

# ENGINEERING DESIGN

In fall 1995, the Watson School began a full, four-year engineering program in addition to the upper-division transfer program it had been offering since the school's inception in 1983. The lower-division program in engineering is coordinated by the Division of Engineering Design, which is responsible for developing and offering an integrated sequence of courses that prepares students for entrance into the junior programs in computer, electrical, mechanical, and industrial and systems engineering. The lower-division syllabus is designed to parallel the experience of students in conventional engineering programs at other institutions, including the engineering science programs at New York state community colleges, to ensure that students from those programs can transfer into the Watson School engineering programs as juniors.

## Design, Technology and Communications (DTeC Sequence)

In keeping with the Watson School philosophy of balancing theory and practice through laboratory and design experience, the lower-division program provides at least one laboratory course in each semester. The focus of the program is the DTeC (Design, Technology and Communications) four-semester course sequence (WTSN 111, 112, 211 and 212), which integrates instruction in computer applications and programming, graphics, and technical writing and speaking through use of open-ended design projects. The first two semesters of DTeC focus on the basic skills of computer usage through applications and programming, writing, speaking and graphics. Students participate in team-based design projects, such as multimedia products, as a way to practice the use of these skills. In the sophomore courses, students learn more advanced computer programming concepts and the design and construction of mechatronic devices using embedded controllers, in preparation for upper-division courses.

In addition to DTeC, special engineering courses and laboratories dealing with mechanics, circuits, science of materials, and physical phenomena are offered as part of the lower-division curriculum.

Students are encouraged to earn an international studies certificate in parallel with their engineering degree. Students interested in this program should seek advice from the Watson School advising office prior to initial registration.

## REQUIREMENTS

To meet the requirements for admission into the

junior-level engineering programs, engineering majors will complete the following lower-division program.

### General Education Requirements

Beginning in fall 1996, all newly admitted Watson School students are subject to the University's General Education requirements within their academic major. (These requirements are waived for all transfers who have earned a minimum of 57 credits prior to entering their Binghamton University major.)

For engineering freshmen, the science, mathematics, composition and aesthetics requirements are automatically met by fulfilling their first year of engineering. The required global vision courses can also be met through the freshman year humanities/social science requirements, by selecting carefully from the special list provided by the Watson School advising office. Physical activity/wellness courses are noted in the schedule of classes each semester. For further information, refer to the General Education section of this *Bulletin*, or see the "General Education and Your Watson School Major" handout available in the Watson School advising office.

<i>Freshman Year/Fall Semester</i>	<i>credits</i>
MATH 221. Calculus I .....	4
CHEM 111. Chemical Principles .....	4
Humanities/Social Sciences* .....	4
WTSN 111. DTeC I .....	4
Physical Activity/Wellness .....	1
<b>TOTAL .....</b>	<b>17</b>

<i>Freshman Year/Spring Semester</i>	<i>credits</i>
MATH 222. Calculus II .....	4
PHYS 131. General Physics I .....	4
Humanities/Social Science* .....	4
WTSN 112. DTeC II .....	4
Physical Activity/Wellness .....	1
<b>TOTAL .....</b>	<b>17</b>

<i>Sophomore Year/Fall Semester</i>	<i>credits</i>
MATH 371. Differential Equations .....	4
PHYS 132. General Physics II .....	4
EE 260. Electrical Circuits .....	4
ME 291. Mechanical Phenomena Lab .....	2
WTSN 211. Engineering Programming .....	3
<b>TOTAL .....</b>	<b>17</b>

<i>Sophomore Year/Spring Semester</i>	<i>credits</i>
MATH 323. Calculus III .....	4
ME 271. Engineering Mechanics .....	5
EE 292. Electrical Phenomena Lab .....	2
WTSN 212. Embedded Control .....	3
WTSN 272. Science of Engineering Materials .....	3
<b>TOTAL .....</b>	<b>17</b>

*\*Humanities/social science courses must meet certain guidelines. Contact the Watson School advising office or your faculty adviser.*

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## COURSE OFFERINGS/ UNDERGRADUATE

### WTSN 111. DESIGN, TECHNOLOGY AND COMMUNICATIONS I *fall only, 4 credits*

First course in a two-semester integrated introduction to computer applications, engineering graphics, audio, technical communications and design. Prerequisite: engineering major or permission of instructor.

### WTSN 112. DESIGN, TECHNOLOGY AND COMMUNICATIONS II *spring only, 4 credits*

Continuation of WTSN 111, introduction to computer programming and computer graphics. Satisfactory completion of WTSN 111 and 112 meets General Education requirements in composition and aesthetics. Prerequisite: WTSN 111.

### WTSN 201. INTRODUCTION TO ENGINEERING GRAPHICS *spring only, 2 credits*

Course emphasizes technical sketching and visualization in three dimensions, using orthogonal projections, isometric and oblique pictorial views, auxiliary views, section views, intersection of lines and planes. Use of CAD system will be introduced. No prerequisites.

### WTSN 204. INTRODUCTION TO ENGINEERING COMPUTING *spring only, 2 credits*

Basic concepts of programming introduced using the C language. Designing, coding, debugging and documentation emphasized. Simple problems from engineering practice used as examples. No prerequisite.

### WTSN 211. ENGINEERING PROGRAMMING *fall only, 3 credits*

Language-independent programming structures, taught in the context of engineering applications. Basics of object-oriented programming with emphasis on classes. Laboratory exercises in using a select object-oriented programming language. Prerequisites: WTSN 112 or equivalent introductory programming course.

### WTSN 212. EMBEDDED CONTROL *spring only, 3 credits*

Introduction to embedded control, A/D and D/A conversion and logic design. Hardware and software interfacing. Application software for engineering. Prerequisite: WTSN 211 or permission of instructor.

### WTSN 272. SCIENCE OF ENGINEERING MATERIALS *spring only, 3 credits*

Introduction to the structures and structure-related properties of engineering materials: metals, ceramics and polymers; quantum mechanics, physical properties of matter. Prerequisites: CHEM 111, PHYS 132.

*Refer to School-Wide section for other WTSN courses.*

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## Electrical Engineering UNDERGRADUATE PROGRAMS

The bachelor of science program in electrical engineering is accredited by the Accreditation Board for Engineering and Technology (ABET). Students at Binghamton enter the junior year from the Watson School Division of Engineering Design. The curriculum is also unique in that it is especially structured to match transfer students to the program in accordance with the Two-Year Engineering Science Association (TYESA) agreement with community colleges in New York state.

The primary goal of the undergraduate program is the preparation of graduates for employment in high technology and for advanced education. The program emphasizes the fundamentals of the discipline and provides specialization through the selection of elective courses in computers, control/communication systems and microelectronics. Graduates have the ability to apply mathematics and science to the practice of electrical engineering. Students also acquire experience and skills in the application of modern engineering software tools and hardware technology. The essence of engineering is design. The graduate can identify, formulate and solve engineering problems, design systems, components and processes to specification. Students also learn to design and conduct experiments, and to analyze and interpret data.

To work as an engineer, the graduate must communicate effectively and participate on multidisciplinary teams. A two-semester senior design project requires the formulation of specifications, scheduling, construction, testing and delivery of the finished product. The group project is done in cooperation with engineers from local industry or other external clients. Students also may, after completing the junior year, apply for paid full-time industrial internships of length from six to 15 months while earning up to six credits of technical elective, and return for their senior year.

The research mission of the department brings the latest scientific and technical developments directly into the classroom, and provides opportunities for undergraduate participation in research. Graduates are prepared to undertake the self-motivated, lifelong learning necessary to maintain their professional skills throughout their career.

Students acquire an understanding of their professional and ethical responsibility, and are introduced to contemporary global and social issues. The department also encourages an

international perspective through the assistance it provides to students seeking such experience overseas and by the welcome it extends to visiting exchange students.

Program objectives are periodically evaluated, based on the needs of students, alumni, industry advisers and other constituencies. Results of evaluations are applied to further development and improvement of the program.

## BS Degree in Computer Engineering

A new bachelor of science degree in computer engineering was recently approved by the State Education Department. For more information, contact the Watson advising office.

## Requirements for BS Degree in Electrical Engineering

To receive the BS degree in electrical engineering, students must complete a minimum of 65 credit hours in the upper-division program as outlined below.

All Binghamton University freshmen must also meet the University's General Education requirements. However, those requirements are waived for all transfers who have earned a minimum of 57 credits prior to entering the University. Any transfer student with the associate degree in engineering science, or equivalent courses, will have this waiver. For more details, refer to the General Education section of this *Bulletin*, or consult with the Watson School advising office.

<i>Junior Year/Fall Semester</i>	<i>credits</i>
EE 301. Signals and Systems .....	3
EE 315. Electronics I .....	4
EE 351. Digital Logic Design .....	3
ISE 361. Analysis of Variability in Systems ...	4
CS 341. Data Structures and Algorithms .....	3
TOTAL .....	17

<i>Junior Year/Spring Semester</i>	
EE 302. Signal Processing .....	4
EE 316. Electronics II .....	3
EE 332. Semiconductor Devices .....	3
EE 361. Control Systems .....	3
Humanities/Social Science Elective I* .....	4
TOTAL .....	17

<i>Senior Year/Fall Semester</i>	
EE 423. Electromagnetics .....	4
EE 487. Senior Project I .....	4
EE Technical Elective I* .....	3
Humanities/Social Science Elective II* .....	4
TOTAL .....	15

### *Senior Year/Spring Semester*

EE 477. Communications Systems .....	3
EE 488. Senior Project II .....	4
EE Technical Elective II** .....	3
EE Technical Elective III** .....	3
Professional Elective*** .....	3
TOTAL .....	16

\* *Humanities/Social Science Electives I and II must be selected from an approved list of upper-division liberal arts maintained in the Electrical Engineering Department office.*

\*\* *EE Technical Electives are numbered 400-level or higher, or 300-level with consent of department chair.*

\*\*\* *Professional Elective must be selected from an approved list maintained in the Electrical Engineering Department office.*

## MINOR IN COMPUTER SCIENCE

A minor in computer science is available for BSEE majors. Students may also apply for an extended program leading to dual degrees in electrical engineering and computer science. For details, students should contact the Watson School advising office prior to registration.

## GRADUATE PROGRAMS

The program leading to the master of science degree in electrical engineering provides the balance of advanced theory and practical knowledge necessary for either professional practice or for continuation into a doctoral program.

Within the broad field of electrical engineering, students must specialize in one of three designated areas: computer engineering, systems (controls/communication/signal processing), or electro-physics (microelectronics, electromagnetics or electro-optics). Specialization is achieved by selection of coursework and thesis topic. Under appropriate circumstances, a research project may be carried out in industrial laboratories, with joint supervision of the thesis by a co-adviser at the student's place of work and a professor from the Watson School regular faculty.

The program has the flexibility required by part-time students and takes advantage of their industrial experience. The master of engineering (MEng) program enables students to combine a specialization in electrical engineering with coursework in several related disciplines. The department is also enriched by adjunct faculty members employed in local industry.

Graduate students are encouraged to apply for part-time work as teaching assistants, research assistants or technical assistants to gain practical experience as well as financial aid and tuition waiver.

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## ADMISSION REQUIREMENTS

- Graduate Record Examination (This requirement may be waived for graduates of Watson School or other ABET-accredited engineering programs. Applicants with strong credentials in related fields may petition to be evaluated without supplying GRE scores. Request should be submitted in writing with the application.)
- Bachelor of science in electrical engineering degree or a baccalaureate in a related field. A student whose undergraduate degree is not in electrical engineering is required to have an acceptable equivalent to each of the following:

Electronics (analog and digital: EE 315/316 and Systems (controls or signal processing: EE 361 or EE 302)

Electro-physics (solid state physics, modern physics or EE 332)

Laboratory experience (EE 385/386 or PHYS 327)

Qualified students with non-EE backgrounds may be admitted on a conditional basis subject to their taking one or more undergraduate EE course(s) prior to being fully matriculated.

Calculus through differential equations, and study of electric circuits, are assumed. Acceptable TOEFL scores are required of students whose native language is not English.

## Master of Science in Electrical Engineering DEGREE REQUIREMENTS

The student must maintain at least a B average in one of the following plans of study:

### *Thesis option*

- EE 599, Research Thesis (6 credits), plus EE 595, Research Seminar and Literature (1 credit) and EE 596, Thesis Seminar (2 credits)
- four EE courses in a single area of specialization
- two EE courses outside the area of specialization
- one approved technical elective (may be taken in other departments)

### *Project option (normally approved only for part-time students)*

- EE 598, MSEE Project (3 credits), plus EE 595, Research Seminar and Literature (1 credit)
- four EE courses in a single area of specialization
- three EE courses outside the area of specialization
- two approved technical electives (may be taken in other departments)

## Master of Engineering with Specialization in Electrical Engineering

### DEGREE REQUIREMENTS

The student must maintain a B average in the following plan of study:

- four graduate courses in EE
- four technical elective graduate courses approved by the EE department graduate adviser (may be taken in other departments)
- two-course sequence in Engineering Practice (WTSN 573 and 574)

For more information on this degree, see also the School-Wide section on the master of engineering degree.

## Master of Engineering with Specialization in Computer Engineering

### DEGREE REQUIREMENTS

The student must maintain a B average in the following plan of study:

- two graduate courses in EE and two graduate courses in CS, chosen with the approval of the computer engineering graduate adviser
- four technical elective graduate courses approved by the adviser to ensure a balance between hardware and software emphasis
- two-course sequence in Engineering Practice (WTSN 573 and 574)

## Doctoral Program in Electrical Engineering

The PhD in electrical engineering is described under Watson School "Graduate Information."

## COURSE OFFERINGS/ UNDERGRADUATE

NOTE: Unless otherwise noted, all undergraduate courses carry 3 credits.

EE 260. ELECTRICAL CIRCUITS *fall, 4 credits*  
Units and definitions. Ohm's Law and Kirchhoff's Laws. Simple resistive circuits. Circuit analysis techniques: Nodal and mesh methods, Norton and Thevenin theorems, maximum power transfer. Capacitance and inductance and the natural and step response of RL, RC and RLC circuits. Sinusoidal steady-state analysis. Series and parallel resonance. Prerequisite: PHYS 131. Corequisite: PHYS 132 or permission of instructor.

## EE 292. ELECTRICAL PHENOMENA LABORATORY

*spring only, 0+2 credits*

Introduction to measurement of physical phenomena such as electrical properties of materials, electromagnetics, light and sound. Laboratory experiments covering Kirchhoff's and Ohm's laws, A-C circuits and phase shift. Prerequisite: PHYS 132 and EE 260 or permission of instructor.

## EE 301. SIGNALS AND SYSTEMS

*fall*

Steady state and transient analysis of linear systems; Fourier and Laplace transforms, convolution, impulse response, transfer function, Fourier analysis. Design of elementary electrical filter circuits. Prerequisites: MATH 371 and EE 260 or equivalent.

## EE 302. SIGNAL PROCESSING

*spring, 3+1 credits*

Discrete time and frequency analysis of linear systems. Random signals, correlation functions, power spectrum. Design of elementary digital filters. Laboratory exercises. Prerequisites: EE 301 and ISE 361. Corequisite: EE 361.

## EE 315. ELECTRONICS I

*fall, 3+1 credits*

Introduction to electronics concentrating on the fundamental devices (diode, transistor, operational amplifier, logic gate) and their basic applications; modeling techniques; elementary circuit design based on devices. Laboratory exercises. Prerequisites: EE 260. Corequisite: EE 351.

## EE 316. ELECTRONICS II

*spring*

Continuation of EE 315 with emphasis on electronic circuit design and system applications (filters, power regulation, oscillators, timing, A/D and D/A conversion). Prerequisite: EE 315.

## EE 332. SEMICONDUCTOR DEVICES

*fall*

Basic theory of semiconductors, p-n junctions, bipolar junction transistors, junction and MOS field effect devices; device design and modelling, fabrication. Prerequisite: WTSN 272.

## EE 351. DIGITAL LOGIC DESIGN

*fall*

Fundamental and advanced concepts of digital logic. Boolean algebra and functions. Design and implementation of combinatorial and sequential logic, minimization techniques, number representation, basic binary arithmetic and finite state machines. Logic families and digital integrated circuits and use of CAD tools for logic design. Prerequisite: EE 260 or equivalent.

## EE 352. COMPUTER ORGANIZATION AND MICROPROCESSORS

*spring*

Organization of computer systems: processor, memory, I/O organization, instruction encoding and addressing modes. Introduction to microprocessors, control unit and interrupt system design. Design of hardware and software for microprocessor applications. Assembly language programming. Microprocessor system case studies. Prerequisite: EE 351.

## EE 361. CONTROL SYSTEMS

*spring*

Introduction to analysis, design and modeling of control systems. Laplace transforms, transfer functions and transient analysis. Concepts of stability; polar and log-frequency plots. Numerical simulation and design of simple control systems. Prerequisite: EE 301 or PHYS 407.

## EE 385. LABORATORY I

*fall, 4 credits*

Experiments for electronics and digital courses. Logbook and memorandum reports, plus one formal written report. Application of engineering software. Prerequisite: junior standing. Corequisites: EE 315 and EE 351.

## EE 386. LABORATORY II

*spring, 4 credits*

Composite experiments for electronics and other electrical engineering courses. Application of basic statistical methods to design of experiments. Prerequisites: EE 301, 315, 332, 385. Corequisites: EE 302, 316, 361.

## EE 395. SEMINAR I

*fall, 1 credit*

Contemporary global and social issues, professional and ethical responsibility. Evaluation based on written presentations. Prerequisite: junior standing.

## EE 396. SEMINAR II

*spring, 1 credit*

Continuation of EE 395. Evaluation based on oral presentations. Prerequisite: junior standing.

## EE 419. POWER ELECTRONICS

*fall*

Electronic processing of electrical energy. Overview of power electronics devices such as DMOSFET, IGBT and Thyristor. Power supply circuits from AC or DC sources as used in computers, inverters and variable-speed motor drives. Analytical and numerical techniques for simulation. Technical elective. Prerequisite: EE 316.

## EE 423. ELECTROMAGNETICS

*fall, 4 credits*

Fundamentals of electromagnetic fields, Maxwell's Equations, plane waves, reflections. Application to transmission lines, antennas, propagation, electromagnetic interference, electronics packaging, wireless communication. Prerequisites: EE 301.

## EE 433. MATERIALS AND DEVICES

*fall*

Properties of electrical engineering materials; device design and fabrication, parameter measurement. Technical elective. Prerequisite: EE 332.

## EE 437. INTRODUCTION TO MICROELECTRONICS PACKAGING

*spring*

Interdisciplinary introduction to packaging of microelectronic components and assembly of circuit boards. Materials processing, mechanical and thermal analysis, reliability testing and analysis. Computer simulation of interconnect structures. Technical elective. Prerequisite: junior standing in engineering or science.

## EE 441. FUNDAMENTALS OF ELECTRO-MECHANICS

*spring*

Principles of electro-mechanical energy conversion; mechanical and electrical forces related to currents and velocities. DC machines, transformers and AC machines, stepping motors, transducers. Three phase power. Terminal characteristics and equivalent circuits. Technical elective. Prerequisite: senior standing.

## EE 452. DIGITAL SYSTEMS II

*fall and summer*

Design of hardware and software for microprocessor applications. Real-time embedded control. Processor architecture, memory, I/O and interrupt system design. Software and monitor system design. Laboratory exercises. Technical elective. Prerequisite: EE 351.

## EE 453. COMPUTER SYSTEMS

*spring*

Computer systems description, arithmetic algorithms, CPU, memory hierarchy, I/O, multiprocessor architectures, operating systems and compilers, neurocomputers, VLSI technology. Technical elective. Prerequisite: EE 351.

## EE 462. CONTROL SYSTEMS II

*fall and summer*

Conventional and state variable techniques for the analysis and design of digital and analog control systems. Z-trans-

form. Sampled data systems. Discrete state variable. Numerical simulation and computer-aided design of control systems. Technical elective. Prerequisite: EE 361.

EE 474. INTRODUCTION TO ELECTRO-OPTICS *spring*

Electro-optic devices and systems. Blackbody, LED and laser sources, photodetectors, modulators, fiber optics, Fourier optics. Design of electro-optic systems. Technical elective. Prerequisites: EE 423.

EE 475. DIGITAL AUDIO AND ELECTRO-ACOUSTICS *spring*

Fundamentals of acoustics, digital signal processing, digital audio technology, selected topics from current literature. Technical elective. Prerequisites: EE 302 and 352.

EE 477. COMMUNICATIONS SYSTEMS *fall*

Modulation and demodulation: AM, FM, PCM, SSB, TV. Noise, channel capacity, optimum detection. Design of communications systems. Prerequisite: EE 302.

EE 487. SENIOR PROJECT I *fall, 4 credits*

Design projects in cooperation with local industry and other external clients. Specifications, proposal, time schedule, paper design. Periodic design reviews with client, written and oral progress reports, final presentation. Evaluation based on individual and team performance. Prerequisites: EE 316 and senior standing.

EE 488. SENIOR PROJECT II *spring, 4 credits*

Continuation of EE 487. Prototype fabrication and test. Demonstration and documentation of functioning system delivered to client. Evaluation based on individual and team performance. Prerequisite: EE 487 or consent of instructor.

EE 489. PROFESSIONAL PRACTICE *every semester, 2 credits*

Preparation for employment and graduate education. Case studies in professional ethics, patent and liability law, engineering economics, accounting principles, entrepreneurship. Written and oral presentations required. Preparation for the Fundamentals of Engineering exam for New York state Professional Engineer License.

EE 491. TEACHING PRACTICUM *every semester, variable credit*

Assist with undergraduate instruction of a formal course under the direct supervision of the course instructor. Prerequisites: approval of the faculty member and the department chair.

EE 496. INDUSTRIAL INTERNSHIP *every semester, variable credit*

Engineering work experience in industry. Daily log book, monthly memo progress reports, and formal final report required. May replace one technical elective. May be repeated for credit. Prerequisite: approval of department chair.

EE 497. INDEPENDENT STUDY *every semester, variable credit*

Individual study under direct supervision of a faculty member. Prerequisites: approval of proposed subject by the faculty member and department chair.

EE 499. UNDERGRADUATE RESEARCH *every semester, variable credit*

Assist with faculty research. Prerequisites: approval of proposed subject by the faculty member and the department chair.

## COURSE OFFERINGS/ GRADUATE

NOTE: Unless otherwise noted, graduate courses carry 3 credits.

EE 501. LINEAR SYSTEMS THEORY *fall*

State space models for linear systems. Controllability and observability. Eigenvalues and eigenvectors. Least squares and singular value decomposition. Computational considerations. Prerequisite: EE 361 or equivalent.

EE 502. EMBEDDED CONTROL *every other year*

Embedded microcontrollers and digital signal processors in control systems; transducer and instrumentation models. Prerequisites: EE 351 and 361 or equivalent.

EE 503. NONLINEAR SYSTEMS DESIGN *every other year*

Characteristics of nonlinear systems, stability theories, design of controllers, computer simulation. Prerequisite: EE 462 or equivalent.

EE 505. ANALYSIS AND DESIGN OF CONTROL SYSTEMS *fall*

Advanced techniques for analysis and design of analog linear and nonlinear control systems. Topics include conventional and state variable techniques for the mathematical description of control systems, stability analysis, conventional and modern design techniques, numerical simulation and computer-aided design of control systems. Prerequisite: EE 462 or equivalent.

EE 506. ADVANCED DIGITAL CONTROL *every other year*

A background overview of S- and Z- transforms and analysis of transfer functions. Introduction of multirate sampling techniques. Description of phantom sampling techniques and Krane Vector Switched Decomposition. Analysis of digital systems. Advanced topics in multirate controls using state space techniques. Prerequisite: EE 462 or equivalent.

EE 507. ADAPTIVE CONTROL SYSTEMS *spring*

Techniques for the mathematical description, analysis and design of adaptive control systems. Concept of adaptation, model reference and self-tuning approaches to system identification. Computer simulation. Prerequisites: EE 462 and approval of graduate adviser.

EE 508. INTRODUCTION TO PROCESS CONTROL *fall*

Applications of statistical, optimization and advanced control techniques for mathematical description, analysis optimization and control of multivariable processes. Topics include: regression analysis, linear, nonlinear and dynamic programming, adaptive control. Prerequisite: EE 361 or equivalent.

EE 509. STOCHASTIC CONTROL *every other year*

Statistical techniques for the description, analysis and design of control systems. Estimation, prediction and Kalman filtering in advanced systems. Prerequisites: EE 505 and a course in probability or equivalent.

EE 510. LINEAR AND SAMPLED DATA CONTROL SYSTEMS

*fall and summer*

Conventional and state variable techniques for the analysis and design of digital and analog control systems. Z-transform. Sampled data systems. Discrete state variable. Numerical simulation and computer-aided design of control systems. Lecture portion meets with EE 462. Prerequisites: EE 361 and approval of the graduate adviser.

EE 515. ELECTROMAGNETIC MODELING FOR MICROELECTRONICS

*spring*

Numerical simulation techniques for the solution of charge, current and electromagnetic field distributions in semiconductor devices, transmission lines, electronics packaging components and other electromagnetic devices. The numerical techniques includes integral equations, finite difference and finite element methods. Prerequisite: EE 423 or equivalent.

EE 516. MATHEMATICAL METHODS IN ELECTRICAL ENGINEERING

*fall and summer*

Selected topics in applied mathematics stressing the unifying concept of the function. Functions are introduced from the computer engineering point of view as notions of set, relation and algebraic structure. The function concept is illustrated by homomorphism and isomorphism. Next, the function concept is interpreted in linear systems as transformation, illustrated with the Z, Laplace and Fourier transforms. The role of equations is considered. Finally, transform methods are applied to the solution of partial differential equations of electro-physics, particularly the heat and wave equations. Prerequisite: Calculus and differential equations.

EE 520. POWER ELECTRONICS

*fall*

Electronic processing of electrical energy. Overview of power electronics devices, such as DMOSFET, IGBT and Thyristor. Power supply circuits from AC or DC sources as used in computers, inverters and variable-speed motor drives. Analytical and numerical techniques for simulation. Four laboratory exercises with formal reports are required. Lecture portion meets with EE 419. Prerequisites: EE 316 and approval of the graduate adviser.

EE 521. DIGITAL SIGNAL PROCESSING

*spring*

Transversal and recursive filters, random discrete-time signals, spectral analysis, detection of signals in noise, estimation of signal parameters. Prerequisite: EE 302 or equivalent.

EE 522. ESTIMATION THEORY

*every other year*

Random processes and their characteristics. Random signals in linear systems. Methods of trend analysis and prediction. System identification. Least square estimation and Kalman filtering. Suboptimal filters. Noise in the information channels and sensitivity of estimation procedures. Confidence analysis of estimates. Prerequisite: courses in probability and linear systems, or equivalent.

EE 531. ELECTROMAGNETIC FIELD THEORY

*fall*

Topics in classical electromagnetic field theory with emphasis on time-varying fields including guided waves and radiation. Prerequisite: EE 423 or equivalent.

EE 532. MICROWAVE ENGINEERING

*every other year*

Apertures, waveguides; microwave network theory; analysis and design of microwave circuits and systems; microwave devices. Prerequisite: EE 423 or equivalent.

EE 533. ELECTROMAGNETIC COMPATIBILITY

*every other year*

Signal paths: conductive, inductive, capacitive, electromagnetic. Shielding and grounding concepts. Methods of measurement. EMC specifications and standards. Prerequisite: EE 423 or equivalent.

EE 534. SIGNAL TRANSMISSION IN ELECTRONICS PACKAGING

*every other year*

General transmission line theory as applied to electronics packaging; digital signal transmission; interconnections; transient analysis of transmission lines by LaPlace Transform. Prerequisite: EE 423 or equivalent.

EE 540. COMMUNICATIONS SYSTEMS

*fall*

Modulation and demodulation: Noise, channel capacity, optimum detection. Design of communication systems. Lecture portion meets with EE 477. Prerequisites: EE 302 and approval of graduate adviser.

EE 541. COMMUNICATION SYSTEM ENGINEERING

*every other year*

Fundamentals of communication theory. Channel capacity, signal-noise ratio and error probability, information-theoretic bounds on transmission. Prerequisite: EE 477 or equivalent.

EE 545. DIGITAL COMMUNICATION SYSTEMS

*spring*

Transmission of information in digital form; coding; packets; error detection, correction; carriers; multipath and intersymbol interference; spread spectrum. Prerequisite: EE 477 or equivalent.

EE 550. DIGITAL SYSTEM ENGINEERING

*spring*

Design of software and hardware for microprocessor applications. Processor architecture, microprogramming and computer design. Lecture portion meets with EE 452. Prerequisite: EE 351 and approval of graduate adviser.

EE 551. DIGITAL SYSTEMS DESIGN

*every other year*

Arithmetic and logic units, control units. Hardware description languages, design verification by simulation, subsystem design using primitives, microprogramming, interrupt and input-output. Prerequisite: EE 452 or equivalent.

EE 552. COMPUTER DESIGN

*fall*

Computer architectures, virtual memory organization, input-output, microprogramming, multiprocessor systems, memory hierarchies, pipelined architecture, RISC machines, fault-tolerant machines. Prerequisite: EE 452 or equivalent.

EE 553. ADVANCED MICROPROCESSOR SYSTEMS

*every other year*

Advanced microprocessors, architectures, instruction sets. Memory and interface design consideration, performance evaluation. Prerequisite: EE 452 or equivalent.

EE 554. VLSI CIRCUIT DESIGN ARCHITECTURES

*fall*

The MOS transistor, circuit characterization and performance estimation. CMOS logic and structured design: electrical design of logic circuits, clocking strategies and design rules. CMOS systems and RISC architectures. Prerequisite: EE 452 or equivalent.

EE 555. DIGITAL COMPUTER ARITHMETIC

*spring*

Classification and structure of finite number systems. Theory of modern high speed computer arithmetic, array arith-

metic processing techniques, case studies of representative arithmetic processors. Prerequisite: EE 452 or equivalent.

**EE 557. NEURAL NETWORK COMPUTERS** *fall*  
Topics on neural network computing, such as network structure, retrieval and learning phases, computational requirements, and types of applications of neural networks. A number of neurocomputers are studied. This study includes digital as well as analog implementations and VLSI approaches. Prerequisite: EE 452 or equivalent.

**EE 559. MACHINE VISION** *spring*  
Discusses low and high level machine vision issues by using methods and tools (architectures, languages, and algorithms). Grouping of machine vision methods: image preprocessing; image processing; image compression; computer graphics (in brief); image analysis; pattern recognition (syntactic methods); OCR systems and methods; image understanding; image interpretation; design project. Prerequisites: high-level programming languages (C or Pascal or Lisp or Prolog), multiprocessor systems architectures, and EE 452 or equivalent.

**EE 560. ELECTRO-OPTICS** *spring*  
Electro-optic devices and systems. Black-body, LED and laser sources, photodetectors, modulators, fiber optics, Fourier optics. Design of electro-optic systems. Lecture portion meets with EE 474. Prerequisites: EE 423, college physics and approval of the graduate adviser.

**EE 564. OPTOELECTRONICS AND FIBER OPTICS** *fall*  
Optical fiber waveguides; single and multimode propagation; coupling and splicing; optical sources and detectors; introduction to holography. Prerequisites: EE 332 and 423, or equivalents.

**EE 567. POWER SUPPLY DESIGN** *summer*  
Switched-mode power supply topologies, design, modeling, and test; related topics. Prerequisite: EE 419 or equivalent.

**EE 570. MICROELECTRONICS MATERIALS AND DEVICES** *fall*  
Properties of microelectronics materials; device design and fabrication, parameter measurement. Lecture portion meets with EE 433. Prerequisites: EE 332 and approval of graduate adviser.

**EE 571. ELECTRONIC PROPERTIES OF MATERIALS** *every other year*  
Selected theory and application of solid state principles in electrical engineering: quantum mechanics, dielectrics, ferromagnetics, piezoelectrics, superconductors, amorphous materials, surfaces, optical interactions. Prerequisite: EE 332 or equivalent.

**EE 574. MOS VLSI DESIGN** *every other year*  
NMOS and CMOS review; design rules; clocking and delays; system design examples. Prerequisites: EE 351 and 433, or equivalents.

**EE 575. SEMICONDUCTOR DEVICE PROCESSING** *spring*  
Semiconductor device fabrication (crystal growth, oxidation, diffusion, etching, lithography, yield), theoretical foundations; process modeling and simulation. Computer simulations. Prerequisites: EE 433 or equivalent.

**EE 576. SEMICONDUCTOR DEVICE DESIGN** *fall*  
Design of bipolar and MOS devices and IC systems; design examples; selected discrete device design; simulation. Prerequisite: EE 433 or equivalent.

**EE 577. SEMICONDUCTOR DEVICE PACKAGING** *every other year*  
Electrical, thermal and mechanical design aspects of packaging. Devices and printed circuit boards, wire-bonding, die attachment, hybrids; electrical interconnections, materials, adhesion; reliability. Prerequisite: EE 332 or equivalent.

**EE 578. THIN FILMS AND NANOELECTRONICS** *every other year*  
Vacuum principles and instrumentation, deposition techniques (thermal, ion-beam, plasma sputtering), nucleation and growth; electrical, optical, mechanical properties; hybrid microelectronics, integrated optics; analytical techniques. Prerequisite: EE 332 or equivalent.

**EE 594. INDUSTRIAL INTERNSHIP** *every semester, variable credit*  
Engineering work experience in industry. Daily logbook, monthly memo progress reports and formal final report required. Prerequisite: permission of department chair.

**EE 595. RESEARCH SEMINAR AND LITERATURE** *every semester, 1 credit*  
Required for all graduate students. Presentation of the prospectus for the MSEE project or thesis. Attendance at weekly department research seminars, preparation of written summaries and completion of library search in area of proposed research required.

**EE 596. THESIS SEMINAR** *every semester, 2 credits*  
Thesis students must demonstrate proficiency formulating their research results into short seminar presentations and also must prepare a research paper to professional journal standards. Attendance at weekly department research seminars and preparation of written summaries required. Prerequisites: EE 595 and 599. Seminar portion meets with EE 595.

**EE 597. INDEPENDENT STUDY** *every semester, variable credit*  
Independent study or graduate laboratory exercises supervised by electrical engineering faculty member. Prerequisites: consent of instructor and department chair.

**EE 598. MSEE PROJECT** *every semester, variable credit*  
Hardware and software design and development or other project as defined by a learning contract, approved by major professor and project adviser. Seminar presentation required. Formal report submitted to EE department library.

**EE 599. RESEARCH THESIS** *every semester, variable credit*  
Mentoring in the methods of research. Theoretical analysis, computer modeling, software and hardware development, and experimentation as determined by a thesis committee, faculty adviser, second reader or co-adviser and department chair. Oral defense. Preparation of journal article required. Bound thesis submitted to Graduate School for the University Library.

EE 606. ROBUST CONTROL OF MULTIVARIABLE SYSTEMS

*spring*

Comprehensive treatment of linear multivariable control. Stability and performance robustness analysis; computer-aided robust control system design frequency-domain minimax (H-infinity) synthesis and Linear-Quadratic-Gaussian synthesis with Loop-Transfer-Recovery. Prerequisite: EE 505 or equivalent.

EE 652. PARALLEL COMPUTER ARCHITECTURES

*spring*

Parallel processing overview, multiple instruction multiple data (MIMD) architectures: wave front arrays, dataflow, reduction machines. Interconnection networks, parallel algorithm implementation and memory organization for parallel machines. Prerequisite: EE 552 or equivalent.

EE 656. MULTIPROCESSOR DESIGN EVALUATION

*every other year*

Stochastic models for the evaluation of multiprocessor systems design; stochastic processes, queuing models; stochastic Petri-nets; analysis of crossbar multiprocessor architectures; aspects of multiprocessor performance evaluation; failures in multiprocessor and recovery techniques. Design project. Prerequisites: EE 552 and a course in probability or equivalent.

EE 659. ENGINEERING APPLICATIONS OF

ARTIFICIAL INTELLIGENCE

*fall*

Fundamental and advanced methods of artificial intelligence with applications to industry. Knowledge-based systems (knowledge representation, acquisition, conversion, manipulation, KB development, expert systems); AI languages (natural languages, NL translations, special AI languages); perception, learning, and planning schemes (symbolic, connectionist, genetic algorithms, vision, speech, path planning); design project. Prerequisite: EE 559 or equivalent.

EE 665. OPTICAL INFORMATION PROCESSING

*spring*

Applications of Fourier optics; optical processing elements; modulation and optical transfer functions; filtering, convolution and correlation; pupil synthesis, textural edge extraction; homodyning and heterodyning; wave mixing, harmonic generation; quantum well lasers, fiber optic amplifiers; optical computing; optical storage in photon echo systems; dichromated gelatin, photorefractive and computer-generated holograms. Prerequisite: EE 564 or equivalent.

EE 697. INDEPENDENT STUDY

*every semester, variable credit*

Independent study supervised by electrical engineering faculty member. Student must obtain consent of instructor and department chairperson, who then determine description of program and number of credits.

EE 698. PRE-DISSERTATION RESEARCH

*every semester, variable credit*

Exploratory research oriented toward PhD dissertation.

EE 699. DISSERTATION

*every semester, variable credit*

Research for and preparation of PhD dissertation.

EE 700. CONTINUOUS REGISTRATION

*every semester, 1 credit*

Required to maintain matriculation through any spring or fall semester when no other courses are taken. If the minimal one-credit registration is not maintained, student must reapply for admission.

EE 701. PRACTICUM FOR RESEARCH AND TEACHING

ASSISTANTS

*every semester*

Required for all funded graduate assistants. Research or teaching supervised by faculty adviser.