

## ELECTRICAL ENGINEERING

<http://www.uvm.edu/~cems/soe/>

### OVERVIEW

The Electrical Engineering (EE) program at the University of Vermont is at the forefront of research in the areas of digital signal processing, control systems, power and energy systems, wireless communications, and electronic circuit and system design and testing. This rigorous and focused program offers competitive funding and prepares graduate students for careers in research and technical leadership. Graduate students can contribute to interdisciplinary research within a broad range of applications, including power/energy, biomedical, aerospace, and transportation. In addition, the EE program partners with other academic units to offer M.S. and Ph.D. degrees in Materials Science and a Ph.D. degree in Biomedical Engineering.

### DEGREES

Electrical Engineering AMP

Electrical Engineering M.S.

Electrical Engineering Ph.D.

### FACULTY

**Almassalkhi, Mads;** Associate Professor, Department of Electrical and Biomedical Engineering; PHD, University of Michigan

**Bates, Jason H. T.;** Professor, Department of Electrical and Biomedical Engineering; DSC, Canterbury University; PHD, University of Otago

**Bongard, Joshua C.;** Professor, Department of Computer Science; PHD, University of Zurich

**Cipolla, Marilyn Jo;** Professor, Department of Neurological Sciences; Chair, Department of Electrical and Biomedical Engineering; PHD, University of Vermont

**Doiron, Amber L.;** Assistant Professor; Department of Electrical and Biomedical Engineering; PHD, University of Texas Austin

**Duffaut Espinosa, Luis;** Assistant Professor, Department of Electrical and Biomedical Engineering; PHD, Old Dominion University

**Frolik, Jeff L.;** Professor, Department of Electrical and Biomedical Engineering; PHD, University of Michigan

**Hines, Paul D.;** Professor, Department of Electrical and Biomedical Engineering; PHD, Carnegie Mellon University

**Jangraw, David;** Assistant Professor, Department of Electrical and Biomedical Engineering, PhD, Columbia University

**Lee, Byung S.;** Professor, Department of Computer Science; PHD, Stanford University

**McGinnis, Ryan;** Assistant Professor, Department of Electrical and Biomedical Engineering; PHD, University of Michigan

**Ossareh, Hamid-Reza;** Assistant Professor, Department of Electrical and Biomedical Engineering, PHD; University of Michigan

**Pandey, Amritanshu;** Assistant Professor, Department of Electrical and Biomedical Engineering, PHD, Carnegie Mellon University

**Wshah, Safwan;** Assistant Professor, Department of Computer Science; PHD, State University of New York at Buffalo

**Xia, Tian;** Professor, Department of Electrical and Biomedical Engineering; PHD, University of Rhode Island

### Courses

#### EE 5310. Electric Energy Systems Analys. 3 Credits.

Transmission line, generator, transformer modeling and control, per-unit conversion, power flow calculations and software, symmetric components and fault analysis, protection/relaying, stability analysis, smart grid. Prerequisite: EE 3315. Co-requisite: MATH 2522 (preferred) or MATH 2544.

#### EE 5320. Smart Grid. 3 Credits.

Smart Grid: Using information/communication technology to modernize electric power/energy systems, including generation, transmission, distribution and consumption. Electricity physics/economics/policy; renewable energy; energy storage; demand response; energy efficiency; distributed generation; advanced metering infrastructure; distribution automation; microgrids; synchrophasors; HVDC and FACTS systems. Prerequisite: Electrical Engineering Graduate student or Instructor permission. Co-requisite: EE 5310 is helpful.

#### EE 5410. Digital VLSI Circuit Design. 0 or 3 Credits.

Covers the techniques for the design, analysis and layout of digital CMOS circuits and systems. Major topics include MOSFET basics (structure and behavior of a MOSFET, CMOS fabrication, and design rules), detailed analysis of the CMOS circuits and systems (static behavior, ratioed vs. ratioless design), noise margins, computing rise and fall times, delay models, resistance. Prerequisite: Electrical Engineering Graduate student or Instructor permission.

#### EE 5420. Analog VLSI Circuit Design. 0 or 3 Credits.

The design and analysis of active and passive radio frequency and microwave circuits. The design, layout, and simulation of VLSI analog circuits. Emphasis on small signal models and circuits used in operational amplifiers as well as a focus on learning the basics of RF circuit design and analysis. Prerequisite: Electrical Engineering Graduate student or Instructor permission.

#### EE 5430. RF Circuit Design. 3 Credits.

Design and analysis of radio frequency and microwave circuits. Covers radio frequency and microwave behavior of passive components, various transmission line structures, electromagnetic (EM) wave propagation in dielectric media, reflection coefficient and load impedance, network properties and applications, impedance matching network design, scattering parameters and their usage for RF. Prerequisite: Electrical Engineering Graduate student or Instructor permission.

**EE 5440. Gr Semiconductor Materials/Dev. 4 Credits.**

Covers energy band theory, effective mass, band structure and electronic properties of semiconductors. Transport of electrons and holes in bulk materials and across interfaces. MOSFETs, BJTs, pn junctions, and Schottky barriers. Experimental portion of course will have a laboratory component for electronic measurements of semiconductor devices. Prerequisite: Electrical Engineering Graduate student or Instructor permission.

**EE 5530. Modern Control Systems. 3 Credits.**

Feedback control theory with application to mechanical and electrical systems. Includes elements of classical control theory such as stability analysis and PID control. A series of labs implemented on an electric motor and rotary inverted pendulum will reinforce the concepts. Emphasis on both theory and design. Prerequisite: Electrical Engineering Graduate student or Instructor permission. Cross-listed with: ME 3320.

**EE 5540. Real-Time Control Systems. 3 Credits.**

Digital control systems analysis and design. Topics include: difference equations, the Z-transforms, discrete-time transfer functions, state-space models, sampled-data systems, discretization, real-time control, microprocessor implementation, and optimal control. Project-based final. Prerequisite: Electrical Engineering Graduate student or Instructor permission.

**EE 5610. Information Theory. 3 Credits.**

Introduction to probability concepts of information theory; entropy of probability models; theoretical derivations of channel capacity; coding methods and theorems, sampling theorems. Prerequisite: Graduate student or Instructor permission.

**EE 5620. Wireless Communication. 3 Credits.**

Modern wireless systems, including cellular design, propagation modeling, multiple access and equalization techniques. Prerequisite: Graduate student or Instructor permission.

**EE 5810. Digital Computer Design I. 3 Credits.**

Hardware organization and realization, hard-wired and microprogrammed control units, interrupt and I/O systems. Hardware design language introduced and used for computer design. Prerequisites: EE 2810; EE 3815 or CS 2210.

**EE 5990. Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

**EE 6110. System Theory. 3 Credits.**

Linear vector spaces. State equations and solution. Diagonalization and Jordan canonical form. Orthogonal and biorthogonal projections. Quadratic forms. Spectral resolution. Principal component analysis, singular value decomposition and Karhunen-Loeve transform. Compressive sensing. Prerequisites: MATH 3230 or MATH 3201; MATH 2544; EE 3150 or ME 2120.

**EE 6120. Stochastic Processes. 3 Credits.**

Probability theory, random variables and stochastic processes. Response of linear systems to random inputs. Applications in engineering. Prerequisites: EE 3150 or ME 2120; STAT 2510 or STAT 2430.

**EE 6130. Convex Optimization. 3 Credits.**

Provides advanced mathematical tools to recognize optimization problems from applications, presents rigorous theory of convex optimization with an emphasis on results that are helpful for implementation/computation/modeling, providing student with the experience and understanding necessary to use the tools in their own research work or applications. Prerequisites: Linear Algebra, multi-variable calculus.

**EE 6391. Master's Thesis Research. 1-18 Credits.****EE 6392. Master's Project Research. 1-3 Credits.**

Master's Project.

**EE 6520. Nonlinear System Theory. 3 Credits.**

Basic nonlinear methods including computational and geometrical techniques for analysis of nonlinear systems. Describing function methods and bifurcation and catastrophe theory. Sensitivity and stability considerations. Prerequisite: MATH 3230 or MATH 3201. Pre/Co-requisite: EE 6110 recommended.

**EE 6530. Estimation Theory. 3 Credits.**

Foundations of linear and nonlinear least squares estimation, smoothing and prediction, computational aspects, Kalman filtering, nonlinear filtering, parameter identification, and adaptive filtering. Applications to students' research. Pre/co-requisite: STAT 2510.

**EE 6990. Special Topics. 1-18 Credits.**

Advanced topics of current interest in Electrical Engineering. Prerequisite: Instructor permission.

**EE 6991. Internship. 1-18 Credits.**

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

**EE 6993. Independent Study. 1-18 Credits.**

A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**EE 6995. Graduate Independent Research. 1-18 Credits.**

Graduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**EE 7491. Doctoral Dissertation Research. 1-18 Credits.**

Research for the Doctoral Dissertation.

**EE 7990. Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

**EE 7991. Internship. 1-18 Credits.**

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

**EE 7995. Graduate Independent Research. 1-18 Credits.**

Graduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.