
ME 521, Fluid Mechanics.....	3
ME 522, Heat Transfer.....	3
PHIL385, Engineering Ethics.....	3
Natural science electives**.....	3

Senior

<i>Course</i>	<i>Hrs.</i>
ME 503, Mechanical Engineering Systems Laboratory.....	3
Mechanical Design elective§.....	3
Thermal Design elective§.....	3
ME 659, Mechanical Control.....	3
ME 662, Mechanical Engineering Practice.....	3
Additional mechanical engineering electives¶.....	6
Humanities and fine arts or social and behavioral sciences electives*.....	9

* Refer to graduation requirements at the beginning of this section.

** To be chosen from a list of approved courses available from the College of Engineering.

§ One thermal design elective and one mechanical design elective must be taken from those being offered.

Lower-Division Courses

ME 101. Introduction to Machines and Design (2). 6L. Students participate in mechanical dissection where they disassemble and reassemble a machine to learn how it operates and develop an understanding of mechanical devices. The knowledge and experience from the mechanical dissection forms the basis for an introduction to the design process. Student groups design and build a mechanical device to perform some task in the design project. Prerequisite: mechanical engineering major declared or departmental consent.

ME 150. Workshop in Mechanical Engineering (1-3). Provides specialized instruction in areas relevant to mechanical engineering. Variable format. Repeatable for credit.

ME 250. Materials Engineering (3). Studies important structural materials used in engineering, including metals, polymers, and composites, primarily from a phenomenological viewpoint. Prerequisites: CHEM 111, MATH 242.

ME 251. Materials Engineering Laboratory (1). 3L. Companion laboratory course to ME 250. Experimental study of important structural materials used in engineering, including metals, polymers, and composites. Co-requisite: ME 250.

Upper-Division Courses

ME 325. Computer Applications (3). Introduces the essential computer tools necessary for the mechanical engineering (ME) curriculum. Covers basic word processing and spreadsheet skills, C programming language as applied to ME problems. Also covers Matlab. Includes fundamentals of linear algebra and other computational tools. Prerequisite: MATH 243.

ME 339. Design of Machinery (3). Introduces engineering design process; synthesis and analysis of machinery and machines. Kinematic (position, velocity, and acceleration) and inverse dynamic analysis of planar mechanisms by analytical, graphical, and computer methods. Design of linkages for motion, path, and function generation; cam design. Computer-aided engineering as an approach in engineering design; projects on practical engineering designs for machinery. Prerequisite: IEN 222. Co-requisite: AE 373.

ME 360. Selected Topics in Mechanical Engineering (1-3). New or special topics presented on sufficient demand. Repeatable for credit when subject material warrants. Prerequisites: as published or departmental consent.

ME 398. Thermodynamics I (3). An introduction to the terminology and analysis techniques specific to thermodynamics centered around a study of the First and Second Laws of Thermodynamics. Prerequisites: MATH 243 and PHYS 313.

ME 439. Mechanical Engineering Design I (3). Principles of mechanical design, emphasizing practice in the application of many mechanical design elements: shafts, bearings, gears, brakes, clutches, thread fasteners, etc. Includes machine elements design, materials selection, fatigue, stress concentration, statistical concepts, and cost standardization. Innovative practical applications demanding integration of machine elements into a practical device. Prerequisites: ME 250 and 251, AE 333, and MATH 555.

ME 450. Selected Topics in Mechanical Engineering (1-3). New or special topics presented on sufficient demand. Repeatable for credit when subject material warrants. Pre-requisite: departmental consent.

ME 451. Technical Entrepreneurship (3). A junior/senior level course which carries design credit and integrates into the design process topics of technical entrepreneurship. The engineering student gains an appreciation for issues faced by a business in bringing a new or improved design to the marketplace. Also the student is encouraged to 'take the next step' toward taking their own engineering ideas beyond the prototype stage and to the marketplace. Exposes the student to a wide range of business topics, including market gap analysis, financial planning, incentive programs, personnel decision making, and business plan preparation, in addition to standard engineering topics. Prerequisite: junior/senior standing in engineering or instructor's consent.

ME 469. Energy Conversion (3). Energy conversion principles and their implementation in engineering devices including thermal, mechanical, nuclear, and direct energy conversion processes. Prerequisite: ME 398.

ME 481A. Co-op Education (3). Introduces the student to engineering practice by working in industry in an engineering-related job and provides planned professional experience designed to complement and enhance the student's academic program. Individualized programs must be formulated in consultation with, and approved by, appropriate faculty sponsors and cooperative education coordinators. Intended for students who will be working full-time on their Co-op assignment and need not be enrolled in any other course. Prerequisites: junior standing and approval by the appropriate faculty sponsor. May be repeated. Offered Cr/NCr only.

ME 481P. Co-op Education (1). Introduces the student to engineering practice by working in industry in an engineering-related job and provides planned professional experience designed to complement and enhance the student's academic program. Individualized programs must be formulated in consultation with, and approved by, appropriate faculty sponsors and cooperative education coordinators. Intended for students who will be working part-time on their Co-op assignment and be currently enrolled in courses leading to a mechanical engineering degree. Prerequisites: junior standing and approval by the appropriate faculty sponsor. May be repeated. Offered Cr/NCr only.

Courses for Graduate/Undergraduate Credit

The courses numbered 502 through 760 are not automatically applicable toward an advanced degree in engineering. They must be approved by the student's advisor, the graduate coordinator, and the chairperson of the department. Courses required for the BS degree normally are not permitted for use toward the graduate degree in mechanical engineering.

ME 502. Thermodynamics II (3).* Continuation of ME 398, emphasizing cycle analysis, thermodynamic property relationships, and psychrometrics, with an introduction to combustion processes and chemical thermodynamics. Prerequisite: ME 398 with a grade of C or better.

ME 521. Fluid Mechanics (3).* Fluid statics. Basic equations of fluid mechanics. Study of flow in closed conduits and over immersed bodies. Includes compressible flow, turbomachinery, and measurements in fluid mechanics. Prerequisites: ME 398 with C or better and MATH 555 and AE 373.

ME 522. Heat Transfer (3).* Temperature fields and heat transfer by conduction, convection, and radiation. Steady and transient multidimensional conduction, free and forced convection, and combined heat transfer. Discusses various analytical methods, analogies, numerical methods, and approximate solutions. Prerequisite: ME 521.

ME 533. Mechanical Engineering Laboratory (3). 2R; 3L. Introduces the basics of engineering measurements. Discusses related theory, followed by applications in such areas as strain, sound, temperature, and pressure measurements. Format includes lectures, recitation (which presents the concept of the experiment to be performed and the required data analysis), and laboratories. Analyzes the data obtained from measuring systems set up and operated in the laboratory to demonstrate and reinforce fundamental concepts of engineering mechanics. Prerequisites: ECE 282 and AE 333. Co-requisite: ME 522.

ME 541. Mechanical Engineering Design II (3). Applications of engineering design principles to the creative design of mechanical equipment. Problem definition, conceptual design, feasibility studies, design calculations to obtain creative solutions of current real engineering problems. Introduction to human factors, economics, and reliability theory. Group and individual design projects. Prerequisite: ME 439.

ME 544. Design of HVAC Systems (3). Analysis and design of heating, ventilating, and air-conditioning systems based on psychrometrics, thermodynamics, and heat transfer fundamentals. Focuses on design procedures for space air-conditioning and heating and cooling loads in buildings. Prerequisites: ME 521 and 522 or equivalent.

ME 550. Selected Topics in Mechanical Engineering (1-3). New or special topics are presented on sufficient demand. Repeatable for credit when subject material warrants. Prerequisite: departmental consent.

ME 602. Engineering for the Environment (3). Engineering for the environment, air, water, and noise pollution, and handling of hazardous wastes. Covers briefly the main pollutants, their major sources, their effects, and their attainment levels set by the U.S. Environmental Protection Agency. Emphasizes engineering systems for pollution control. Prerequisites: ME 398, AE 223, IEN 255, or departmental consent.

ME 631. Heat Exchanger Design (3). Covers analytical models for forced convection through tubes and over surfaces, experimental correlations for the Nusselt number and pressure drop; design of single and multiple pass shell and tube heat exchangers; compact baffled, direct contact, plate, and fluidized bed heat exchangers, radiators, recuperators, and regenerators. Prerequisites: ME 521 and 522, or equivalent.

ME 633. Mechanical Engineering Systems Laboratory (3). 2R, 3L.* Selected experiments illustrate the methodology of experimentation as applied to mechanical and thermal systems. Experiments include the measurement of performance of typical systems and evaluation of physical properties and parameters of systems. Group design and construction of an experiment is an important part of the course. Team and individual efforts are stressed as are written and oral communication skills. Prerequisites: ME 533, ENGL102.

ME 637. Computer-Aided Engineering (3). 2R, 3L. Integrates computer-aided design, finite element analysis, kinematics analysis, heat transfer analysis, and other considerations for design of mechanical components and systems. Provides a blend of theory and practice. Prerequisite: ME 439 or equivalent.

ME 639. Applications of Finite Element Methods in Mechanical Engineering (3). 2R, 3L. Introduces the finite element method (FEM) as a powerful and general tool for solving differential equations, arising from modeling practical engineering problems. Finite element solutions to one- and two-dimensional mechanical engineering problems in fluid mechanics, heat transfer, solid mechanics, and vibrations. Includes Galerkin's and variational finite element models. Introduces commercial finite element computer tools such as ALGOR and ANSYS. Prerequisites: ME 439, 522 or equivalent.

ME 641. Thermal Systems Design (3). Modeling, simulation, and optimization used as tools in the design of thermal systems. Engineering design principles, characteristics of thermal equipment, and economic considerations. Studies open-ended problems, including work on design projects in small groups. Prerequisites: ME 502 and 521.

ME 650. Selected Topics in Mechanical Engineering (1-3). New or special topics are presented on sufficient demand. Repeatable for credit when subject material warrants. Prerequisite: departmental consent.

ME 653. Internal Combustion Engines (3). A broad coverage of the basics of internal combustion engines empha-

sizing spark ignition and diesel engines. Definition of engine types and configurations and important variables used to evaluate performance and efficiency. Fundamentals learned in thermodynamics, chemistry, and mechanical design are used to understand engine design, performance, and control. Applications discussed are focused primarily on automotive use and involve power output, fuel consumption, and exhaust emissions. Prerequisite: ME 398.

ME 659. Mechanical Control (3).* Modeling and simulation of dynamic systems. Theory and analysis of the dynamic behavior of control systems, based upon the laws of physics and linear mathematics. Concerns classical methods of feedback control systems and design. Prerequisites: ME 403, ECE 282, and MATH 555.

ME 662. Mechanical Engineering Practice (3). 1R; 6L.* An exercise in the practice of mechanical engineering; students engage in a comprehensive design project requiring the integration of knowledge gained in prerequisite engineering science and design courses. Team effort and both oral and written presentations are a part of the experience. Prerequisite: mechanical engineering students in their last semester of study.

ME 664. Introduction to Fatigue and Fracture (3). Deals with the primary analytical methods used to quantify fatigue damage. These are the stress life approach, strain life approach, and the fracture mechanics approach. Prerequisites: ME 250, AE 333.

ME 665. Selection of Materials for Design and Manufacturing (3). Focuses on the selection of engineering materials to meet product and manufacturing requirements. Solution to various product and manufacturing problems by appropriate selection of materials is illustrated through the use of numerous examples and case studies. Prerequisites: ME 250, AE 333.

ME 666. Materials in Manufacturing Processes (3). Deals with fundamental principles of materials and their applications to manufacturing processes. Prerequisite: ME 250.

ME 667. Mechanical Properties of Materials I (3). Major focus on deformation mechanisms and on crystal defects that significantly affect mechanical properties. Also covers plasticity theory, yield criteria for multi-axial states of stress, fracture mechanics, and fracture toughness. Includes some review of basic mechanics of materials and elasticity as needed. Prerequisite: ME 250 or departmental consent.

ME 669. Acoustics (3). Fundamentals of acoustics including the study of simple harmonic systems, acoustic waves, transmission phenomena, and environmental and architectural acoustics. Prerequisites: MATH 555, AE 373.

ME 678. Studies in Mechanical Engineering (1-3).* Arranged individual, independent study in specialized content areas in mechanical engineering under the supervision of a faculty member. Requires written report or other suitable documentation of work for departmental records.

Three (3) hours maximum technical elective credit. Not for graduate credit. Prerequisite: departmental consent.

ME 719. Basic Combustion Theory (3). Introduction to the fundamental principles of combustion processes. Examines the chemistry and physics of combustion phenomena, that is, detonation and flames, explosion and ignition processes. Prerequisites: CHEM 111 and ME 502.

ME 729. Computer-Aided Analysis of Mechanical Systems (3). Modeling and analysis of planar motion for multibody mechanical systems including automatic generation of governing equations for kinematic and dynamic analysis, as well as computational methods and numerical solutions of governing equations. Open-ended student projects on engineering applications such as vehicle ride stability simulations for different terrains. Prerequisites: ME 339, AE 373, and MATH 555.

ME 737. Robotics and Control (3). A systems engineering approach to robotic science and technology. Fundamentals of manipulators, sensors, actuators, end-effectors, and product design for automation. Includes kinematics, trajectory planning, control, programming of manipulator, and simulation, along with introduction to artificial intelligence and computer vision. Prerequisite: ME 659 or equivalent.

ME 739. Advanced Machine Design (3). A broad coverage of principles of mechanical analysis and design of machine elements. Emphasizes dynamic system modelling, prediction of natural frequencies and forced response, effect of support flexibility, failure theories used in design, and fatigue life prediction. Typical mechanical systems studied are gears, bearings, shafts, rotating machinery, and many types of spring-mass systems. Uses fundamentals learned in mechanics, strength of materials, and thermal sciences to understand mechanical system modelling, analysis, and design. Prerequisite: ME 541 or instructor's consent.

ME 747. Microcomputer-Based Mechanical Systems (3). 2R; 3L. Microcomputer-based real-time control of mechanical systems. Familiarizes students with design and methodology of software for real-time control. Includes an introduction to the C programming language which is most relevant to interfacing and implementation of control theory in computer-based systems. Laboratory sessions involve interfacing microcomputers to mechanical systems and software development for control methods such as PID. Prerequisite: ME 659 or instructor's consent.

ME 750. Special Topics in Mechanical Engineering (1-3). New or special topics are presented on sufficient demand. Repeatable for credit when subject material warrants. Prerequisite: departmental consent.

ME 755. Intermediate Thermodynamics (3). Laws of thermodynamics, introduction to statistical concepts of thermodynamics, thermodynamic properties, chemical thermodynamics, Maxwell's relations. Prerequisite: ME 502 or departmental consent.

ME 759. Neural Networks for Control (3). Introduces specific neural network architectures used for dynamic system modeling and intelligent control. Includes theory of feed-forward, recurrent, and Hopfield networks; applications in robotics, aircraft and vehicle guidance, chemical processes, and optimal control. Prerequisite: ME 659 or departmental consent.

ME 760. Fatigue and Fracture (3). Covers fracture mechanics in metals, ceramics, polymers and composites. Suitable for graduate and undergraduate study in metallurgy and materials, mechanical engineering, civil engineering, and aerospace engineering where a combined materials-fracture mechanics approach is stressed. Prerequisite: ME 250 or departmental consent.

ME 762. Polymeric Composite Materials (3). A basic understanding and knowledge about the structure and mechanical properties of polymeric composite materials in detail. Discusses both short fiber and continuum fiber composites. Emphasizes special design considerations for composite materials including fracture mechanics and performance of composites under adverse conditions (fatigue and impact). Prerequisite: ME 250 or equivalent or departmental consent.

ME 764. Thermodynamics of Solids (3). Presents basic thermodynamic concepts which will form the working tools throughout the course. Emphasizes the interpretation of certain types of phase diagrams—not upon the use of thermodynamics to assist phase diagram construction but upon the use of phase diagrams to obtain thermodynamic quantities. Also, the thermodynamics of defects and defect interactions in metals, ceramics, polymers, elemental semiconductors, and compounds. Prerequisites: ME 250 and 398 or departmental consent.

ME 766. SEM and EDAX (3). Introduces Scanning Electron Microscopy (SEM), a powerful tool in materials science and engineering which can be used to analyze structural defects in materials. Discusses both the theory and experimental methods, as well as the application of these methods. Prerequisite: ME 250 or departmental consent.

ME 767. X-Ray Diffraction (3). Theory of X-ray diffraction, experimental methods, and their applications which can include determination of the crystal structure of materials, chemical analysis, stress and strain measurements, study of phase equilibria, measurement of particle size, and determination of the orientation of a single crystal. Prerequisites: ME 250 and AE 333 or departmental consent.

ME 781. Cooperative Education (1-8). A work-related placement with a supervised professional experience to complement and enhance the student's academic program. Intended for master's level or doctoral students in mechanical engineering. Repeatable for credit. May not be used to satisfy degree requirements. Prerequisite: graduate standing, department's consent, and graduate GPA of 3.000 or above. Offered Cr/NCr only.

* Normally not permitted for use toward the graduate degree in mechanical engineering.

Courses for Graduate Students Only

ME 801. Boundary Layer Theory (3). Development of the Navier-Stokes equation, laminar boundary layers, transition to turbulence, turbulent boundary layers, and an introduction to homogeneous turbulence. Prerequisite: ME 521 or departmental consent.

ME 802. Turbulence (3). An overview of the theory, practical significance, and computation of turbulent fluid flow. Prerequisites: ME 521 and 801.

ME 829. Advanced Computer-Aided Analysis of Mechanical Systems (3). Computational methods in modeling and analysis of spatial multibody mechanical systems. Includes Euler parameters; automatic generation of governing equations of kinematics and dynamics; numerical techniques and computational methods; computer-oriented projects on ground vehicles with suspension and steering mechanisms, crashworthiness, and biodynamics. Prerequisite: ME 729 or instructor's consent.

ME 832. Failure Analysis Applications in Mechanical Design (3). Application of engineering fundamentals to the study of mechanical failure brought about by the stresses, strains, and energy transfers in machine elements that result from the forces, deflections, and energy inputs applied. Emphasizes recognition, identification, prediction, and prevention of failure modes that are prevalent in machine-element design. Prerequisite: ME 439 or departmental consent.

ME 847. Applied Automation and Control Systems (3). **2R; 3L.** Control theory condensed to engineering practice with the analysis, design, and construction of operating control systems. Experiments with pneumatic, hydraulic, and electro-mechanical servo-systems. Implementation of feedback and feedforward control schemes for various industrial systems and machine tools. The experiments are project-oriented and intended to be representative of the current state-of-the-art in classical and modern control practice. Prerequisite: ME 659 or equivalent.

ME 850. Special Topics in Mechanical Engineering (3). New or special topics are presented on sufficient demand. Repeatable for credit when subject material warrants. Prerequisite: departmental consent.

ME 851. Principles and Applications of Conduction Heat Transfer (3). Theory and measurement, Fourier's equation, steady and unsteady state with and without heat sources, and sinks and numerical methods. Prerequisites: ME 522, MATH 757, or departmental consent.

ME 852. Principles and Applications of Convective Heat Transfer (3). Free and forced convection in laminar and turbulent flow. Includes analysis and synthesis of heat transfer equipment. Prerequisite: ME 522 or departmental consent.

ME 853. Principles and Applications of Radiative Heat Transfer (3). Radiative properties of real surfaces, configu-

ration factor analysis, radiative transfer in participating media, exchange factor analysis, Monte Carlo methods. Prerequisite: ME 522 or departmental consent.

ME 854. Two-Phase Flow Heat Transfer (3). Thermodynamic and mechanical aspects of interfacial phenomena, boiling, and condensation near immersed surface, pool boiling, internal flow convective boiling, and condensation. Prerequisites: ME 522, MATH 555, or departmental consent.

ME 858. Computational Fluid Dynamics and Heat Transfer I (3). Basic finite difference/finite volume methods; finite difference/volume representation of partial differential equations; stability analysis; finite difference/volume methods for solution of heat and fluid flow equations; grid generation and use of modern computer codes/software for analysis and visualization. Prerequisites: ME 521 and 522 or equivalent.

ME 860. Introduction to Ceramics (3). Introduces the fundamental principles of ceramic science and engineering with application on ceramics processes and fabrications. Presents the concepts and properties utilizing the crystal structure background. Discusses non-equilibrium aspect of phase relation in ceramics systems and their influence on processing parameters. Covers the microstructure form by liquid, liquid-solid, and solid-state reaction with some detail in combination with heat treatment. Students are expected to have backgrounds in chemistry, physics, math, thermodynamics, mechanics of solids, and introduction to materials in undergraduate engineering courses.

ME 864. Physical Metallurgy (3). Covers a range of basic concepts in physical metallurgy essential for further study in materials engineering. Topics include structure and diffusion, dislocations, defects and thermal processes, solid solution and hardening, diffusion, and phase diagrams and transformations. Prerequisites: ME 250 and 398, AE 333, or departmental consent.

ME 866. Advanced Fracture Mechanics (3). Covers the fracture mechanics of elastic-brittle, ductile, time dependent, and heterogeneous materials at an advanced level. The material is suitable for graduate study only in metallurgy and materials, mechanical engineering, and aerospace engineering where a combined materials-fracture mechanics approach is stressed. Prerequisites: ME 250, AE 333, or departmental consent.

ME 867. Mechanical Properties of Materials II (3). After a brief review of pertinent concepts of the macro-mechanical behavior of deformable bodies, course focuses on deformation mechanisms and on crystal defects that significantly affect mechanical properties and strengthening mechanisms. This includes point, line, and planar crystalline defects; dislocation dynamics; and various hardening and strengthening mechanisms. Concludes with discussion of physical properties and testing methods to measure these properties. Prerequisite: ME 667 or departmental consent.

ME 876. Thesis (1-4). Graded *S/U* only. Repeatable for credit toward the MS thesis option up to 6 hours. Prerequisite: consent of MS thesis advisor.

ME 878. MS Directed Project (1-3). A project conducted under the supervision of an academic advisor for the directed project option. Requires a written report and an oral presentation on the project. Graded *S/U* only. Prerequisite: consent of academic advisor.

ME 890. Independent Study in Mechanical Engineering (1-3). Arranged individual, independent study in specialized content areas. Prerequisite: instructor's consent.

ME 901. Advanced X-Ray Diffraction Theory (3). First part concentrates on the fundamental X-ray diffraction theories including dynamical theory of X-ray and anomalous absorption, with which a serious student in this field must be thoroughly familiar. Second part emphasizes the general theory of X-ray diffraction in a concise and elegant form using Fourier transforms. The general theory is then applied to various atomic structures, ideal crystals, imperfect crystals, and amorphous bodies. Prerequisites: ME 767, MATH 757.

ME 958. Computational Fluid Dynamics and Heat Transfer II (3). Vector form of the Navier-Stokes and energy equations; generalized transformation of the flow equations to the computational domain; numerical methods for inviscid flow equations, boundary layer-type equations, "parabolized" Navier-Stokes equations, and the Navier-Stokes equations. Prerequisite: ME 858 or equivalent.

ME 960. Advanced Selected Topics (1-3). New or specialized advanced topics in mechanical engineering. Prerequisite: instructor's consent.

ME 962. Advanced Ceramics (3). Covers concepts in ceramics science and engineering essential to understanding and using advanced ceramic materials such as high temperature metaloceramics. Expands coverage of fundamental concepts and physical properties presented in ME 860. Provides deeper understanding of crystalline solids and characteristic properties of ceramics. Incorporates many of the most recent advances in the area. Students are expected to have backgrounds in chemistry, physics, math, thermodynamics, mechanics of solids, and introduction to materials in undergraduate engineering courses.

ME 976. PhD Dissertation (1-16). Graded *S/U* only. Repeatable for credit. Prerequisite: admission to doctoral aspirant status.

ME 990. Advanced Independent Study (1-16). Arranged individual, independent study in specialized content areas. Repeatable toward the PhD degree. Prerequisites: advanced standing and instructor's consent.

The following abbreviations are used in the course descriptions; R stands for lecture and L for laboratory. For example, 4R; 2L means 4 hours of lecture and 2 hours of lab.