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 adviser for the directed project option. Requires a written report and an oral presentation on the project. Graded *S/U* only. Prerequisite: consent of academic adviser.

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. Explores 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). Repeatable for credit. Graded *S/U* only. Prerequisite: admission to doctoral aspirant status.

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

Electrical Engineering and Computer Science (EECS)

Graduate Faculty

Professors: Ward T. Jewell, Hyuck M. Kwon, Ravindra Pendse (associate provost and chief information officer, academic affairs and research), M. Ed Sawan, Steven R. Skinner

Associate Professors: Rajiv Bagai, Prakash Ramanan, Asrat Teshome, John M. Watkins (graduate coordinator and chairperson)

Assistant Professors: Yanwu Ding, Neeraj Jaggi, Preethika Kumar, Vinod Nambodoori, Sejun Song, Bin Tang

Lecturer: Keenan Jackson, Julie Taylor

The department of electrical engineering and computer science offers courses of study leading to three Master of Science (MS) degrees; one in computer networking, one in computer science, and another in electrical engineering. It also offers courses leading to the Doctor of Philosophy (PhD) degree in electrical engineering.

Master of Science in Computer Networking

This is a comprehensive degree program that prepares graduate students for careers in computer networking and information security. The curriculum structure provides students with an integrated experience in system engineering, economics, architecture, computer security, and policies of computer communication networks.

Master of Science in Computer Science

Through a combination of advanced courses and electives, the MS degree in computer science seeks to provide a level of concentration suitable for advanced professional work and/or further graduate study in computer science.

Master of Science in Electrical Engineering

In addition to the general admission requirements for all engineering students, electrical engineering and computer science students must submit official general GRE scores in order to be considered for admission.

Courses of study leading to the MS degree are available with specializations in any of the following six fields: (1) control systems, (2) communication, (3) signal processing, (4) computers and digital systems, (5) energy and power systems, and (6) computer networking. Details of the MS program can be found at the beginning of this chapter.

Doctor of Philosophy

Courses of study leading to the Doctor of Philosophy (PhD) degree in electrical engineering are available with specializations in control theory, communication/signal processing, digital systems, energy and power systems, and computer networking. Details of the PhD program can be found at the beginning of this chapter.

In addition to the general admission requirements for all doctoral engineering students, admission to the PhD program in the electrical engineering and computer science department requires the completion of a master's degree in engineering or physical sciences and a graduate grade point average of at least 3.500 on a 4.000 scale.

Facilities

Modern electrical engineering laboratories contain facilities for experimental work in areas of instrumentation, control systems, computers and digital systems, electronics, circuits, energy conversion, power electronics, power quality, and computer networking.

Computer Science (CS)

Courses for Graduate/Undergraduate Credit

CS 510. Programming Language Concepts (3). 3R; 1L. Theoretical concepts in the design and use of programming languages, including scope of declarations, storage allocation, subroutines, modules, formal methods for the description of syntax, and semantics. Introduction to the concepts of different styles of languages—imperative languages, functional languages, logic languages, object-oriented languages, etc. Prerequisites: CS 300 and 322, each with a *C* or better.

CS 540. Operating Systems (3). 3R; 1L. The fundamental principles of operating systems: process synchronization, scheduling, resource allocation, deadlocks, memory management, file systems. Studies a specific operating system in depth. Programming assignments consist of modifications and enhancements to the operating system studied. Prerequisites: CS 300 and 312, each with a *C* or better.

CS 544. Digital Design and Simulation with Verilog. (3). Behavioral and structural modeling of digital systems using the Verilog Hardware Description Language. Students use a commercial computer-aided design tool. Modeling and simulation from register-transfer level through switch level. Top-down modular design and test; introduction to verification and validation. Prerequisite: CS 294. Corequisite: CS 300.

CS 560. Data Structures and Algorithms II (3). 3R; 1L. Design and analysis of algorithms and proof of correctness. Analysis of space and time complexities of various algorithms including several sorting algorithms. Hashing, binary search trees, and height balanced trees. Algorithm design techniques including divide and conquer, greedy strategies, and dynamic programming. Elementary graph algorithms. Prerequisites: CS 300, 322; MATH 243 and STAT 460 with a *C* or better in each.

CS 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: CS 394, or 238 and 294.

CS 615. Compiler Construction (3). 2R; 2L. First compiler course for students with a good background in programming languages and sufficient programming experience. Covers over-all design and organization of compilers and interpreters, lexical and syntax analysis, construction of symbol tables, scope analysis, type checking, error recovery, run-time organization, intermediate code and its interpretation, code generation, and optimization. Project-oriented course. Emphasizes practical experience gained through the design and implementation of a simplified but non-trivial compiler for a strongly typed, procedural language. The implementation is carried out in a modern systems programming environment. Prerequisite: CS 510 with a *C* or better.

CS 644. Advanced Unix Programming (3). 3R; 1L. Improves skills in C programming under the Unix environment. Covers file I/O, both buffered and unbuffered, working with the Unix file system, concurrent programming with multiple processes, and process control. Also includes the use of signals and concepts of interprocess communication with pipes and FIFOs. Students must have prior knowledge of C language and its use of structures and pointers. Prerequisite: CS 300 with a *C* or better or instructor's consent.

CS 655. Information Delivery on the Internet (3). 3R; 1L. Explores the capabilities of providing information on the World Wide Web. Information is typically provided through some sort of Web site that incorporates static text and the dynamic capabilities of the Web. Learn how to create an interactive Web site through the use of CGI and Java programming and how to interconnect a Web site to databases and generate images on the fly. Java portion covers a wide range of Java language and the Applet interface and utilities. Prerequisite: CS 300 with a *C* or better or instructor's consent.

CS 665. Introduction to Database Systems (3). 3R; 1L. Fundamental aspects of database systems, including conceptual database design, entity-relationship modeling, and object-oriented modeling; the relational data model and its foundations, relational languages, and SQL (Structured Query Language); logical database design, dependency theory, and normal forms; physical database design, file structures, indices, and decomposition; integrity, security, concurrency control, recovery techniques, and optimization of relational queries. Prerequisites: CS 300 and 322, each with a *C* or better.

CS 666. Computer Forensics (3). Computer crimes include security violations, unauthorized access, and theft of sensitive information. Discusses procedures for the identification, preservation, and extraction of electronic evidence that can be legally used when a computer crime is committed. From the network perspective, course discusses auditing and investigation of network and host intrusions. Forensic tools and resources for system administrators and information system security officers are covered. Legal issues related to computer and network forensics are discussed. There are about eight programming-related laboratory exercises in this class. Intended for senior undergraduate students and graduate students majoring in computer science. Prerequisites: CS 138 and 540. In addition, good programming skills in one of the languages (C, C++, or Java), familiarity with the operating systems (UNIX/Windows) are required.

CS 680. Introduction to Software Engineering (3). 2R; 2L. An introduction to the body of knowledge, presently available tools, and current theories and conjectures regarding the process of program development. Studies these topics from several different viewpoints, ranging from the individual program statement to a large programming project. Prerequisites: CS 300 and 410, each with a *C* or better.

CS 684. Applications Systems Analysis (3). 3R; 1L. A study of the methods for analyzing business systems problems and other large-scale applications of the computer. At the crossroads of computer technology, management science and human relations, systems analysis is the keystone in the education of the well-trained computer applications analyst. Includes systems design, cost benefit analysis, database design, distributed processing, project management, and documentation. Prerequisite: CS 300 with a *C* or better.

CS 697. Selected Topics (1–3). 1–3R; 1L. Selected topics of current interest. Repeatable for credit with departmental consent. Prerequisite: departmental consent.

CS 720. Theoretical Foundations of Computer Science (3). 3R; 1L. Provides an advanced level introduction to the theoretical bases of computer science. Computer science theory includes the various models of finite state machines, both deterministic and nondeterministic, and concepts of decidability, computability, and formal language theory. Prerequisite: MATH 322 or equivalent with a *C* or better.

CS 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 broadband networks. Prerequisite: EE 383 or departmental consent.

CS 737. Wireless Networking (3). Covers topics ranging from physical layer to application layer in the wireless and mobile networking fields. Explores physical layer issues of wireless communications, wireless cellular telephony, ad-hoc networks, mobile IP and multicast, wireless LAN (IEEE 802.11), security, Bluetooth and WAP, etc. Imparts general knowledge about wireless communication technologies and ongoing research activities. Prerequisite: CS 736.

CS 738. Embedded Systems Programming (3). Studies 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: CS 594 or equivalent.

CS 742. Computer Communication Networks (3). 2R; 2L. Introduction to network programming for the Internet environment including the basic concepts of TCP/IP, client-server paradigm, programming of clients, and various types of servers, remote procedure calls, concurrency management, and interconnection techniques. Emphasizes the design principles that underlie implementation of practical applications. Prerequisite: CS 300 with a *C* or better or departmental consent.

CS 744. Introduction to VHDL (3). 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: CS 138 and 394.

CS 750. Workshop in Computer Science (1–5). Short-term courses with special focus on introducing computer science concepts. Repeatable for credit. Prerequisite: departmental consent.

CS 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 CS department's routing and switching lab. Prerequisite: CS 736 or departmental consent.

CS 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 EECS department's routing and switching lab. Prerequisite: CS 764 or departmental consent.

CS 766. Information Assurance and Security (3). Provides basic concepts in information assurance and security including encryption, digital certificates, security in networks, operating systems, and databases. Topics in intrusion detection, legal and ethical issues in security administration will also be discussed. Prerequisite: CS 736 or 764, or departmental consent.

CS 771. Artificial Intelligence (3). 3R; 1L. Heuristic versus algorithmic methods, principles of heuristic approach, and cognitive processes. Also covers objectives and methods of artificial intelligence research and simulation of cognitive behavior. Includes a survey of appropriate examples from various areas of artificial intelligence research. Prerequisites: CS 300 and 322 with a grade of *C* or better in each.

CS 781. Cooperative Education in Computer Science (1–3). Practical experience in a professional environment to complement and enhance the student's academic program. For master's level CS students. Repeatable, but may not be used to satisfy degree requirements. Offered *Cr/NCr* only. Prerequisites: departmental consent and graduate GPA of 3.000 or above.

CS 798. Individual Projects (1–3). Allows beginning graduate students and mature undergraduate students to pursue individual projects of current interest in computer science. Graded *S*/*U* only. Prerequisite: departmental consent.

Courses for Graduate Students Only

CS 805. Compiler Theory (3). 3R; 1L. Theory of compilation of programming languages. Finite state machines and lexical analysis. Context-free languages and recognizers. Theory of parsing, including recursive-descent, top-down, and bottom-up parsers. Formal description of semantics and code generation. Code optimization. Compiler-compilers. Not open for credit to those with previous credit for CS 811. Prerequisites: CS 510 and 720.

CS 810. Programming Languages: Advanced Concepts (3). 3R; 1L. An advanced study of programming language structures and design. Data and control structures and their abstraction. Concurrent programming structures. Formal specifications of syntax and semantics, including models for establishing program correctness. Criteria for language design. Prerequisites: CS 510 and 720.

CS 817. Advanced Java Technology (3). 3R; 1L. Covers advanced features of the Java language, the underlying implementation technology (Java Virtual Machine), and extensions of the Java technology. Includes concurrent object-oriented programming and Java core reflection, and extensions of the Java technology providing parametric polymorphism and persistence. Includes challenging programming projects. Time also devoted to recent Java research and development results. Prerequisite: CS 510 with a *B* or better.

CS 836. Computer Performance Analysis (3). Teaches the basic concepts in stochastic modeling of systems for analysis and for simulation. Analytic modeling techniques include discrete- and continuous-time Markov chains, queuing theory, and queuing networks, as well as approximate methods based on these techniques. Operational analysis presents a non-stochastic, measurement-based perspective to the analysis of computer systems. Also emphasizes discrete-event simulation, a widely-used technique in many areas of performance evaluation. Performance metrics taken from stochastic simulations are phantom variables, and are subject to the same types of statistical analysis as data obtained from real systems. Prerequisite: EE 754.

CS 843. Distributed Computing Systems (3). 3R; 1L. A study of hardware and software features of online multiple computer systems emphasizing network design and telecommunication. Includes distributed databases, interprocessor communication and centralization versus distribution. Also includes study of the use of microcomputers in representative configurations. Prerequisites: CS 540 and 742.

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

CS 862. Advanced Database Systems (3). 3R; 1L. Covers recent developments and advances in database technology. Designed for students who have had a first database course and have a good background in the related computer science disciplines. Possible topics include: extended relational database management systems, object-oriented database management systems, deductive databases, database type systems and database programming language, persistent languages and systems, distributed databases. Prerequisite: CS 665.

CS 863. Multimedia Database Systems (3). 3R; 1L. Presents state-of-the-art techniques for representing and manipulating information in multimedia databases. Emphasizes image, audio, video, and document data. Covers theoretical principles underlying storage, retrieval, querying, and delivery of such data. Requires good prior knowledge of relational and/or object-oriented databases. Prerequisite: CS 665 with a grade of *C* or better.

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: CS 764 and graduate standing in EECS.

CS 864. Database Query and Processing Optimization (3). 3R; 1L. Covers concepts and techniques for efficient and accurate processing of queries for a variety of data forms, such as centralized and distributed relational databases as well as object-oriented, fuzzy, and multimedia databases. Prerequisite: CS 665 with a grade of *C* or better; CS 560 recommended.

CS 865. Principles of DBMS Implementation (3). 3R; 1L. Deals with two of the three main components of a relational Database Management System (DBMS): storage management and query processing. The third component, transaction management, is covered as time permits. Prerequisite: CS 665 with a grade of *C* or better; CS 560 recommended.

CS 866. XML Databases (3). 3R; 1L. Deals with modeling semi-structured Web databases as XML databases, their schema (DTD and XML schema), integrity constraints, and their query languages (XPath, XSLT, and XQuery). Prerequisite: CS 665 with a grade of *C* or better.

CS 867. Object-Oriented Databases (3). 3R; 1L. Covers object-oriented technology as it applies to databases and persistent object systems. Focuses on the advantages of the object-oriented database technology in complex application areas. Java database and persistent technologies and the associated tools have an important role here, along with the related industrial standards, such as ODMG. Provides design and implementation experience using a challenging application. Devoted to recent research and development results. Prerequisites: CS 665 and an object-oriented programming language course such as CS 217 or 350L or instructor's consent.

CS 868. Database Transaction Management (3). 3R; 1L. Topics covered include logging and recovery from system failures, concurrency control, serial and serializable schedules, schedulers, and deadlock detection and recovery. Prerequisite: CS 665.

CS 891. Project (3). An intensive project involving the analysis and solution of a significant practical problem which must be supervised by a CS graduate faculty adviser; it can be job-related. Students must write a report on the project and pass an oral final examination by an ad hoc faculty committee headed by the project adviser. Graded *S*/*U* only. Prerequisite: departmental consent.

CS 892. Thesis (1–6). May be repeated for up to 6 hours of credit. Graded *S*/*U* only. Prerequisite: departmental consent.

CS 893. Individual Reading (1–5). Graded *S*/*U* only. Prerequisite: departmental consent.

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

CS 898. Special Topics (2–3). 2–3R; 1L. Topics of current interest to advanced students of computer science. Repeatable for credit with departmental consent. Prerequisite: departmental consent.

Electrical Engineering (EE)

Courses for Graduate/Undergraduate Credit

EE 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, EE 383.

EE 577. Special Topics in Electrical and Computer Engineering (1–4). New or special courses presented on sufficient demand. Repeatable for credit. Prerequisite: departmental consent.

EE 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. Does not count toward a graduate electrical engineering degree.

EE 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 shite Gaussian noise channel. Additional topics such as PSK and FSK digital communication systems covered as time permits. Prerequisites: EE 383 and either STAT 471 or IME 254.

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

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

EE 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: EE 282.

EE 616. Introduction to Wireless Communications (3). Introduces students to the basic principles and issues related to wireless communications. Students consider the basic technical aspects of the wireless communications, the market issues, social and cultural impact of the wireless communications, deregulation issues as well as political issues relating to the development and wide popularity of wireless communications. The level of the course is applicable to junior or senior undergraduates as well as beginning graduate students. Prerequisites: EE 383, IME 254.

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

EE 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: EE 492.

EE 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: CS 194 and 493 or departmental consent.

EE 697. Electric Power Systems Analysis II (3). Analysis, design, modeling, and simulation of high-voltage electric power transmission systems and rotating generators. Simulations include short circuit studies, economic dispatch, and transient stability. Prerequisite: EE 598.

EE 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 baseband and band-pass systems; intersymbol interference; effects of noise on system performance; optimum systems; and general Mary digital systems in signal-space. Prerequisites: EE 586 and 754.

EE 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: EE 383 and either STAT 471 or IME 254.

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

EE 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: EE 383 and 492.

EE 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: EE 383 or departmental consent.

EE 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.

EE 791. Design of Analog Integrated Circuits (3). Concerned primarily with the design of analog integrated circuits, and detailed analysis. The design concentrates on MOS devices, but some attention will also be given to bipolar technology. Dynamic loads will dominate, as the need is to limit passive components such as resistors and capacitors as much as possible. Specific circuits include current sources, voltage references, differential amplifiers, with operational amplifiers receiving the emphasis. SPICE simulation will be extensively used, including parameter sweeps, temperature effects, and sensitivity analysis as well as frequency response and time-domain analysis. Prerequisite: EE 691.

EE 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 use in analysis and design of linear control systems. Prerequisite: EE 383.

EE 796. Electric Power Distribution (3). Analysis, design, modeling, and simulation of radial medium-voltage electric power distribution systems. Simulations include power flow and short circuit. Prerequisite: EE 598.

Courses for Graduate Students Only

EE 810. Optical Networks (3). A comprehensive study of fiber optic communication systems, components, and networks. Subjects include modulation, wavelength division multiplexing, dispersion, single mode and multimode fibers, fiber optic components, optical cross-connects, and SONET rings. Prerequisite: EE 510.

EE 816. Advanced Signal Processing for Wireless Communication (3). Introduces the role of statistical signal processing in wireless communication and studies various signal processing techniques. Begins with an overview of the fundamentals of wireless communication and physical properties of the wireless channel. Covers topics such as adaptive filtering, interference suppression, space-time processing and MIMO techniques. Corequisites: EE 726 and 754.

EE 817. Theory of Detection and Estimation (3). Introduces students to the fundamental ideas of detection and estimation theory. Some of the topics covered include binary hypothesis testing, potimal signal detection, performance analysis of optimum detectors, elements of parameter estimation and signal estimation. These ideas are basic to statistical signal processing and communication transceiver design. Prerequisite: EE 754.

EE 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) communication. Prerequisite: EE 726.

EE 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 prior 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: EE 754.

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

EE 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.

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

EE 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 communication systems. Prerequisite: EE 726.

EE 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: EE 792.

EE 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: EE 598.

EE 898. Electric Power Quality (3). Measurement, analysis, modeling, simulation, and mitigation of electric power quality on the medium- and low-voltage distribution systems. Prerequisite: ECE 798.

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

EE 981. Co-op (1). A work-related placement with a supervised professional experience to complement and enhance the academic program. Intended for master's-level or doctoral students in electrical engineering. Repeatable for up to 8 hours. May not be used to satisfy degree requirements. Graded *S*/*U* only. Prerequisites: departmental consent and a graduate GPA of at least 3.000.

EE 986. Wireless Spread-Spectrum Communication (3). Explains what spread-spectrum communication is and why direct-sequence code-division multiple access (DS-CDMA) spread-spectrum is used for wireless communication. Studies the block diagrams of the IS-95 forward and reverse wireless communication links under multi-path mobile fading environment using analysis techniques and simulation. Analyzes pseudo-noise (PN) signal generation, the band-limited waveform shaping filter, convolutional 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: EE 726.

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

EE 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 nonlinearities, 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: EE 893.

Industrial and Manufacturing Engineering (IME)

Graduate Faculty

Professors: Krishna K. Krishnan (graduate coordinator), Viswanathan Madhavan, Don Malzahn, (undergraduate coordinator and interim chairperson), Janet M. Twomey

Associate Professors: Michael Jorgensen, Gamal Weheba, Lawrence Whitman, Bayram Yildirim

The industrial and manufacturing engineering (IME) department at WSU is committed to instruction and research in design, analysis, and operation of manufacturing and other integrated systems of people, material, equipment, and capital. The graduate programs are directed toward both full-time and part-time students with a special emphasis on providing training and experience in performing independent research on topics with theoretical as well as applied interest. Students are encouraged to conduct research or take courses on topics that overlap several disciplines.

The IME department offers Master of Engineering Management (MEM), Master of Science, and Doctor of Philosophy degree programs in industrial engineering (MSIE and PhDIE, respectively). Fields of specialization for the MSIE and PhDIE programs include engineering systems, ergonomics/human factors, and manufacturing systems engineering. The department also offers seven graduate certificate programs in the following areas: advanced manufacturing analysis, composite materials and their processing, design for manufacturing, foundations of six sigma and quality improvement, industrial ergonomics and safety, lean systems, and system engineering and management.

Facilities

The following facilities used in teaching and research are available for graduate students:

Cessna Manufacturing Lab: Activities include research and teaching. The laboratory supports all courses offered in the areas of manufacturing engineering, tool design, advanced and nontraditional machining, composite machining, and computer-aided manufacturing. The lab is also used by other departments, mainly the ME department, for its educational and research needs. The Mini Baja team makes extensive use of this lab which also supports multi-disciplinary courses and senior design projects.

Composites Manufacturing Lab: This newly established laboratory supports a number of courses on composites materials and manufacturing processes. It is designed to provide students with hands-on experience in composites manufacturing and testing methods used in the aerospace industry.

Reliability and Maintenance Engineering Lab: This new laboratory supports courses in the reliability and maintainability areas. Its main goal is to provide students with hands-on experiences in modeling accelerated life testing and degradation testing, optimal design of testing plans, robust reliability design, system reliability optimization, condition-based maintenance (CBM), and engineering risk assessment. To carry out these teaching-related activities, the lab hosts accelerated life/degradation testing equipment and several test beds for CBM.

Ergonomics and Occupational Biomechanics Laboratory: This lab supports teaching and research in fields related to industrial ergonomics.

CAD/Systems Lab: A teaching lab that supports a number of courses including engineering graphics, systems simulation, and neural networks. The lab is also used on a regular basis by the ME and other departments to support a number of courses.

IME Senior Project Studio: This new lab is designed for the IME senior project using funds set aside from the IME general budget. The lab houses five stations with computers and a printer and a place for student groups to hold their design meetings.

Rapid Prototyping and Product Development Labs: Activities include research and teaching, and support courses in all IME areas as well as the senior design course.

Manufacturing Process Lab: This lab is used to carry out research in machining, sheet metal forming, and in support of manufacturing engineering courses.

Virtual Reality Development Lab: This lab has been established with funds provided by the project *Innovation in Aircraft Manufacturing Through System-Wide Virtual Reality Models and Curriculum Integration*, an NSF *Partnerships for Innovation* program. Additional funding is provided by NSF-EPSCoR through the *Virtual Reality of Manufacturing Processes* project.