University of Michigan
Dept. of EECS
1301 Beal Avenue
Ann Arbor, MI 48109-2122

www.eecs.umich.edu
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Welcome, Prospective Graduate Students:

We’re pleased that you’re considering the University of Michigan for graduate work in electrical engineering and computer science, and we think you’ll be glad you did. We can offer you some of the most highly ranked programs in the country, with diverse and dynamic research opportunities. Our students work in a premier engineering college, surrounded by facilities and programs that are second to none. They become members of the highly regarded University of Michigan academic community, which can offer you an unparalleled university experience.

In the Department of Electrical Engineering and Computer Science, we recognize that the best graduate students are a critical component of our continued success. You, as a graduate student in EECS, will become an integral part of our varied educational and research missions, and will receive in the process a rigorous and thorough education that is recognized for quality around the world.

Sincerely,

David C. Munson, Jr.
Chair

A Note From the Chair

Front cover design and photograph by Elizabeth Olsen.
Inside back cover photograph: Media Union, by Bob Kalmbach, Larime Photos, Inc.
Sept. 2000
Electrical Engineering and Computer Science
Graduate Programs

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To request an application, visit our Web site at
http://www.eecs.umich.edu/eecs/graduate/admit.html

Applications can also be downloaded from
http://www.rackham.umich.edu/admis/rackhamalt.html

To contact us by mail:
EECS Graduate Programs
The University of Michigan
1301 Beal Ave.
Ann Arbor, MI 48109-2122
GRADUATE WORK IN EECS AT THE UNIVERSITY OF MICHIGAN

The Department of Electrical Engineering and Computer Science
EECS at the University of Michigan is a large and diverse department, recognized as one of the best in the country—ranked in the top five by U.S. News and World Report, the individual graduate programs and research laboratories are also highly rated in their respective fields. As a graduate student in EECS, you will have an opportunity to work with internationally recognized faculty in path-breaking research projects. The faculty in EECS are at the forefront of interdisciplinary research, working with colleagues from a broad range of disciplines within EECS and from across campus. The University of Michigan provides an ideal environment for multidisciplinary research: many of our engineering departments are ranked in the top five nationally, and Michigan is home to prestigious medical and business schools. EECS faculty collaborate with colleagues in all of these units, the College of Literature, Science and the Arts, the Schools of Music, Education, Architecture and Urban Planning, and the innovative new School of Information.

EECS has highly flexible degree programs that can be tailored to the students’ needs and interests. Master’s and Ph.D. degrees are offered in three programs: Computer Science and Engineering; Electrical Engineering; and Electrical Engineering: Systems. Although each faculty member in EECS is associated with one of these three programs, students in one program may work with faculty in another. In fact, as the number of interdisciplinary research projects increases, we fully expect that students will be exposed to faculty and projects that cross these disciplinary lines.

For more information about the Department, visit our website at http://www.eecs.umich.edu. Details about the requirements of the graduate programs can be found in the section beginning on page 19 of this booklet.

The College of Engineering

The University of Michigan College of Engineering was established in 1853-54, when fewer than a half-dozen other American colleges offered engineering courses. The founding of an aeronautical engineering program in 1914, just 11 years after the flight at Kitty Hawk, is only one of many firsts for the College of Engineering. We also were the first engineering school in the following important disciplines: Metallurgical Engineering (1854), Naval Architecture and Marine Engineering (1881), Electrical Engineering (1895), Chemical Engineering (1898), Nuclear Engineering (1953), and Computer Engineering (1965). The College’s Department of Biomedical Engineering was also one of the first such interdisciplinary programs in the country. Today, the College is consis-
tently ranked among the top engineering schools in the world and most of its degree programs are rated in the top ten nationwide.

Last year, the college enrolled 7,000 undergraduate and graduate students and awarded more than 1,100 bachelor’s degrees and 800 master’s and doctoral degrees. Our 400 faculty and research scientists build probes to explore alien worlds, peer inside atoms, grow replacement tissues for humans and etch complex systems of sensors and moving parts onto tiny silicon chips. Our graduates have walked on the moon and raced cars across Australia using nothing more than sunlight.

The College of Engineering shares Michigan’s 800-acre North Campus in Ann Arbor with the School of Music, the School of Art and Design, the College of Architecture and Urban Planning, undergraduate dormitories, and family housing. A University recreation facility, the Nichols Arboretum and the scenic Huron River are all a pleasant lunchtime walk away.

The engineering quadrangle is ringed by state-of-the-art facilities built or remodeled during the last decade and linked by a very high capacity fiber-optic network. Our tools include an immersive virtual reality CAVE, the world’s most powerful laser, a fission reactor and nearly 150 research labs. At the center of campus stands the Ann and Robert H. Lurie Tower, which boasts a magnificent 60-bell carillon.

The University of Michigan

The University, lauded as the first model of a state university in America, is one of a small number of state universities consistently ranked in the top ten American universities. It now enrolls more than 50,000 students on the Ann Arbor campus, and has a faculty of over 3,000. Over 13,000 of these students from all parts of the world are enrolled in master’s and doctoral level programs in more than 120 departments and programs, many of which are ranked among the best in the country. State-of-the-art research facilities support one of the largest university research programs in the country. The University’s Vice-President for Research recently gave this overview of research activity at U-M:

"Let me reveal a secret. The U-M is number one in research volume because its faculty derive strength, inspiration, ideas, and assistance from one another. Our university is a great place for scholars to work because they can interact with top-flight individuals outside their own discipline. One in every eight funded research proposals involves the collaboration of faculty members from different disciplines, and one-third of our research dollars are awarded to us for interdisciplinary and multidisciplinary research.

Work at the intersections of disciplines is extraordinarily exciting and frequently leads to unpredictable outcomes. That’s why some of the most creative scholars are those that seek out collaborators from alien traditions. Furthermore, all the problems that afflict the human condition are complex, defying solution by any one discipline. That’s why federal agencies and national foundations insist on multidisciplinary projects.

The University’s wide range of outstanding academic programs leads to exciting interdisciplinary research opportunities.

As befits a major university, U-M offers a year-round schedule of cultural, recreational and sporting events to satisfy every interest. Musical offerings
range from international orchestras to U-M School of Music concerts. Sports include exciting Big 10 athletic competition—including Wolverine football in the largest open-air college arena in the country—intramural sports, and excellent sports facilities for individual endeavors.

The City of Ann Arbor
Ann Arbor is a city of 130,000 which combines the comfort and charm of a small city with the excitement of a cosmopolitan center. Acknowledged as the center of the state’s booming high technology industry and a cultural mecca as well, the Ann Arbor landscape is a blend of parks, office buildings, boutiques, historic preservation areas, shopping malls, bike paths, busy tree-lined streets, and the open-air Farmers’ Market. It exerts a charm that has turned many students to life-long residents or at least regular visitors.

Ann Arbor’s extensive parks and recreation facilities provide ample opportunity for exercise and relaxation. There is sailing, canoeing, and windsurfing on the Huron River, which flows through the city. The nearby countryside features lakes, woods and productive farmland, ideal for bicycle jaunts and picnics. And yet, it is less than an hour’s drive to Detroit. An international airport is only 25 minutes away and both Chicago and Toronto are only four hours by train.

THE GRADUATE PROGRAMS AND RESEARCH ACTIVITY

The faculty in the Electrical Engineering and Computer Science Department are involved in an extremely broad and challenging array of activities. The areas of activities are currently identified by laboratories as shown in Table 1 (next page). The work is very interdisciplinary in nature and students are encouraged to exploit resources from various laboratories.

Computer Science and Engineering
The Computer Science and Engineering (CSE) program offers master’s and Ph.D. degrees. Coursework in CSE provides a broad background by exposing students to selected courses in the academic areas of hardware, software, intelligent systems, theory, and VLSI. When a student identifies his or her primary area of interest, research is conducted in one of the Department’s research laboratories. The research laboratories most closely associated with CSE are Advanced Computer Architecture, Artificial Intelligence, Real-Time Computing, Software Systems, and Theory in Computer Science.

Advanced Computer Architecture Laboratory
Computer systems hardware research has strong links with software (operating systems, programming languages), solid-state circuits (VLSI design), and several computer application areas (robotics, artificial intelligence, instrumentation and numerical methods). Hardware research is conducted primarily in the Advanced Computer Architecture Laboratory (ACAL), which serves as the focal point for an interdisciplinary program of research that includes the theory, design, programming, and applications of advanced computer systems. The Laboratory has an extensive network of advanced workstations and advanced test and design equipment to support its activities in experimental research. Researchers also have access to a number of state-of-the-art experimental parallel computers.

EECS operates an advanced computer-aided VLSI design
Department of Electrical Engineering and Computer Science

Advanced Computer Architecture Laboratory: Focuses on all aspects of computer hardware including theory, design, programming and applications.

Artificial Intelligence Laboratory: Studies to develop agents that can behave autonomously in a variety of physical and software environments. Highly interdisciplinary work including teams from linguistics, biology, controls, etc., is carried out.

Software Systems and Real Time Computing Laboratories: Carries out interdisciplinary research in software systems and applications. Design, implementation and evaluation of wide-ranging system applications are a major focus.

Theory in Computer Science: Research to develop theories and techniques to understand computation and communication. Researchers collaborate closely with scientists in software, hardware, artificial intelligence, etc.

Optical Sciences and Ultrafast Optical Sciences Laboratories: Studies are conducted in holography, optical communication, quantum optoelectronics and ultrafast optical sciences. Cross-disciplinary work is carried out with the Medical School, the Chemistry & Physics Departments, and others.

Radiation Laboratory: Study of applied electromagnetics for technologies such as remote sensing, radars, wireless communications, and antenna design.

Solid State Laboratory: Research on a variety of technologies based on Si, GaAs, InP, GaN, etc. Technologies being studied are sensors, micromechanical systems, lasers, microwave devices, and VLSI design.

Bioelectrical Systems Laboratory: Conducts highly interdisciplinary work involving applications of signal processing techniques to biological systems.

Control Laboratory: Develop and implement algorithms to modify the behavior of dynamical systems through control. A variety of important manufacturing processes are studied.

Communications and Signal Processing Laboratory: Examination of the fundamental limits of communication system performance. Representation, manipulation and analysis of signals, particularly natural signals.

TABLE 1:

<table>
<thead>
<tr>
<th>Computer Science and Engineering</th>
<th>Electrical Engineering</th>
<th>Electrical Engineering: Systems</th>
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</tr>
</tbody>
</table>
system. While VLSI circuits are fabricated primarily by the NSF/DARPA MOSIS service, our in-house IC fabrication facility, capable of submicron VLSI, is also used. Research into VLSI design ranges from CAD tools, such as logic simulation programs, to the design of components for advanced computer systems.

Laboratory Faculty: Todd Austin, Valeria Bertacco, David Blaauw, Peter Chen, John Hayes, Scott Mahlke, Igor Markov, Trevor Mudge, Marios Papaefthymiou, Steven Reinhardt, Karem Sakallah, Quentin Stout.

VLSI Faculty: John Hayes, Igor Markov, Pinaki Mazumder, Trevor Mudge, Marios Papaefthymiou, Karem Sakallah (CSE program); Richard Brown, Khalil Najafi, Clark Nguyen, Dennis Sylvester, and Kensall Wise (EE program).

For additional information about the Advanced Computer Architecture Laboratory, visit their website at http://www.eecs.umich.edu/ acal/.

Artificial Intelligence Laboratory
The long-term goal of research in the AI Laboratory is to develop autonomous agents capable of behaving effectively in physical and software environments. Achieving this goal involves theoretical, experimental, and applied investigations on many topics in AI including distributed systems of multiple agents, rational decision making, machine learning, cognitive modeling, design, collaboration technology, default reasoning, natural language processing, real-time and intelligent dynamical control, autonomous robotic systems, computer vision, digital libraries and AI architectures. Research in the AI Laboratory is often highly interdisciplinary, building on ideas from computer science, information science, linguistics, psychology, economics, biology, controls, and philosophy. In pursuing this approach, laboratory faculty and students work closely with colleagues throughout the University. This collaborative environment, coupled with this unusually diverse perspective, leads to a valuable interchange of ideas within and across research groups.

Breakthroughs in theory often are best evaluated in the context of real-world applications. Among the various applications currently explored by members of the AI Laboratory are digital libraries, simulated environments for training, user interfaces to complex automation systems, mobile robotics for nuclear reactor maintenance, intelligent transportation systems, Internet auctions, information systems for K-12 education and computer games.

Laboratory Faculty: Steven Abney, Mark Ackerman, Satinder Baveja, Edmund Durfee, Igor Guskov, Steven Kaplan, David Kieras, Daniel Koditschek, John Laird, Lee Markosian, Martha Pollack, William Rounds, Elliot Soloway, Gregory Wakefield, Michael Wellman.

For further information about the Artificial Intelligence Laboratory, refer to their website at http://www.ai.eecs.umich.edu/.

Software Systems and Real-Time Computing Laboratories
Software research is conducted primarily in the Software Systems Laboratory (SSL) and the Real-Time Computing Laboratory (RTCL). These laboratories serve as the focal point for interdisciplinary research on software systems and applications at the University of Michigan. A major focus is on experimental design, implementation, and evaluation of systems software technologies that enable development of a wide range of emerging applications. Active areas of research include cluster computing, collaborative computing, compiler design, information retrieval and database systems, network protocols and architectures, network security and smartcards, mobile computing, operating system and architecture interactions, and real-time and fault-tolerant computing. Emerging applications enabled by these software foundations include computer-supported workspaces; secure video conferencing; electronic commerce; multi-player games; virtual environments; anywhere anytime data access; distrib-
uted agile manufacturing; and many others.

Laboratory Faculty: Chandra Boyapati, Peter Chen, Jason Flinn, Farnam Jahanian, H.V. Jagadish, Sugih Jamin, David Kieras, Morley Mao, Jignesh Patel, Atul Prakash, Brian Noble, Steven Reinhardt, Kang Shin, Quentin Stout, Toby Teorey.

For additional information on SSL and RTCL, refer to their websites at http://www.eecs.umich.edu/RTCL/ and http://www.eecs.umich.edu/ssl/.

Theory in Computer Science
Theoretical computer science provides the mathematical foundation for computer science and computer engineering. Its goal is to develop the theories and techniques needed to understand computation and communication. Researchers in the Theory in Computer Science Center (THINCS) have a broad range of interests within theoretical computer science and collaborate with researchers in other areas such as software, hardware, discrete systems, artificial intelligence, mathematics, statistics, and physics. Research topics within THINCS include specification and validation of computer systems, finite model theory, complexity theory, parallel computing, design and analysis of algorithms, parallel architectures, image processing, scientific and statistical computing, computational linguistics, semantics of programming languages, theories of concurrency, computer security, design and verification of protocols, and combinatorial methods in computer science.

Laboratory Faculty: Kevin Compton, Satyanarayana Lokam, William Rounds, Yaoyun Shi, Quentin Stout.

Information about this group can be found on their website at http://www.eecs.umich.edu/theory/.

Electrical Engineering
The program in Electrical Engineering offers master’s and Ph.D. degrees in electrical engineering. Students in the EE program choose both a major and minor concentration area to ensure a broad academic background. The academic areas they choose from are circuits and microsystems, electromagnetics, electro-optics, and solid-state. VLSI circuits is considered to be both the major and minor. When a student identifies his or her primary area of interest, research is conducted in one of the Department’s research laboratories. The research laboratories most closely associated with the EE program include Optical Sciences, Radiation, Solid-State Electronics, and Ultrafast Optical Sciences.

Optical Sciences and Ultrafast Optical Sciences Laboratories
These laboratories conduct research in the general areas of holography, optical information processing and communications, quantum optoelectronics and ultrafast optical science. Specific areas presently under investigation include spectroscopy of quantum dots; quantum computing; spectroscopy of solids; development of new optical materials, integrated optics; semi-conductor quantum-opto-electronics; coherent phonon-driven devices; cavity quantum electrodynamics; holography including imaging through tissue such as for optical mammography; biophysical studies of biomolecular structure; 100 terahertz optical communications networks; and
production of high power femtosecond laser systems for applications in coherent x-ray generation, particle acceleration, and laser surgery. In addition, this area is home to the Center for Ultrafast Optical Science, the country’s foremost center for academic research in ultrafast science. The Center’s research focuses on the development of high peak-power optical sources; ultrafast electronic and optical science; high field physics and technology; and development and application of short wavelength, short pulse optical sources with intensities exceeding \(10^{18}\) watts/cm\(^2\) and pulse widths shorter than 100 fsec. Although students usually work with faculty in the EECS Department, it is possible to conduct research with faculty in other departments working on problems such as laser cooling and trapping of atoms and coherent control and wave function engineering in atomic systems and phonons in solids.


Information about these programs can be found at [http://www.eecs.umich.edu/OSL/](http://www.eecs.umich.edu/OSL/) and [http://www.eecs.umich.edu/CUOS/](http://www.eecs.umich.edu/CUOS/).

Radiation Laboratory

The applied electromagnetics faculty and graduate students are members of the Radiation Laboratory. Areas of focus include antennas from HF to terahertz frequencies; computational electromagnetics and modeling techniques; electromagnetic wave interactions with the environment; microwave and millimeter remote sensing; plasma electrodynamics and space electric propulsion; polarimetric radars and radiometric imaging; radar scattering computations and measurements; radio wave propagation predictions for mobile communications; RF and microwave front-end design for wireless applications; RFIC circuit design; and RF/microwave and millimeter-wave micromachined active and passive components and sub-systems.

The Radiation Laboratory offers outstanding experimental facilities for solving engineering science problems. These facilities include two anechoic chambers—one of which is instrumented for surface and near field measurements over a wide range of microwave frequencies—microwave and millimeter wave laboratories and truck-mounted field measurement systems.

Laboratory Faculty: Anthony England, Brian Gilchrist, Mahta Moghaddam, Amir Mortazawi, Gabriel Rebeiz, Kamal Sarabandi, Fawwaz Ulaby (also Vice-President for Research).

For additional information about the Radiation Laboratory, visit their website at [http://www.eecs.umich.edu/RADLAB/](http://www.eecs.umich.edu/RADLAB/).

Solid-State Electronics

Research is conducted in both silicon and compound semiconductor devices in the Solid-State Electronics Laboratory (SSEL). The silicon research includes process development, device design and fabrication for integrated circuits, integrated physical and chemical sensors, and other microelectromechanical systems (MEMS); advanced semiconductor processes; semiconductor
process control and automation; metrology and optical measurement systems; and amorphous thin-film silicon devices. Research in compound semiconductors is focused on growth and characterization of wide- and narrow-bandgap semiconductors, new high-speed and microwave device structures, optoelectronic devices, and millimeter-wave heterostructure devices.

Research also is conducted in analog integrated circuits, low-power and high-precision sensor and actuator interface circuits, telecommunication and RF circuits, wireless telemetry and biomedical systems. This area includes the circuits and systems aspects of MEMS, encompassing physical, chemical and biological integrated sensing systems; flow-control systems; microfluidic systems for chemical and DNA analysis; systems incorporating implantable biomedical sensors; hermetic micropackaging technologies; microinstruments for environmental sensing; inertial sensing systems; MEMS in wireless communication applications; and display systems.

Research in VLSI includes circuit design: digital (microprocessor) and mixed signal (microcontroller) circuits, with emphasis on low-power and high-performance; computer-aided design, including clocking and timing, logic synthesis, physical design, and design verification; testing and design for testability; advanced logic families and packaging; integrated circuit micro-architectures; and system integration.

Central to solid-state electronics research is the microelectronics processing facility. This $25-million facility, which is housed in 6000 sq. ft. of class 1000, class 100, and class 10 clean space, is equipped with state-of-the-art tools for materials preparation and characterization with in-situ diagnostics, epitaxial growth, device fabrication with feature sizes smaller than 0.1 mm, and device characterization.

Laboratory Faculty: Pallab Bhattacharya, Richard Brown, Michael Flynn, Ranjit Gharpurey, Yogesh Gianchandani, Lingjie Guo, George Haddad, Jerzy Kanicki, Michel Maharbiz, Leo McAfee, Khalil Najafi, Clark Nguyen (on leave), Stella Pang, Dimitris Pavlidis (on leave), Jamie Phillips, Jasprit Singh, Dennis Sylvester, Fred Terry, and Kensall Wise.

VLSI Faculty: Richard Brown, Khalil Najafi, Clark Nguyen, Dennis Sylvester, and Kensall Wise (EE program); John Hayes, Igor Markov, Pinaki Mazumder, Trevor Mudge, Marios Papaefthymiou, Karim Sakallah (CSE program).

Additional information about SSEL and its associated centers can be found on the web at http://www.eecs.umich.edu/ssel/aboutssel.html.

NSF Engineering Research Center in Wireless Integrated MicroSystems

This Engineering Research Center is focused on the development of integrated microsystems capable of measuring a variety of physical parameters, interpreting the data, and communicating over a bi-directional wireless link. Merging microelectronics, wireless communications, and microelectromechanical systems (MEMS), these microsystems are expected to become pervasive in society during the coming decade, providing button-sized information-gathering nodes for applications ranging from environmental monitoring (weather, global change, air and water quality) to improved health care (wearable and implantable biomedical systems). They will consist of a power source, an embedded microcontroller, software, a hardwired or wireless interface to the external world, and front-end microinstruments selected for a given application. Operating at less than 100 mW, they will occupy volumes as small as 1 cc and communicate over distances from a few inches to a few miles.

EECS Faculty: David Anderson, Richard Brown, Michael Flynn, Ranjit Gharpurey, Yogesh Gianchandani, Michel Maharbiz, Leo McAfee, Khalil Najafi, Clark Nguyen [on leave], Stella Pang, Gabriel Rebeiz, Kamal Sarabandi, Kensall Wise.
Electrical Engineering: Systems
The program in Electrical Engineering: Systems offers master’s and Ph.D. degrees. Students in the EE:S program choose both a major and minor concentration area to ensure a broad academic background. The academic areas they choose from for their major concentration are communications, control systems, or signal processing. The minor areas are biosystems, circuits and microsystems, computers, electromagnetics, electrophysics, manufacturing, or solid-state; in addition, any major area can be chosen as a minor area. When a student identifies his or her primary area of interest, research is conducted in one of the Department's research laboratories. The research laboratories most closely related to EE:S include Bioelectrical Systems, Communications and Signal Processing, and Control. (Although many of the faculty in the Department of Electrical Engineering and Computer Science have joint appointments in the Department of Biomedical Engineering, these are two different departments, each with its own graduate programs.)

Bioelectrical Systems Laboratory
This laboratory focuses on interdisciplinary research involving the application of signal processing and analysis methods to biological problems. Ongoing projects include computerized electrocardiography; tomographic medical imaging (MRI, PET, SPECT); therapeutic and diagnostic ultrasound; processing of complex sounds by the central auditory system; coding of images by the retina; pattern recognition and classifications of visual evoked potentials; evaluation of multichannel recordings from small neural circuits; EEG signal analysis, and evoked potential clustering. Many projects are collaborative and involve faculty from across the EECS Department, the UM Medical Center, and the Department of Biomedical Engineering.

Laboratory Faculty: David Anderson, Jeffrey Fessler, Daryl Kipke, Matthew O'Donnell (also Chair, Department of Biomedical Engineering), Gregory Wakefield.

Additional information about research in the area of controls can be found at the website http://www.engin.umich.edu/research/controls/.

Control Laboratory
Faculty in the Control Laboratory study fundamental properties of dynamical systems and develop algorithms to modify their behavior through control in order to satisfy performance objectives. Numerous system models are employed, including linear, nonlinear, stochastic, discrete event and queuing models. The faculty work on a wide variety of applications projects, including process control of semiconductor manufacturing equipment, automotive powertrain control, manufacturing systems, communication networks, robotics, aerospace, and intelligent transportation systems.

Laboratory Faculty: James Freudenberg, Jessy Grizzle, Daniel Koditschek, Stéphane Lafortune, Semyon Meerkov, Demosthenis Teneketzis.

Communications and Signal Processing Laboratory
Communications research focuses on system design, optimization, and performance analysis as well as on the development of theory to characterize the fundamental limits from Bioelectrical Systems and the Solid-State Electronics Laboratory, can be found at the website http://www.engin.umich.edu/center/cnct/.

To request an application, go to: http://www.eecs.umich.edu
of communication system performance, including its mathematical foundations. Areas of specialization include digital modulation, channel coding, source coding, information theory, optical communications, detection and estimation, spread spectrum communication, and multi-user communications and networks.

Signal processing research focuses on the representation, manipulation, and analysis of signals, particularly natural signals. Signal processing research overlaps with many other research disciplines, particularly in the areas of communication and biosystems. Projects include fast algorithms, inverse scattering, wavelets and time-frequency distributions, image and video coding, signal detection and target tracking, parameter estimation and bounds, musical instrument sound synthesis and analysis.

Laboratory Faculty:
Achilleas Anastasopoulos, David Anderson, Jeffrey Fessler, Alfred Hero, Mingyan Liu, David Neuhoff, Matthew O’Donnell [also Chair, Dept. of Biomedical Engineering], Sandeep Sadanandarao, Serap Savari, Wayne Stark, Demosthenis Teneketzis, Gregory Wakefield, Kim Winick, Andrew Yagle.

Additional information about the laboratory is available at their website, http://www.eecs.umich.edu/ systems/ HOMEcspl.html.

FACILITIES
The EECS Department is housed primarily in one of the newest buildings on the North Campus of the University of Michigan. The research laboratories are assigned space that includes offices for faculty, staff and graduate students, and laboratory facilities. Extensive computing facilities include:
• Supercomputer access through NSF and other agencies.
• The College of Engineering’s Computer-Aided Engineering Network (CAEN), one of the largest integrated, multi-vendor workstation networks in the world, which operates fifteen labs on North Campus.
• North Campus’ Media Union, with over 500 workstations placed throughout the building, including Macintosh, Windows-based, and Unix operating systems. These are available on a walk-up basis; additional wireless support is available for mobile computers.
• The Center for Advanced Computing (CAC), also located in the Media Union, houses the world’s largest AMD Opteron cluster. The emphasis is on high performance computing, with 50 nodes of dual Athlon 1600 MP CPUs plus 17 nodes of dual Athlon 2600 MP CPUs, and 128 nodes of dual Athlon 2000 MP CPUs
• EECS’ own Departmental Computing Organization (DCO) administers over 1600 engineering workstations, provides file service, high capacity automated back-up system, and network connectivity with a state-of-the-art optical fiber gigabit ethernet.

In addition, individual faculty, instructional and research laboratories within the Department maintain dedicated computing systems specific to their instructional and research needs. A variety of specialized computing equipment is used, including several parallel multiprocessor systems and special-purpose systems for modeling and simulating computer architectures, database research, and artificial intelligence.
EECS FACULTY

Computer Science and Engineering Division

Faculty associated with the CSE Division are the primary advisors for students in the CSE graduate program.

* Steven Abney, Associate Professor
  Also Department of Linguistics
  Ph.D., M.I.T.
  Computational linguistics, learning, syntax

Mark S. Ackerman, Associate Professor
  Also School of Information
  Ph.D., M.I.T.
  Human-computer interaction, collaborative technologies, computer-supported cooperative work

* Daniel E. Atkins, Professor
  Also School of Information
  Ph.D., U-Illinois
  Computer-supported cooperative work, collaborative technologies, digital libraries, computer and information technology for disadvantaged communities

Todd Austin, Associate Professor
  Ph.D., U-Wisconsin
  Computer architecture, compilers, VLSI design, hardware modeling and verification

Satinder Singh Baveja, Associate Professor
  Ph.D., U-Massachusetts
  Reinforcement learning, machine learning, computational game theory, adaptive human-computer interaction

Valeria Bertacco, Assistant Professor
  Ph.D., Stanford
  Scalable hardware verification using symbolic and formal simulation methods.

David T. Blaauw, Associate Professor
  Ph.D., University of Illinois
  Circuit analysis, computer-aided design, high performance design.

Chandrasekhar Boyapati, Assistant Professor
  Ph.D., MIT
  Use of programming language constructs to eliminate certain classes of programming errors.

Richard B. Brown, Professor
  Ph.D., U-Utah
  Integrated circuit design (VLSI); solid-state chemical sensors; microelectromechanical systems; mixed-signal circuits; high-performance, radiation-hard, and low-power microprocessors; CMOS, SOI and GaAs

Peter M. Chen, Associate Professor
  Ph.D., UC-Berkeley
  Computer systems, computer architecture, performance evaluation

Kevin J. Compton, Associate Professor
  Ph.D., U-Wisconsin
  Theory of computation, complexity of combinatorial and logical problems, analysis of algorithms, automata theory

Stephen W. Director, Robert J. Vlasic Dean of Engineering and Professor
  I.E.E.E. Fellow; Member, National Academy of Engineering
  Ph.D., UC-Berkeley
  Computer-aided design, CAD frameworks, statistical design, circuit theory, technology enhanced learning, numerical analysis

Edmund Durfee, Professor
  Also School of Information
  Ph.D., U-Massachusetts
  Multi-agent coordination and intelligent real-time systems

Jason Flinn, Assistant Professor
  Ph.D., Carnegie Mellon
  Mobile and pervasive computing, operating systems, distributed systems, energy management.

* George Furnas, Professor
  Also School of Information
  Ph.D., Stanford
  Human-computer interaction, specializing in areas related to information access and visualization; multivariate statistics and graphical reasoning.

Igor Guskov, Assistant Professor
  Ph.D., Princeton
  Computer graphics and data compression

John P. Hayes, Claude E. Shannon Professor of Engineering Science
  A.C.M. Fellow, I.E.E.E. Fellow
  Ph.D., U-Illinois
  Computer architecture, fault tolerant computers, VLSI design, computer-aided design and testing

Alfred O. Hero III, Professor
  I.E.E.E. Fellow
  Also Department of Biomedical Engineering and Department of Statistics
  Ph.D., Princeton
  Statistical communication theory, signal processing, detection and estimation theory, tomographic imaging

* John H. Holland, Professor
  Also Department of Psychology, External Professor, Santa Fe Institute
  Ph.D., U-Michigan
  Artificial intelligence (complex adaptive systems), architectures and algorithms for parallel computation, mathematical theory of adaptive systems and cognitive processes

H. V. Jagadish, Professor
  Ph.D., Stanford
  Database systems, data analysis, internet data management

Farnam Jahanian, Professor
  Ph.D., U-Texas, Austin
  Real-time system specification and verification; fault-tolerant systems

Sugih Jamin, Associate Professor
  Ph.D., USC
  Computer networks

* Stephen Kaplan, Professor
  Also Department of Psychology
  Ph.D., U-Michigan
  Natural intelligence, active symbols and associative structure, attention and mental fatigue

To request an application, go to: http://www.eecs.umich.edu
David Kieras, Professor
Also Department of Psychology
Ph.D., U-Michigan
Human-computer interaction, user interface design, human cognition and performance, natural language processing

Daniel Koditschek, Professor
Ph.D., Yale
Dexterous robotic systems, intelligent manufacturing, nonlinear control, real-time control

Stéphane Lafortune, Professor
I.E.E.E. Fellow
Ph.D., UC-Berkeley
Modeling, analysis and control of discrete event systems, intelligent vehicle highway systems, semiconductor manufacturing

John Laird, Professor
Association of Artificial Intelligence Fellow
Ph.D., Carnegie Mellon
Artificial intelligence, cognitive architectures, machine learning, and computer games

Richard Lewis, Associate Professor
Also Department of Psychology
Ph.D., Carnegie Mellon
Computational models of natural language sentence understanding

Mingyan Liu, Assistant Professor
Ph.D., U-Maryland
Wireless, satellite and terrestrial hybrid networks, mobile Ad Hoc networks, network performance analysis, modeling and simulation, communication protocol design and analysis

Satyanarayana Lokam, Assistant Professor
Ph.D., U-Chicago
Computational complexity, lower bounds, randomized computation, and combinatorics

Scott Mahlke, Assistant Professor
Ph.D., U-Illinois
Compilers, compiler-directed architecture

Morley Mao, Assistant Professor
Ph.D., UC-Berkeley
Wide-area networks and distributed systems.

Lee Markosian, Assistant Professor
Ph.D., Brown University
Computer graphics, with a focus on techniques for non-photo-realistic (NPR) rendering.

Igor Markov, Assistant Professor
Ph.D., UCLA
Algorithms, large-scale optimization, VLSI, CAD for physical design, quantum computing

Pinaki Mazumder, Professor
I.E.E.E. Fellow
Ph.D., U-Illinois
VLSI circuit design, VLSI testing, and VLSI layout tools

Trevor N. Mudge, Bredt Family Professor of Engineering
I.E.E.E. Fellow
Ph.D., U-Illinois
Computer systems design, parallel processing, computer-aided design, impact of technology on computer architecture

Brian D. Noble, Assistant Professor
Morris Wellman Faculty Development Assistant Professor
Ph.D., Carnegie Mellon
Mobile and pervasive computing, distributed systems, file systems

Marios Papaefthymiou, Associate Professor
Ph.D., MIT
Computer-aided design, VLSI design, algorithms, parallel and distributed computing

Jignesh Patel, Assistant Professor
Ph.D., U-Wisconsin
Bioinformatics, spatial query processing, XML query processing, interactions between DBMSs and processor architectures

Thad Polk, Associate Professor
Also Department of Psychology
Ph.D., Carnegie Mellon
Cognitive neuroscience; functional neuroimaging; computational modeling; neural networks; reading; unified theories of cognition

Martha Pollack, Professor
American Association of Artificial Intelligence Fellow
Ph.D., U-Pennsylvania
Artificial intelligence, planning and execution, agent-based systems, computational models of rationality

Atul Prakash, Professor
Ph.D., UC-Berkeley
Computer-supported cooperative work, security, distributed systems

* Dragomir R. Radev, Assistant Professor
Also School of Information
Ph.D., Columbia University
Information retrieval, natural language processing, digital libraries, text and data mining, artificial intelligence

Steven Reinhardt, Associate Professor
Ph.D., Stanford
Theoretical computer science, natural language processing

Kareem A. Sakallah, Professor
I.E.E.E. Fellow
Ph.D., Carnegie Mellon
VLSI, computer-aided design, timing verification, optimal clocking

Yaojun Shi, Assistant Professor
Ph.D., Princeton
Theory of computation and quantum computing

Kang G. Shin, Kevin and Nancy O'Connor Professor of Computer Science
A.C.M. Fellow, I.E.E.E. Fellow
Ph.D., Cornell
QoS-sensitive computation and networking, especially focusing on Internet services and applications; networked embedded real-time systems; fault-tolerant system design, analysis, and validation
Elliot Soloway, Professor  
Also School of Education, School of Information  
Ph.D., U-Massachusetts  
Artificial intelligence and software engineering; artificial intelligence and education

Quentin F. Stout, Professor  
Ph.D., Indiana  
Parallel computing, algorithms, software, scientific and statistical computing, adaptive designs, mathematics

Demosthenis Teneketzis, Professor  
I.E.E.E. Fellow  
Ph.D., MIT  
Stochastic control, decentralized stochastic systems, decentralized stochastic systems, communication and queuing networks, stochastic scheduling and resource allocation problems, semiconductor manufacturing

Toby J. Teorey, Professor  
Ph.D., U-Wisconsin  
Database design and data warehousing, OLAP, data mining, performance of computer systems

Gregory H. Wakefield, Associate Professor  
Also Department of Otolaryngology  
Ph.D., U-Minnesota  
Spectral estimation theory, array processing, speech coding, music processing

Michael Wellman, Professor  
Ph.D., MIT  
Artificial intelligence, electronic commerce, distributed computation

Electrical and Computer Engineering Division

Faculty in the ECE Division are the primary advisors for students in the EE and EE:S degree programs.

Achilleas Anastasopoulos, Assistant Professor  
Ph.D., USC  
Communication theory (detection in uncertain environments, iterative detection based on soft-decision algorithms), coding (turbo codes, TCM for non-interleaved fading channels)

David J. Anderson, Professor  
AIMBE Fellow  
Also Department of Biomedical Engineering, Department of Otolaryngology  
Ph.D., U-Wisconsin  
Bioengineering, space medicine, neurophysiology of the auditory and vestibular systems, digital signal processing

Todd Austin, Associate Professor  
Ph.D., U-Wisconsin  
Computer architecture, compilers, VLSI design, hardware modeling and verification.

Pallab Bhattacharya, James R. Mellow Professor of Engineering  
I.E.E.E. Fellow, O.S.A. Fellow  
Ph.D., U-Sheffield  
Compound semiconductor materials growth and characterization, optoelectronic devices and device physics

David T. Blaauw, Associate Professor  
Ph.D., University of Illinois  
Circuit analysis, computer-aided design, high performance design.

Richard B. Brown, Professor  
Ph.D., U-Utah  
Integrated circuit design (VLSI); solid-state chemical sensors; microelectromechanical systems; mixed-signal circuits; high-performance, radiation-hard, and low-power microprocessors; CMOS, SOI and GaAs

*Charles A. Cain, Professor  
I.E.E.E. Fellow; AIMBE Fellow  
Also Department of Biomedical Engineering  
Ph.D., U-Michigan  
Biomedical ultrasound, hyperthermia cancer therapy, acoustic imaging

Stephen W. Director, Robert J. Vlastic Dean of Engineering and Professor  
I.E.E.E. Fellow; Member, National Academy of Engineering  
Ph.D., UC-Berkeley  
Computer-aided design, CAD frameworks, statistical design, circuit theory, technology enhanced learning, numerical analysis

Anthony W. England, Professor  
Also Department of Atmospheric, Oceanic, and Space Sciences  
I.E.E.E. Fellow  
Ph.D., MIT  
Radiative transfer and remote sensing

Jeffrey A. Fessler, Associate Professor  
Also: Department of Biomedical Engineering and Department of Radiology  
Ph.D., Stanford  
Statistical signal and image processing, tomographic imaging, parameter estimation

Michael P. Flynn, Assistant Professor  
Ph.D., Carnegie Mellon  
Analog circuits, analog-to-digital conversion, high-speed serial transceivers, RF circuits

James S. Freudenberg, Professor  
I.E.E.E. Fellow  
Ph.D., U-Illinois  
Linear multivariable feedback systems, robustness and sensitivity issues, frequency domain methods, semiconductor manufacturing

Almantas Galvanauskas, Associate Professor  
Ph.D., Royal Institute of Technology (Sweden)  
Fiber optics, fiber and ultrafast lasers and amplifiers, nonlinear optics, electrically poled ferroelectric materials, semiconductor lasers, integrated optics

Ranjit Gharpurey, Assistant Professor  
Ph.D., UC-Berkeley  
RF and analog circuit design, system analysis and architecture design for wireless communication transceivers

Yogesh Gianchandani, Associate Professor  
Ph.D., U-Michigan  
Design and fabrication of microsensors, microactuators, and micro-electro-mechanical systems (MEMS); development of manufacturing processes using combinations of traditional and novel materials and techniques

To request an application, go to: http://www.eecs.umich.edu
<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Research Interests</th>
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<tbody>
<tr>
<td>Brian Gilchrist</td>
<td>Associate Professor</td>
<td>Databases and information systems, computer security</td>
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<td></td>
<td>Also Department of Atmospheric, Oceanic, and Space Sciences</td>
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<td>Ph.D., Stanford</td>
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<tr>
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<td>Plasma electrodynamics in space and propulsion, microwave plasma diagnostics, radiowave propagation in the ionosphere</td>
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<tr>
<td>Lingjie Guo</td>
<td>Assistant Professor</td>
<td>Databases and information systems, computer security</td>
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<td>Ph.D., U-Minnesota</td>
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<tr>
<td></td>
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<td>Nanoelectronics, nanofabrication technology with applications in optical and organic devices</td>
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<tr>
<td>* Daniel Green</td>
<td>Professor</td>
<td>High capacity optical routers, secure communication networks, networks for bio-medical applications</td>
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<td></td>
<td>I.E.E.E. Fellow; OSA Fellow</td>
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<tr>
<td>George I. Haddad</td>
<td>Robert J. Hiller</td>
<td>Research Interests: systems science and control, applications to automotive systems, semiconductor manufacturing</td>
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<td></td>
<td>Professor</td>
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<td>I.E.E.E. Fellow; Member, National Academy of Engineering</td>
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<td>Ph.D., U-Michigan</td>
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<td>Microwave and millimeter-wave solid-state devices and integrated circuits, microwave theory and techniques, microwave-optical interactions, optoelectronic devices and circuits</td>
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<tr>
<td>John P. Hayes</td>
<td>Claude E. Shannon</td>
<td>Research Interests: systems science and control, applications to automotive systems, semiconductor manufacturing</td>
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<td>Professor</td>
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<td>A.C.M. Fellow, I.E.E.E. Fellow</td>
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<td>Ph.D., U-Illinois</td>
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<td>Computer architecture, fault tolerant computers, VLSI design, computer-aided design and testing</td>
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<td>Alfred O. Hero III</td>
<td>Professor</td>
<td>Research Interests: systems science and control, applications to automotive systems, semiconductor manufacturing</td>
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<tr>
<td>Mohammed Islam</td>
<td>Professor</td>
<td>High capacity optical routers, secure communication networks, networks for bio-medical applications</td>
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<td>OSA Fellow; MIT</td>
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<td>* Pierre T. Kabamba</td>
<td>Professor</td>
<td>Research Interests: systems science and control, applications to automotive systems, semiconductor manufacturing</td>
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<td>Jerzy Kanicki</td>
<td>Professor</td>
<td>Research Interests: systems science and control, applications to automotive systems, semiconductor manufacturing</td>
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<td>Dr. es Sciences, Free Univ. of Brussels</td>
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<td>Molecular and organic electronics; amorphous and polycrystalline semiconductor (inorganic and organic) thin film devices and circuits; flat panel displays and sensors technology</td>
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<tr>
<td>* Daryl R. Kipke</td>
<td>Associate Professor</td>
<td>Research Interests: systems science and control, applications to automotive systems, semiconductor manufacturing</td>
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<td></td>
<td>Also, Department of Biomedical Engineering</td>
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<td>Ph.D., U-Michigan</td>
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<td>Neural prostheses, bioMEMS, neural implants, functional electrical stimulation, cortical plasticity and function, minimally invasive technologies for neurosurgery</td>
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<tr>
<td>Daniel Koditschek</td>
<td>Professor</td>
<td>Research Interests: systems science and control, applications to automotive systems, semiconductor manufacturing</td>
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<td>Ph.D., Yale</td>
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<td>Dexterous robotic systems, intelligent manufacturing, nonlinear control, real-time control</td>
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<td>Stéphane Lafortune</td>
<td>Professor</td>
<td>Research Interests: systems science and control, applications to automotive systems, semiconductor manufacturing</td>
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<td>I.E.E.E. Fellow</td>
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<tr>
<td>Emmett N. Leith</td>
<td>Schlumberger Professor in Engineering</td>
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<td></td>
<td>I.E.E.E. Fellow; O.S.A. Fellow; National Medal of Science; Member, National Academy of Engineering</td>
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<td>Ph.D., Wayne State</td>
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<td>Optical spatial filtering and correlation techniques, holography, interferometry, optical information processing</td>
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<tr>
<td>Mingyan Liu</td>
<td>Assistant Professor</td>
<td>Research Interests: systems science and control, applications to automotive systems, semiconductor manufacturing</td>
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<td>Ph.D., U-Maryland</td>
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<td>Wireless, satellite and terrestrial hybrid networks, mobile Ad Hoc networks, network performance analysis, modeling and simulation, communication protocol design and analysis</td>
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<tr>
<td>Michel Maharbiz</td>
<td>Assistant Professor</td>
<td>Research Interests: systems science and control, applications to automotive systems, semiconductor manufacturing</td>
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<td>Ph.D., UC-Berkeley</td>
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<td>MEMS with a focus on biomolecular applications</td>
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<tr>
<td>Igor Markov</td>
<td>Assistant Professor</td>
<td>Research Interests: systems science and control, applications to automotive systems, semiconductor manufacturing</td>
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<td>Ph.D., UCLA</td>
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<td>Algorithms, large-scale optimization, VLSI, CAD for physical design, quantum computing</td>
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<td>Pinaki Mazumder</td>
<td>Professor</td>
<td>Research Interests: systems science and control, applications to automotive systems, semiconductor manufacturing</td>
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<td>I.E.E.E. Fellow; Member, National Academy of Engineering</td>
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<td>Ph.D., U-Illinois</td>
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<td>VLSI circuit design, VLSI testing, and VLSI layout tools</td>
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<td>Leo C. McAfee</td>
<td>Associate Professor</td>
<td>Research Interests: systems science and control, applications to automotive systems, semiconductor manufacturing</td>
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<td>Ph.D., U-Michigan</td>
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<td>Modeling of integrated circuits for computer-aided analysis and design, automated semiconductor manufacturing</td>
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<tr>
<td>* N. Harris McClamroch</td>
<td>Professor</td>
<td>Research Interests: systems science and control, applications to automotive systems, semiconductor manufacturing</td>
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<td>I.E.E.E. Fellow</td>
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<tr>
<td>Roberto D. Merlin</td>
<td>Professor</td>
<td>Research Interests: systems science and control, applications to automotive systems, semiconductor manufacturing</td>
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<td>František Moravec</td>
<td>Professor</td>
<td>Research Interests: systems science and control, applications to automotive systems, semiconductor manufacturing</td>
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<td>I.E.E.E. Fellow</td>
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<tr>
<td>Semyon M. Meerkov</td>
<td>Professor</td>
<td>Research Interests: systems science and control, applications to automotive systems, semiconductor manufacturing</td>
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<td>I.E.E.E. Fellow</td>
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<td>Alfredo Diapolitis Fumagalli</td>
<td>Associate Professor</td>
<td>Research Interests: systems science and control, applications to automotive systems, semiconductor manufacturing</td>
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<td>Ph.D., UC-Illinois</td>
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<td>Modeling of integrated circuits for computer-aided analysis and design, automated semiconductor manufacturing</td>
</tr>
</tbody>
</table>

Mailing Address: EECS Dept., University of Michigan, 1301 Beal Ave., Ann Arbor, MI 48109-2122
Mahta Moghaddam, Associate Professor
Ph.D., U-Illinois
Radar remote sensing

Amir Mortazawi, Associate Professor
Ph.D., U-Texas, Austin
RF and microwave circuits including: microwave and millimeter-wave power amplifiers, spatial power combining and thin film ferroelectric based frequency agile circuits

Gerard A. Mourou, A.D. Moore
Distinguished Professor of Electrical Engineering and Computer Science
I.E.E.E. Fellow; OSA Fellow; Member, National Academy of Engineering
Ph.D., U-Paris
Optics in the single cycle regime, applications to physical electronics, ultra intense beams

Trevor N. Mudge, Breit Family Professor of Engineering
I.E.E.E. Fellow
Ph.D., U-Illinois
Computer systems design, parallel processing, computer-aided design, impact of technology on computer architecture

*Andrew F. Nagy, Professor
Also Department of Atmospheric, Oceanic, and Space Sciences
Ph.D., U-Michigan
Studies of the atmospheres, ionospheres, and magnetospheres of the Earth and planets

Khalil Najafi, Professor
I.E.E.E. Fellow
Also Department of Biomedical Engineering
Ph.D., U-Michigan
Solid-state integrated sensors, microactuators, micromechanics, analog and digital integrated circuits

David L. Neuhoff, Professor
I.E.E.E. Fellow
Ph.D., Stanford
Communication and information theory, source coding, quantization and data compression, coding for magnetic recording, digital image halftoning

Clark Nguyen, Associate Professor
[On leave]
Ph.D., UC-Berkeley
Micro electromechanical systems, including integrated micromechanical signal processors and integrated sensors, merged circuit/micromechanizations, integrated circuit design and technology

Theodore B. Norris, Professor
Ph.D., U-Rochester
Ultrashort pulse lasers, ultrafast relaxation processes in semiconductors, semiconductor devices

*Matthew O'Donnell, J erry W and Carol L. Levine Professor of Engineering
I.E.E.E. Fellow; AIMBE Fellow
Also Department of Biomedical Engineering
Ph.D., Notre Dame
Medical imaging

Stella Pang, Professor
I.E.E.E. Fellow; American Vacuum Society Fellow; Electro Chemical Society Fellow
Ph.D., Princeton
Nanofabrication technology, dry etching, dry deposition, microelectronic, optical, micromechanical devices

Marios Papaefthymiou, Associate Professor
Ph.D., MIT
Computer-aided design, VLSI design, algorithms, parallel and distributed computing

Dimitris Pavlidis, Professor
I.E.E.E. Fellow
Ph.D., U-Newcastle
Heterostructure devices and monolithic integrated circuits for high-speed and millimeter-wave applications, device design, technology and characterization, MOVPE growth of III-V materials

Jamie Phillips, Assistant Professor
Ph.D., U-Michigan
Crystal growth and characterization of semiconductors and related materials or electronic and optoelectronic devices, semiconductor nanostructures, IR detectors

Stephen C. Rand, Professor
Also Department of Physics, Division of Applied Physics
Ph.D., U-Toronto
Solid-state laser materials, laser spectroscopy, optical physics, condensed matter physics, widegap semiconductors, upconversion and fiber lasers

Gabriel Rebeiz, Professor
I.E.E.E. Fellow
Ph.D., Caltech
RF MEMS: Switches, varactors, tunable filters, tunable networks, tunable antennas, low-loss phase shifters; packaging and reliability of RF MEMS; RFIC oscillators, amplifiers and tunable filters using CMOS and SiGe transistors; millimeter-wave antennas and front-ends; automotive radars and phased arrays

Steven Reinhardt, Associate Professor
Ph.D., U-Wisconsin
Computer architecture, parallel and distributed systems, operating systems, and computer system simulation

*Christopher S. Ruf, Associate Professor
Also Department of Atmospheric, Oceanic, and Space Sciences
Earth environmental remote sensing; satellite microwave sensor design and development, atmospheric propagation and radiation, oceanic processes

Karem A. Sakallah, Professor
I.E.E.E. Fellow
Ph.D., Carnegie Mellon
VLSI, computer-aided design, timing verification, optimal clocking

Sandeep P. Sandanandaroa, Assistant Professor
Ph.D., UC-Berkeley
Distributed source coding, coding for sensor networks and ad-hoc networks, multi-user communication theory, channel coding theory, quantization, multiple description coding, multimedia watermarking, wavelets, multi-rate signal processing, multi-carrier communication

To request an application, go to: http://www.eecs.umich.edu
FINANCIAL AID

Research assistantships, teaching assistantships and fellowships are available to students through the EECS Department.

Research assistants work with faculty and advanced graduate students on specific research projects. Teaching assistants provide classroom assistance to students through recitations, laboratories, office hours and projects. The typical research or teaching appointment is for fifteen to twenty-five hours a week.

Department fellowships come from the University, government, and industry and provide support that is generally unencumbered by specific duties or requirements. Students with fellowships will participate in one or more research projects to identify a research area.

Fellowship and assistantship awards typically include full tuition coverage, a stipend ranging from $1,100 to $1,750 per month, and health insurance. For recipients of National Science Foundation Fellowships, the University waives any tuition not covered by NSF. The EECS Department may also supplement other external funding to provide the student with a complete financial aid package. Students receiving such aid should contact the EECS Financial Aid Officer for additional details.
To Apply for Financial Aid

Financial awards made by EECS vary from a single term to support throughout graduate study. Details on length of departmental commitment will be given when an award is made.

To apply for financial aid, answer question 23 on the Rackham application form. No additional application is required for departmental financial aid, although completion of the Free Application for Federal Student Aid (FAFSA) form will increase the number of departmental programs for which a student can be considered. The FAFSA is required by the University’s Office of Financial Aid for loans or Work/Study support.

GRADUATE PROGRAMS

MASTER’S DEGREE PROGRAMS

Each of the graduate programs offers specialization in several areas of academic interest. By clustering courses into these areas, or “kernels,” students have the opportunity to develop breadth—by taking core courses across kernels—and depth—by taking multiple courses in one of the kernels. Each EECS graduate program maintains a handbook that outlines the specific requirements in detail. Students are strongly encouraged to meet regularly with EECS faculty advisors and the graduate program staff to ensure that they are following an appropriate and productive path.

In all three graduate programs, students must satisfy the following requirements:

- 30 credit hours of graduate level coursework.
- At least 24 credit hours in technical coursework.
- Specialized “kernel” courses:
  * 15 credit hours of CSE coursework at the 500 level or above for CSE, or
  * at least 12 credit hours of EECS coursework at the 500 level or above for EE & EE:S.

Each program designates a set of kernel courses from which to choose for this requirement.

Students who enter the program with an undergraduate engineering degree can choose to receive either the M.S. or M.S.E. degree. Students who enter without an undergraduate engineering degree receive an M.S. degree.

In addition, all students must meet the general master’s degree requirements of the Rackham School of Graduate Studies and the College of Engineering. The Rackham Bulletin and the College of Engineering Bulletin can be viewed in detail on their websites at http://www.rackham.umich.edu and http://www.engin.umich.edu.

CSE: Incoming graduate students are assigned an academic advisor in their area of interest. The program is designed to give students broad training in the major areas of computer science and engineering, and includes required selections in hardware, software, intelligent systems, theory, and VLSI. A research-oriented directed study or master’s thesis is optional.

EE: Students in the EE master’s program choose a major area, complete a kernel of courses in each, and earn three credit hours in mathematics. Major areas are: applied electromagnetics and RF circuits, circuits and microsystems, electro-optics, solid-state, and VLSI. While majoring in the areas above, students can also take courses from the following areas: biosystems, communications, computers, control systems, or signal processing. A master’s thesis is optional.

EE:S: Students in the EE:S master’s program choose a major and a minor area and complete a kernel of courses in each. Major areas are communications, control systems, or signal processing. The minor area must be different from the major and generally is chosen from the major area list or from the following list: biosystems, circuits and electronics, com-
puters, electromagnetics, electro-optics, manufacturing, or solid-state. In addition, some flexibility is available to students who want to tailor their major or minor to research areas that cut across traditional disciplinary boundaries.

DOCTORAL DEGREE REQUIREMENTS
The Ph.D. degree is conferred for outstanding scholarship in a relatively broad field of knowledge and a demonstrated ability to plan and carry out independent research that yields significant original results.

EECS offers the Ph.D. degree in each of its three graduate programs.

The three doctoral programs have essentially the same degree requirements, but differ in technical content. The principal requirements of the Ph.D. degree are:

- Completion of thirty-six credit hours of relevant graduate level coursework beyond the bachelor's degree, including a set of courses known as the Doctoral Coursework.
- Completion and defense of a dissertation presenting original research results.
- Completion of all Rackham School requirements. The Rackham Student Handbook is available on-line at the Horace H. Rackham School of Graduate Studies website at http://www.rackham.umich.edu/.

Checkpoints along the way include: qualification, candidacy, thesis proposal and the dissertation defense.

Doctoral Coursework
A student entering with a master's degree may meet some of these course requirements by counting equivalent courses taken elsewhere. Policies vary among the three programs, and equivalency credit is always subject to program approval.

CSE Program: Courses from the kernel areas of study must be successfully completed before qualification. The kernel areas are: theory, software, hardware, intelligent systems, and VLSI. One area forms a major for the area part of the qualifying examination.

EE Program: Four courses from the kernel of a major area must be completed before qualification. Six courses from the kernel of a major area must be completed before candidacy. The major areas are the same as those for the EE master's degree.

EE:S Program: Three or four courses from the kernel of a major area and two courses from the kernel of a minor area must be completed before qualification. Six courses from the kernel of a major area and three courses from the kernel of a minor area must be completed before candidacy. The major and minor areas are the same as for the EE:S master's degree.

Qualification and Candidacy
The basic qualification require-
EECS GRADUATE LEVEL COURSE LIST

Graduate courses are 500 level and above; 400 level courses may also be admissible for some of your graduate credit.

EECS 401. Probabilistic Methods in Engineering
Prerequisite: EECS 206 or 212/316 and Junior Standing. I, II (4 credits)
Basic concepts of probability theory. Random variables: discrete, continuous, and conditional probability distributions; averages; independence. Introduction to discrete and continuous random processes: wide sense stationarity, correlation, spectral density. A student can receive credit for only one: EECS 401 or EECS 501.

EECS 411. Microwave Circuits I
Prerequisite: EECS 330 or Graduate Standing. I (4 credits)
Transmission-line theory, microstrip and coplanar lines, S-parameters, signal-flow graphs, matching networks, directional couplers, low-pass and band-pass filters, diode detectors. Design, fabrication, and measurements (1-10 GHz) of microwave-integrated circuits using CAD tools and network analyzers.

EECS 413. Monolithic Amplifier Circuits
Prerequisite: EECS 311 and EECS 320 or Graduate Standing. II (4 credits)

EECS 414. Introduction to MEMS
Prerequisite: (Math 215, Math 216, Physics 240 and Senior Standing) or Graduate Standing. I (4 credits)
Micro electro mechanical systems (MEMS), devices, and technologies. Micromachining and microfabrication techniques, including planar thin-film processing, silicon etching, wafer bonding, photolithography, deposition, and etching.

EECS 417 (BiomedE 417). Electrical Biophysics
Prerequisite: EECS 206 and 215 or Graduate Standing. I (4 credits)
Electrical biophysics of nerve and muscle; electrical conduction in excitable tissue; quantitative models for nerve and muscle, including the Hodgkin Huxley equations; biopotential mapping, cardiac electrophysiology, and functional electrical stimulation; group projects. Lecture and recitation.

EECS 420. Introduction to Quantum Electronics
Prerequisite: (EECS 320 and EECS 330 or equivalent) or Graduate Standing. I (4 credits)
Introduction to quantum mechanics of electrons and photons. Electrons in crystals. Metals, semiconductors and insulators. Effective mass, holes, valence and conduction band. Quantum wells, wires and dots. Tunneling effects and applications. Introduction to scattering theory. Charge transport, mobilities in semiconductors. Optical absorption and gain in semiconductors. Physical phenomena discussed in this course will be related to important microelectronic devices.

EECS 421. Properties of Transistors
Prerequisite: EECS 320 or Graduate Standing. I (3 credits)
DC, small and large signal AC, switching and power-limiting characteristics, and derivation of equivalent circuit models of: PN junctions, metal-semiconductor and metal-insulator semiconductor diodes, bipolar junction transistors, junction and insulated-gate field-effect transistors, and thyristors.

EECS 423. Solid-State Device Laboratory
Prerequisite: EECS 320 or Graduate Standing. I (4 credits)
Semiconductor material and device fabrication and evaluation: diodes, bipolar and field-effect transistors, passive components. Semiconductor processing techniques: oxidation, diffusion, deposition, etching, photolithography. Lecture and laboratory. Projects to design and simulate device fabrication sequence.

EECS 425. Integrated Microsystems Laboratory
Prerequisite: EECS 311 or 320 or Graduate Standing. II (4 credits)
Development of a complete integrated microsystem, from functional definition to final test. MEMS-based transducer design and electrical, mechanical and thermal limits. Design of MOS interface circuits. MEMS and MOS chip fabrication. Mask making, pattern transfer, oxidation, ion implantation and metallization. Packaging and testing challenges. Students work in interdisciplinary teams.

EECS 427. VLSI Design I
Prerequisite: EECS 270 and EECS 312 or Graduate Standing. I, II (4 credits)

EECS 429. Semiconductor Optoelectronic Devices
Prerequisite: EECS 320 or Graduate Standing. II (4 credits)

EECS 430. Radiowave Propagation and Link Design
Prerequisite: EECS 330 and Senior Standing or Graduate Standing. II (4 credits)
Fundamentals of electromagnetic wave propagation in the ionosphere, the troposphere, and near the Earth. Student teams will develop practical radio link designs and demonstrate critical technologies. Simple antennas, noise, diffraction, refraction, absorption, multipath interference, and scattering are studied.

To request an application, go to: http://www.eecs.umich.edu
EECS 434. Principles of Photonics
Prerequisite: EECS 330 or EECS 334 or permission of instructor or Graduate Standing. I (4 credits)
Introduction to photonics, optoelectronics, lasers and fiber-optics. Topics include mirrors, interferometers, modulators and propagation in waveguides and fibers. The second half treats photons in semiconductors, including semiconductor lasers, detectors and noise effects. System applications include fiber lightwave systems, ultra-high-peak power lasers, and display technologies.

EECS 435. Fourier Optics
Prerequisite: (EECS 212/316 or 306, preceded or accompanied by EECS 334 and/or Junior Standing) or Graduate Standing. II odd years (3 credits)

EECS 438. Advanced Lasers and Optics Laboratory
Prerequisite: EECS 334 or EECS 434 or Graduate Standing. II (4 credits)
Construction and design of lasers; gaussian beams; nonlinear optics; fiber optics; detectors; dispersion; Fourier optics; spectroscopy. Project requires the design and set-up of a practical optical system.

EECS 442. Computer Vision
Prerequisite: EECS 281 or Graduate Standing. I (4 credits)
Computational methods for the recovery, representation, and application of visual information. Topics from image formation, binary images, digital geometry, similarity and dissimilarity detection, matching, curve and surface fitting, constraint propagation relaxation labeling, stereo, shading texture, object representation and recognition, dynamic scene analysis, and knowledge-based techniques. Hardware, software techniques.

EECS 451. Digital Signal Processing and Analysis
Prerequisite: EECS 212/316 or 306 or Graduate Standing. II (4 credits)

EECS 452. Digital Signal Processing Design Laboratory
Prerequisite: EECS 212/316 or 306 or Graduate Standing. III (4 credits)
Architectural features of single-chip DSP processors are introduced in lecture. Laboratory exercises using two different state-of-the-art fixed-point processors include sampling, A/D and D/A conversion, digital wave form generators, real-time FIR and IIR filter implementations. The central component of this course is a 12-week team project in real-time DSP Design (including software and hardware development).

EECS 455. Digital Communication Signals and Systems
Prerequisite: (EECS 401 and EECS 212/316 or 306) or Graduate Standing. I (3 credits)
Digital transmission techniques in data communications, with application to computer and space communications; design and detection of digital signals for low error rate; forward and feedback transmission techniques; matched filters; modems, block and convolutional coding; Viterbi decoding.

EECS 458 (BiomedE 458). Biomedical Instrumentation and Design
Prerequisite: EECS 215, or 314 or consent of instructor or Graduate Standing. II (4 credits)
Measurement and analysis of biopotentials and biomedical transducer characteristics; electrical safety; applications of FETs, integrated circuits, operational amplifiers for signal processing and computer interfacing; signal analysis and display on the laboratory minicomputer. Lectures and laboratory.

EECS 460. Control Systems Analysis and Design
Prerequisite: EECS 212/316 or 306 or Graduate Standing. I (3 credits)
Basic techniques for analysis and design of controllers applicable in any industry (e.g. automotive, aerospace, semiconductor, bioengineering, power, etc.) are discussed. Both time- and frequency-domain methods are covered. Root locus, Nyquist stability criterion, and Bode plot-based techniques are used as tools for analysis and design.

EECS 461. Embedded Control Systems
Prerequisite: EECS 306 or EECS 373 or Graduate Standing. I (4 credits)

EECS 470. Computer Architecture
Prerequisite: EECS 370 or Graduate Standing. I, II (4 credits)

EECS 477. Introduction to Algorithms
Prerequisite: EECS 281 or Graduate Standing. I (4 credits)
Fundamental techniques for designing efficient algorithms and basic mathematical methods for analyzing their performance. Paradigms for algorithm design: divide-and-conquer, greedy methods, graph search techniques, dynamic programming. Design of efficient data structures and analysis of the running time and space requirements of algorithms in the worst and average cases.
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To request an application, go to: [http://www.eecs.umich.edu](http://www.eecs.umich.edu)
EECS 497. EECS Major Design Projects
Prerequisite: Senior Standing and successful completion of at least two-thirds of the credit hours required for the program subjects. A student may select this course more than once only with the explicit approval of the Chief Program Advisor. I, II (4 credits)
Professional problem-solving methods developed through intensive group studies. Normally one significant design project is chosen for entire class requiring multiple EECS disciplines and teams. Use of analytic, computer, design, and experimental techniques where applicable are used. Projects are often interdisciplinary allowing non-EECS seniors to also take the course (consult with instructor).

EECS 498. Special Topics
Prerequisite: permission of instructor.
(1-4 credits)
Topics of current interest selected by the faculty. Lecture, seminar or laboratory.

EECS 499. Directed Study
Prerequisite: Senior Standing in EECS. I, II, III (1-4 credits)
Individual study of selected topics in Electrical Engineering and Computer Science. May include experimental investigation or library research. Primarily for undergraduates.

EECS 500. Tutorial Lecture Series in System Science
Prerequisite: Graduate Standing; mandatory satisfactory/unsatisfactory. I, II (1 credit)
Students are introduced to the frontiers of System Science research. Sections 01, 02, and 03 are devoted, respectively to Communications, Control, and Signal Processing. The tutorials are delivered by leaders of the respective research fields, invited from academia and industry. The presentations are self-contained and accessible to all graduate students in System Science.

EECS 501 (Aero 552). Probability and Random Processes
Prerequisite: Graduate Standing. I (4 credits)
Introduction to probability and random processes. Topics include probability axioms, sigma algebras, random vectors, expectation, probability distributions and densities, Poisson and Wiener processes, stationary processes, autocorrelation, spectral density effects of filtering, linear least-squares estimation, and convergence of random sequences. A student may receive credit for only one: EECS 401 and EECS 501.

EECS 502. Stochastic Processes
Prerequisite: EECS 501. II odd years (3 credits)
Correlations and spectra. Quadratic mean calculus, including stochastic integrals and representations, wide-sense stationary processes (filtering, white noise, sampling, time averages, moving averages, autoregression). Renewal and regenerative processes, Markov chains, random walk and run, branching processing, Markov jump processes, uniformization, reversibility and queueing applications.

EECS 503. Introduction to Numerical Electromagnetics
Prerequisite: EECS 330. I (3 credits)
Introduction to numerical methods in electromagnetics including finite difference, finite element and integral equation methods for static, harmonic and time dependent fields; use of commercial software for analysis and design purposes; applications to open and shielded transmission lines, antennas, cavity resonances and scattering.

EECS 506. Computing System Evaluation
Prerequisite: EECS 183 or EECS 280, and EECS 370 and EECS 501. II odd years (3 credits)

EECS 509 (IOE 517). Traffic Modeling
Prerequisite: IOE 316, Stat 310, or EECS 401. I alternate years (3 credits)
Traffic Models and their analysis in the context of ITS (Intelligent Transportation Systems). Those aspects of traffic theory relevant to ITS are presented including traffic flow and signalized intersections, with particular emphasis on the optimization via route guidance and signal control of large scale traffic networks.

EECS 510. Intelligent Transportation Systems Research Topics
Prerequisite: two ITS-Certificate courses (may be taken concurrently). II (2 credits)
Topics include driver-highway interactions (traffic modeling, analysis and simulation), driver-vehicle interactions (human factors), vehicle-highway interactions (computer/communications systems architecture), collision prevention, ITS technologies (in-vehicle electronic sensors, etc.), socioeconomic aspects (user acceptance and liability), and system integration (comprehensive modeling and competitive strategy).

EECS 512. Amorphous and Microstavalline Semiconductor Thin Film Devices
Prerequisite: EECS 421 and/or permission of instructor. I (3 credits)
Introduction and fundamentals of physical, optical and electrical properties of amorphous and microcrystalline semiconductor based devices: MIM structures, Schottky diodes, p-n junctions, heterojunctions, MIS structures, thin-film transistors, solar cells, threshold and memory switching devices and large area x-ray radiation detectors.

EECS 513. Flat Panel Displays
Prerequisite: EECS 423, EECS 512 and/or permission of instructor. II (3 credits)
Introduction and fundamentals to the passive, active, reflective and emissive flat panel display technologies. This course will discuss the physics, operating principles, properties and technology of the flat panel displays.

EECS 516 (BiomedE 516). Medical Imaging Systems
Prerequisite: EECS 451. I (3 credits)
Principles of modern medical imaging systems. For each modality the basic physics is described, leading to a systems model of the imager. Fundamental similarities between the imaging equations of different modalities will be stressed. Modalities covered include radiography, x-ray computed tomography (CT), MRI imaging (MRI) and real-time ultrasound.

EECS 517 (NERS 578). Physical Processes in Plasmas
Prerequisite: EECS 330. II even years (3 credits)
Plasma physics applied to electrical gas discharges used for material processing. Gas kinetics; atomic collisions; transport
coefficients; drift and diffusion; sheaths; Boltzmann distribution function calculation; plasma simulation; plasma diagnostics by particle probes, spectroscopy, and electromagnetic waves; analysis of commonly used plasma tools for materials processing.

EECS 518 (AOS 595). Magnetosphere and Solar Wind
Prerequisite: Graduate Standing. I, even years (3 credits)
General principles of magnetohydrodynamics; theory of the expanding atmospheres; properties of solar wind, interaction of solar wind with the magnetosphere of the Earth and other planets; bow shock and magnetotail, trapped particles, auras.

EECS 519 (NERS 575). Plasma Generation and Diagnostics Laboratory
Prerequisite: preceded or accompanied by a course covering electromagnetism. II (4 credits)
Laboratory techniques for plasma ionization and diagnosis relevant to plasma processing, propulsion, vacuum electronics, and fusion. Plasma generation includes: high voltage-DC, radio frequency, and electron beam sustained discharges. Diagnostics include: Langmuir probes, microwave cavity perturbation, microwave interferometry, laser schlieren, and optical emission spectroscopy. Plasma parameters measured are: electron/ ion density and electron temperature.

EECS 520. Electronic and Optical Properties of Semiconductors
Prerequisite: EECS 420 or EECS 540. II (4 credits)
The course discusses in detail the theory behind important semiconductor-based experiments such as Hall effect and Hall mobility measurement; velocity-field measurement; photoluminescence; gain; pump-probe studies; pressure and strain-dependent studies. Theory will cover: Bandstructure in quantum wells; effect of strain on bandstructure; transport theory; Monte Carlo methods for high field transport; excitons, optical absorption, luminescence and gain.

EECS 521. High-Speed Transistors
Prerequisite: EECS 421 or EECS 422. II (3 credits)
Detailed theory of high-speed digital and high-frequency analog transistors. Carrier injection and control mechanisms. Limits to miniaturization of conventional transistor concepts. Novel submicron transistors including MESFET, heterojunction and quasi-ballistic transistor concepts.

EECS 522. Analog Integrated Circuits
Prerequisite: EECS 413. II (4 credits)
Review of integrated circuit fabrication technologies and BJT and MOS transistor models. Detailed analysis and design of analog integrated circuits, including power amplifiers, voltage references, voltage regulators, rectifiers, oscillators, multipliers, mixers, phase detectors, and phase-locked loops. Design projects. Lectures and discussion.

EECS 523. Digital Integrated Technology
Prerequisite: EECS 311 and EECS 320 and EECS 423 or 425. I (4 credits)
Integrated circuit fabrication overview, relationships between processing choices and device performance characteristics. Long-channel device I-V review, short-channel MOSFET-IV characteristics including velocity saturation, mobility degradation, hot carriers, gate depletion. MOS device scaling strategies, silicon-on-insulator, lightly-doped drain structures, on-chip interconnect parasitics and performance. Major CMOS scaling challenges. Process and circuit simulation.

EECS 524. Field-Effect-Transistors and Microwave Monolithic Integrated Circuits Technology
Prerequisite: Graduate Standing and EECS 421, and either EECS 525 or EECS 528. II even years (3 credits)
Physical and electrical properties of III-V materials, epitaxy and ion-implantation, GaAs and InP based devices (MESFETS, HEMTs varactors) and Microwave Monolithic Integrated Circuits (MMICs). Cleaning, Photolithography, metal and dielectric deposition, wet and dry etching. Device isolation, ohmic and Schottky contacts, dielectrics, passive component technology, interconnects, wa holes, dicing and mounting. Study of the above processes by DC characterization.

EECS 525. Advanced Solid State Microwave Circuits
Prerequisite: EECS 411, EECS 421 or EECS 521. I (3 credits)
General properties and design of linear and nonlinear solid state microwave circuits including: amplifier gain blocks, low-noise, broadband and power amplifiers, oscillators, mixer and multiplier circuits, packaging, system implementation for wireless communication.

EECS 526. High-Performance Dynamic Device Models and Circuits
Prerequisite: EECS 413, or both EECS 311 and EECS 320. II (4 credits)
Models for devices (B) Ts, FETs, and integrated circuits), with primary emphasis on large-signal dynamic charge-control models. Mathematics and physics fundamentals for measurement concepts and methods. Mathematical and computer analysis and design of high-speed dynamic circuits. Dynamic circuit functional blocks, level detection/ comparison circuits; sweep/ ramp, multivibrator, and logic gate circuits.

EECS 527. Layout Synthesis and Optimization
Prerequisite: EECS 478. II (3 credits)
Theory of circuit layout partitioning and placement algorithms. Routing algorithms, parallel design automation on shared memory and distributed memory multi-processors, simulated annealing and other optimization techniques and their applications in CAD, layout transformation and compaction, fault-repair algorithms for RAMs and PLAs hardware synthesis from behavioral modeling, artificial intelligence-based CAD.

EECS 528. Principles of Microelectronics Process Technology
Prerequisite: EECS 421, EECS 423. II (3 credits)
Theoretical analysis of the chemistry and physics of process technologies used in micro-electronics fabrication. Topics include: semiconductor growth, material characterization, lithography tools, photo-resist models, thin film deposition, chemical etching, plasma etching, electrical contact formation, microstructure processing, and process modeling.

EECS 529. Semiconductor Lasers and LEDs
Prerequisite: EECS 429. I (3 credits)
Optical processes in semiconductors, spontaneous emission, absorption gain, stimulated emission. Principles of light-emitting diodes, including transient effects, spectral and spatial radiation fields. Principles of semiconducting lasers; gain-current relationships, radiation fields, optical confinement and transient effects.

To request an application, go to: http://www.eecs.umich.edu
EECS 530 (Appl Phys 530). Electromagnetic Theory I
Prerequisite: EECS 330 or Physics 438. I (3 credits)

EECS 531. Antenna Theory and Design
Prerequisite: EECS 330. II (3 credits)

EECS 532. Microwave Remote Sensing I: Radiometry
Prerequisite: EECS 330, Graduate Standing. I odd years (3 credits)
Radiative transfer theory: blackbody radiation; microwave radiometry; atmospheric propagation and emission; radiometer receivers; surface and volume scattering and emission; applications to meteorology, oceanography, and hydrology.

EECS 533. Microwave Measurements Laboratory
Prerequisite: EECS 330, Graduate Standing. II (3 credits)
Advanced topics in microwave measurements: power spectrum and noise measurement, introduction to state-of-the-art microwave test equipment, methods for measuring the dielectric constant of materials, polarimetric radar cross section measurements, near field antenna pattern measurements, electromagnetic emission measurement (EM compatibility). Followed by a project that will include design, analysis, and construction of a microwave subsystem.

EECS 534. Design and Characterization of Microwave Devices and Monolithic Circuits
Prerequisite: Graduate Standing, EECS 421 or EECS 525. I odd years (4 credits)
Theory and design of passive and active microwave components and monolithic integrated circuits including: microstrip, lumped inductors and capacitors, GaAs FETs, varactor and mixer diodes, monolithic phase shifters, attenuators, amplifiers and oscillators. Experimental characterization of the above components using network analyzer, spectrum analyzer, power and noise meters. Lecture and laboratory.

EECS 535. Optical Information Processing
Prerequisite: EECS 334. I even years (3 credits)
Theory of image formation with holography; applications of holography; white light interferometry; techniques for optical digital computing; special topics of current research interest.

EECS 536. Classical Statistical Optics
Prerequisite: EECS 334 or EECS 434, and EECS 401 or Math 425. I odd years (3 credits)
Applications of random variables to optics; statistical properties of light waves. Coherence theory. Spatial and temporal information retrieval; imaging through inhomogeneous media; noise processes in imaging and interferometric systems.

EECS 537 (Appl Phys 537). Classical Optics
Prerequisite: EECS 330 and EECS 334. I (3 credits)

EECS 538 (Appl Phys 550) (Physics 650). Optical Waves in Crystals
Prerequisite: EECS 434. I (3 credits)
Propagation of laser beams: Gaussian wave optics and the ABCD law. Manipulation of light by electrical, acoustical waves; crystal properties and the dielectric tensor; electro-optic, acousto-optic effects and devices. Introduction to nonlinear optics; harmonic generation, optical rectification, four-wave mixing, self-focusing, and self-phase modulation.

EECS 539 (Appl Phys 551) (Physics 651). Lasers
Prerequisite: EECS 537 and EECS 538. II (3 credits)
Complete study of laser operation: the atom-field interaction; homogeneous and inhomogeneous broadening mechanisms; atomic rate equations; gain and saturation; laser oscillation; laser resonators, modes, and cavity equations; cavity modes; laser dynamics, Q-switching and modelocking. Special topics such as femto-seconds lasers and ultrahigh power lasers.

EECS 540 (Appl Phys 540). Applied Quantum Mechanics I
Prerequisite: permission of instructor. I (3 credits)
Introduction to nonrelativistic quantum mechanics. Summary of classical mechanics, postulates of quantum mechanics and operator formalism, stationary state problems (including quantum wells, harmonic oscillator, angular momentum theory and spin, atoms and molecules, band theory in solids), time evolution, approximation methods for time independent and time dependent interactions including electromagnetic interactions, scattering.

EECS 541 (Appl Phys 541). Applied Quantum Mechanics II
Prerequisite: EECS 540. II (3 credits)
Continuation of nonrelativistic quantum mechanics. Advanced angular momentum theory, second quantization, nonrelativistic quantum electrodynamics, advanced scattering theory, density matrix formalism, reservoir theory.

EECS 542. Vision Processing
Prerequisite: EECS 442. I odd years (3 credits)
Details of image formation theory, including the consideration of dynamic image sequences. The theoretical frameworks for edge detection, feature extraction, and surface description are presented. The relationship between image formation and object features is examined in detail. Programming required.

EECS 543. Knowledge-Based Systems
Prerequisite: EECS 281 and Graduate Standing or permission of instructor. I (3 credits)
Techniques and principles for developing application software based on explicit representation and manipulation of domain...
knowledge, as applied to areas such as pattern matching, problem-solving, automated planning, and natural-language processing. Discussion of major programming approaches used in the design and development of knowledge-based systems.

**EECS 545. Machine Learning**
Prerequisite: EECS 492. (3 credits)
Survey of recent research on learning in artificial intelligence systems. Topics include learning based on examples, instructions, analogy, discovery, experimentation, observation, problem-solving, and explanation. The cognitive aspects of learning will also be studied.

**EECS 546 (Appl Phys 546). Ultrafast Optics**
Prerequisite: EECS 537. II (3 credits)

**EECS 547 (SI 652). Electronic Commerce**
Prerequisites: EECS 281 or SI 502 or permission of instructor. I or II (3 credits)
Introduction to the design and analysis of automated commerce systems, from both a technological and social perspective. Infrastructure supporting search for commerce opportunities, negotiating terms of trade, and executing transactions. Issues of security, privacy, incentives, and strategy.

**EECS 548 (BiomedE 548). Advanced Bioinstrumentation and Computation**
Prerequisite: EECS 458, EECS 451. I (3 credits)
Application of computer hardware and software to acquisition, pattern recognition, analysis, and diagnosis of physiological signals. These include, but are not restricted to, the electrocardiogram, the electroencephalogram, the electromyogram, and blood pressure measurement. This course will teach skills required for computer-based analysis of clinical signals, and computer modelling of physiological systems. Lecture and laboratory.

**EECS 550. Information Theory**
Prerequisite: EECS 501. I (3 credits)

**EECS 551. Wavelets and Time-Frequency Distribution**
Prerequisite: EECS 451. I (3 credits)

**EECS 552 (Appl Phys 552). Fiber Optical Communications**
Prerequisite: EECS 434 or EECS 538 or permission of instructor. II odd years (3 credits)

**EECS 554. Introduction to Digital Communication and Coding**
Prerequisite: EECS 212/ 316 or 306 and EECS 401. I (3 credits)
Digital transmission of information across discrete and analog channels. Sampling; quantization; noiseless source codes for data compression; Huffman's algorithm and entropy; block and convolutional channel codes for error correction; channel capacity, digital modulation methods: PSK, MSK, FSK, QAM; matched filter receivers. Performance analysis: power, bandwidth, data rate, and error probability.

**EECS 555. Digital Communication Theory**
Prerequisite: EECS 501, EECS 554. II (3 credits)

**EECS 556. Image Processing**
Prerequisite: EECS 451, EECS 501. II (3 credits)
Theory and application of digital image processing. Random field models of images. Sampling, quantization, image compression, enhancement, restoration, segmentation, shape description, reconstruction of pictures from their projections, pattern recognition. Applications include biomedical images, time-varying imagery, robotics, and optics.

**EECS 557. Communication Networks**
Prerequisite: Graduate Standing, preceded by EECS 401 or accompanied by EECS 501. I (3 credits)

**EECS 558. Stochastic Control**
Prerequisite: EECS 501, EECS 560. I odd years (3 credits)

To request an application, go to: http://www.eecs.umich.edu
EECS 559. Advanced Signal Processing
Prerequisite: EECS 451, EECS 501. II (3 credits)

EECS 560 (Aero 550) (ME 564). Linear Systems Theory
Prerequisite: Graduate Standing. I (4 credits)

EECS 561 (Aero 571) (ME 561). Design of Digital Control Systems
Prerequisite: EECS 460 or Aero 471 or ME 461. I (4 credits)

EECS 562 (Aero 551). Nonlinear Systems and Control
Prerequisite: Graduate Standing. II (3 credits)
Introduction to the analysis and design of nonlinear systems and nonlinear control systems. Stability analysis using Liapunov input-output and asymptotic methods. Design of stabilizing controllers using a variety of methods: linearization, absolute stability theory, vibrational control, sliding modes and feedback linearization.

EECS 564. Estimation, Filtering, and Detection
Prerequisite: EECS 501. II (3 credits)

EECS 565 (Aero 580). Linear Feedback Control Systems
Prerequisite: EECS 460 or Aero 471 or ME 461 and EECS 560 (Aero 550). II (3 credits)
Control design concepts for linear multivariable systems. Review of single variable systems and extensions to multivariable systems. Purpose of feedback. Sensitivity, robustness, and design tradeoffs. Design formulations using both frequency domain and state space descriptions. Pole placement/observer design. Linear quadratic Gaussian based design methods. Design problems unique to multivariable systems.

EECS 567 (Mfg 567) (ME 567). Introduction to Robotics: Theory and Practice
Prerequisite: EECS 281. II (3 credits)
Introduction to robots considered as electro-mechanical computational systems performing work on the physical world. Data structures representing kinematics and dynamics of rigid body motions and forces and controllers for achieving them. Emphasis on building and programming real robotic systems and on representing the work they are to perform.

EECS 568 (Mfg 570). Process Control for Microelectronics Manufacturing
Prerequisite: Graduate Standing or permission of instructor. I (3 credits)
Selected processing steps in microelectronics manufacturing, design of experiments, process and substrate sensors, statistical process control, run-to-run control, real-time control, failure diagnostics, computer implementation of control systems.

EECS 570. Parallel Computer Architecture
Prerequisite: EECS 470. I (4 credits)

EECS 571. Principles of Real-Time Computing
Prerequisite: EECS 470, EECS 482 or permission of instructor. I (3 credits)
Principles of real-time computing based on high performance, ultra reliability and environmental interface. Architectures, algorithms, operating systems and applications that deal with time as the most important resource. Real-time scheduling, communications and performance evaluation.

EECS 573. Microarchitecture
Prerequisite: EECS 470 or permission of instructor. II alternate years (3 credits)

EECS 574. Theoretical Computer Science
Prerequisite: EECS 376. I (4 credits)
Fundamentals of the theory of computation and complexity theory. Computability, undecidability and logic. Relations between complexity classes, NP-completeness, P-completeness, and randomized computation. Applications in selected areas such as cryptography, logic programming, theorem proving, approximation of optimization problems, and parallel computing.

EECS 575. Advanced Cryptography
Prerequisite: EECS 203 or equivalent (EECS 574 recommended) II (4 credits)
A rigorous introduction to the design of cryptosystems and to cryptanalysis. Topics include cryptanalysis of classical cryptosystems; theoretical analysis of one-way functions; DES and differential cryptanalysis; the RSA cryptosystem; ElGamal, elliptic, hyperelliptic and hidden monomial cryptosystems; attacks on signature schemes, identification schemes and authentication codes; secret sharing; and zero knowledge.
EECS 577. Reliable Computing Systems  
Prerequisite: EECS 280 and EECS 478. (3 credits)  
An introduction to models and methods used in the analysis and design of reliable hardware systems, software systems and computing systems. Aspects of reliability considered include fault tolerance, fault detection and diagnosis, reconfiguration, design verification and testing, and reliability evaluation.

EECS 578. Computer-Aided Design  
Verification of Digital Systems  
Prerequisite: EECS 478. II (3 credits)  
Topics will be drawn from a variety of research issues in operating systems. Course discusses advanced topics and very high level languages. Methodologies, incremental programming, architecture, modular languages, design metrics, and tools. Information hiding engineering including life-cycle-paradigms, programming experience. II (3 credits)

EECS 579. Digital System Testing  
Prerequisite: Graduate Standing. I (3 credits)  

EECS 581. Software Engineering Tools  
Prerequisite: EECS 481 or equivalent programming experience. II (3 credits)  
Fundamental areas of software engineering including life-cycle-paradigms, metrics, and tools. Information hiding architecture, modular languages, design methodologies, incremental programming, and very high level languages.

EECS 582. Advanced Operating Systems  
Prerequisite: EECS 482. II (4 credits)  
Topics will be drawn from a variety of operating systems areas such as distributed systems and languages, networking, security, and protection, real-time systems, modeling and analysis, etc.

EECS 583. Advanced Compilers  
Prerequisite: EECS 281 and 370 (EECS 483 is also recommended) II (4 credits)  
In-depth study of compiler backend design for high-performance architectures. Topics include control-flow and data-flow analysis, optimization, instruction scheduling, register allocation. Advanced topics include memory hierarchy management, instruction-level parallelism, predicated and speculative execution. The class focus is processor-specific compilation techniques, thus familiarity with both computer architecture and compilers is recommended.

EECS 584. Advanced Database Systems  
Prerequisite: EECS 484. I (3 credits)  

EECS 585. Web Technologies  
Prerequisites: EECS 482 or EECS 485 or permission of instructor. I alternate years (3 credits)  
Web-related client-server protocols and performance issues; web proxies; web coaching and prefetching; dynamic web content; server-side web applications support; scalable web servers; security topics such as user authentication, secure sockets layer and secure HTTP; electronic payment systems; web-based virtual communities; information discovery.

EECS 586. Design and Analysis of Algorithms  
Prerequisite: EECS 281. II (3 credits)  
Design of algorithms for nonnumeric problems involving sorting, searching, scheduling, graph theory, and geometry. Design techniques such as approximation, branch-and-bound, divide-and-conquer, dynamic programming, greed, and randomization applied to polynomial and NP-hard problems. Analysis of time and space utilization.

EECS 587. Parallel Computing  
Prerequisite: EECS 281 and Graduate Standing. I (3 credits)  
The development of programs for parallel computers. Basic concepts such as speedup, load balancing, latency system taxonomies. Design of algorithms for idealized models. Programming on parallel systems such as shared or distributed memory machines, networks. Performance analysis. Course includes a substantial term project.

EECS 588. Advanced Computer Networks  
Prerequisite: EECS 489. II (4 credits)  
Advanced topics and research issues in computer networks. Topics include routing protocols, multicast delivery congestion control, quality of service support, network security, pricing and accounting, and wireless access and mobile networking. Emphasis is placed on performance trade-offs in protocol and architecture designs. Readings assigned from research publications. A course project allows in-depth exploration of topics of interest.

EECS 589. Advanced Computer Networks  
Prerequisite: EECS 482 and Graduate Standing. I (4 credits)  
Principles and practice of distributed system design. Computations, consistency semantics, and failure models. Programming paradigms including group communication, RPC, distributed shared memory, and distributed objects. Operating system kernel support; distributed system services including replication, caching, file system management, naming, clock synchronization, and multicast communication. Case studies.

EECS 591. Distributed Systems  
Prerequisite: EECS 482 or EECS 485 or permission of instructor. II (3 credits)  
Topics involving distributed computing, consistency, and failure models. Programming paradigms including group communication, RPC, distributed shared memory, and distributed objects. Operating system kernel support; distributed system services including replication, caching, file system management, naming, clock synchronization, and multicast communication. Case studies.

EECS 592. Advanced Artificial Intelligence  
Prerequisite: EECS 492 or permission of instructor. II (4 credits)  
Advanced topics in artificial intelligence. Issues in knowledge representation, knowledge-based systems, problem solving, planning and other topics will be discussed. Students will work on several projects.

To request an application, go to: http://www.eecs.umich.edu
EECS 594. Introduction to Adaptive Systems
Prerequisite: EECS 203, Math 425 (Stat 425). II (3 credits)
Programs and automata that “learn” by adapting to their environment; programs that utilize genetic algorithms for learning. Samuel’s strategies, realistic neural networks, connectionist systems, classifier systems, and related models of cognition. Artificial intelligence systems, such as NETL and SOAR, are examined for their impact upon machine learning and cognitive science.

EECS 595 [Ling 541] [SI 661]. Natural Language Processing
Prerequisite: Senior Standing. I (3 credits)
A survey of syntactic and semantic theories for natural language processing, including unification-based grammars, methods of parsing, and a wide range of semantic theories from artificial intelligence as well as from philosophy of language. Programming will be optional, though a project will normally be required.

EECS 596. Master of Engineering Team Project
Prerequisite: enrollment in the Masters of Engineering program in EECS. I, II, Illa, Illb, and III (1-6 credits)
To be elected by EECS students pursuing the Master of Engineering degree. Students are expected to work in project teams, may be taken more than once up to a total of 6 credit hours.

EECS 597 [SI 760] [Ling 702]. Language and Information
Prerequisite: SI 503 or EECS 281 and Graduate Standing or permission of instructor. I alternate years (3 credits)
A survey of techniques used in language studies and information processing. Students will learn how to explore and analyze textual data in the context of Web-based information retrieval systems. At the conclusion of the course, students will be able to work as information designers and analysts.

EECS 598. Special Topics in Electrical Engineering and Computer Science
Prerequisite: permission of instructor or counselor. I, II, Illa, Illb, and III (1-4 credits)
Topics of current interest in electrical engineering and computer science. Lectures, seminar, or laboratory. Can be taken more than once for credit.

EECS 599. Directed Study
Prerequisite: prior arrangement with instructor; mandatory satisfactory/unsatisfactory. I, II, Illa, Illb and III (1-4 credits)
Individual study of selected advanced topics in electrical engineering and computer science. May include experimental work or reading. Primarily for graduate students. To be graded on satisfactory/unsatisfactory basis ONLY.

EECS 600 (IOE 600). Function Space Methods in System Theory
Prerequisite: Math 419. II (3 credits)

EECS 623. Integrated Sensors and Sensing Systems
Prerequisite: EECS 413, and either EECS 423, or EECS 425, or EECS 523. I (4 credits)
Fundamental principles and design of integrated solid-state sensors and sensing systems. Micromachining and wafer bonding. Microstructures for the measurement of visible and infrared radiation, pressure, acceleration, temperature, gas purity, an ion concentrations. Merged process technologies for sensors and circuits. Data acquisitions circuits, microactuators and integrated microsystems.

EECS 627. VLSI Design II
Prerequisite: EECS 427. I (4 credits)
Advanced very large scale integrated (VLSI) circuit design. Design methodologies (architectural simulation, hardware description language design entry, silicon compilation, and verification), microarchitectures, interconnect, packaging, noise sources, circuit techniques, design for testability, design rules, VLSI technologies (silicon and GaAs), and yield. Projects in chip design.

EECS 631. Electromagnetic Scattering
Prerequisite: EECS 530 and Graduate Standing. I even years (3 credits)
Boundary conditions, field representations. Low and high frequency scattering. Scattering by half plane (Wiener-Hopf method) and wedge (Maluzhinet's method); edge diffraction. Scattering by a cylinder and sphere: Watson transformation, Airy and Fock functions, creeping waves. Geometrical and physical theories of diffraction.

EECS 632. Microwave Remote Sensing II - Radar
Prerequisite: EECS 532. II even years (3 credits)
Radar equation; noise statistics; resolution techniques; calibration; synthetic aperture radar; scatterometers; scattering models; surface and volume scattering; land and oceanographic applications.

EECS 633. Numerical Methods in Electromagnetics
Prerequisite: EECS 530. I odd years (3 credits)
Numerical techniques for antennas and scattering; integral representation; solutions of integral equations: method of moments, Galerkin's technique, conjugate gradient FFT; finite element methods for 2-D and 3-D simulations; hybrid finite element/ boundary integral methods; applications: wire, patch and planar arrays; scattering composite structures.

EECS 634 [Appl Phys 611] [Physics 611]. Nonlinear Optics
Prerequisite: EECS 537 or EECS 538 or EECS 530. I (3 credits)
Formalism of wave propagation in nonlinear media; susceptibility tensor; second harmonic generation and three-wave mixing; phase matching; third order nonlinearities and four-wave mixing processes; stimulated Raman and Brillouin scattering. Special topics: nonlinear optics in fibers, including solitons and self-phase modulation.

EECS 638 [Appl Phys 609] [Physics 542]. Quantum Theory of Light
Prerequisite: quantum mechanics electrodynamics and atom physics. II (3 credits)
The atom-field interaction; density matrix; quantum theory of radiation including spontaneous emission; optical Bloch equations and theory of resonance fluorescence; coherent pulse propagation; dressed atoms and squeezed states; special topics in nonlinear optics.

EECS 643 [Psych 643]. Theory of Neural Computation
Prerequisite: Graduate Standing or permission of instructor. II alternate years (2-4 credits)
This course will review computational models of human cognitive processes with
four goals in mind: (1) to learn about the wide variety of approaches to cognitive modeling (e.g., self-organizing nets, multi-layer nets, and back-propagation, production systems, ACT*, EPIC, Soar...), and the advantages and disadvantages of each, (2) to study some of the most important cognitive models of specific domains (e.g., dual task performance, reasoning, explicit learning, working memory...), (3) to evaluate when cognitive modeling is an appropriate and useful research strategy, and (4) to give students an opportunity to gain hands-on experience in implementing their own cognitive models. Students will be expected to take turns in leading discussion of specific papers and to work in groups in implementing a computational model.

EECS 644 (Psych 644). Computational Modeling of Cognition
Prerequisite: Graduate Standing or permission of instructor.
II alternate years (2-4 credits)
This course will examine computational models of human cognitive processes. Course goals include learning about important computational models of specific cognitive domains and evaluating the appropriateness and utility of different computational approaches to substantive problems in cognition.

EECS 650. Channel Coding Theory
Prerequisite: EECS 501 and Math 419. II alternate years (3 credits)
The theory of channel coding for reliable communication and computer memories. Error correcting codes; linear, cyclic and convolutional codes; encoding and decoding algorithms; performance evaluation of codes on a variety of channels.

EECS 651. Source Coding Theory
Prerequisite: EECS 501. II odd years (3 credits)
Introduction to a variety of source coding techniques such as quantization, block quantization; and differential, predictive, transform and tree coding. Introduction to rate-distortion theory. Applications include speech and image coding.

EECS 658. Fast Algorithms for Signal Processing
Prerequisite: EECS 451, EECS 501. I odd years (3 credits)
Introduction to abstract algebra with applications to problems in signal processing. Fast algorithms for short convolutions and the discrete Fourier transform; number theoretic transforms; multi-dimensional transforms and convolutions; filter architectures.

EECS 659. Adaptive Signal Processing
Prerequisite: EECS 559. I even years (3 credits)
Theory and applications of adaptive filtering in systems and signal processing. Iterative methods of optimization and their convergence properties: transversal filters; LMS (gradient) algorithms. Adaptive Kalman filtering and least-squares algorithms. Specialized structures for implementation: e.g., least-squares lattice filters, systolic arrays. Applications to detection, noise cancelling, speech processing, and beam forming.

EECS 661. Discrete Event Systems
Prerequisite: EECS 376 or EECS 560 or equivalent. I even years (3 credits)

EECS 662 (Aero 672) (ME 662). Advanced Nonlinear Control
Prerequisite: EECS 562 or ME 548. I (3 credits)
Geometric and algebraic approaches to the analysis and design of nonlinear control systems. Nonlinear controllability and observability, feedback stabilization and linearization, asymptotic observers, tracking problems, trajectory generation, zero dynamics and inverse systems, singular perturbations, and vibrational control.

EECS 670. Special Topics in Computer Architecture
Prerequisite: permission of instructor. (3 credits)
Current topics of interest in computer architecture. This course may be repeated for credit.

EECS 674. Special Topics in Theoretical Computer Science
Prerequisite: permission of instructor. (3 credits)
Current topics of interest in theoretical computer science. This course can be repeated for credit.

EECS 676. Special Topics in Software Systems
Prerequisite: permission of instructor. (3 credits)
Current topics of interest in software systems. This course can be repeated for credit more than once.

EECS 684. Current Topics in Databases
Prerequisite: EECS 484. I (3 credits)
Research issues in database systems chosen for in-depth study. Selected topics such as spatial, temporal, or real-time databases; data mining, data warehousing, or other emerging applications. Readings from recent research papers. Group projects.

EECS 685. Fast Algorithms for Signal Processing
Prerequisite: EECS 451, EECS 501. I odd years (3 credits)
Introduction to abstract algebra with applications to problems in signal processing. Fast algorithms for short convolutions and the discrete Fourier transform; number theoretic transforms; multi-dimensional transforms and convolutions; filter architectures.

EECS 686. Special Topics in Artificial Intelligence
Prerequisite: permission of instructor. (3 credits)
Current topics of interest in artificial intelligence. This course can be repeated for credit more than once.

EECS 689 (Psych 640). Neural Models and Psychological Processes
Prerequisite: permission of instructor. II (3 credits)
Consideration of adaptively and biologically oriented theories of human behavior. Emphasis on both the potential breadth of application and intuitive reasonableness of various models. There is a bias toward large theories and small simulations.

EECS 698. Master's Thesis
Prerequisite: election of an EECS master's thesis option. I, II, IIIa, IIIb, and III (1-6 credits)
To be elected by EE and EES students pursuing the master's thesis option. May be taken more than once up to a total of 6 credit hours. To be graded on a satisfactory/unsatisfactory basis ONLY.

To request an application, go to: http://www.eecs.umich.edu
EECS 699. Research Work in Electrical Engineering and Computer Science  
Prerequisite: Graduate Standing, permission of instructor; mandatory satisfactory/unsatisfactory. I, II, IIIa, IIIb, III (1-6 credits)
Students working under the supervision of a faculty member plan and execute a research project. A formal report must be submitted. May be taken for credit more than once up to a total of 6 credit hours. To be graded satisfactory/unsatisfactory ONLY.

EECS 700. Special Topics in System Theory  
Prerequisite: permission of instructor. (to be arranged)

EECS 720. Special Topics in Solid-State Devices, Integrated Circuits, and Physical Electronics  
Prerequisite: permission of instructor. (1-4 credits)
Special topics of current interest in solid-state devices, integrated circuits, microwave devices, quantum devices, noise, plasmas. This course may be taken for credit more than once.

EECS 730. Special Topics in Electromagnetics  
Prerequisite: permission of instructor. (1-4 credits) (to be arranged)

EECS 731 (A0SS 731). Space Terahertz Technology and Applications  
Prerequisite: permission of instructor; mandatory satisfactory/unsatisfactory. I (1 credit)
Study and discussion of various topics related to high frequency applications in space exploration. Topics will be chosen from the following areas: planetary atmospheres and remote sensing, antennas, active and passive circuits, space instrumentation.

EECS 735 Special Topics in the Optical Sciences  
Prerequisite: Graduate Standing, permission of instructor. (to be arranged) (1-4 credits)
Key topics of current research interest in ultrafast phenomena, short wavelength lasers, atomic traps, integrated optics, nonlinear optics and spectroscopy. This course may be taken for credit more than once under different instructors.

EECS 750. Special Topics in Communication and Information Theory  
Prerequisite: permission of instructor. (to be arranged)

EECS 755. Special Topics in Signal Processing  
Prerequisite: permission of instructor. (to be arranged) (1-4 credits)

EECS 760. Special Topics in Control Theory  
Prerequisite: permission of instructor. (to be arranged)

EECS 765. Special Topics in Stochastic Systems and Control  
Prerequisite: permission of instructor. (to be arranged) (3 credits)
Advanced topics on stochastic systems such as stochastic calculus, nonlinear filtering, stochastic adaptive control, decentralized control, and queuing networks.

EECS 770. Special Topics in Computer Systems  
Prerequisite: permission of instructor. (to be arranged)

EECS 800. Seminar in Optical Science and Engineering  
Prerequisite: Graduate Standing. I, II (1 credit)
Advanced overviews of research, industrial and governmental projects not covered by the optics curriculum. Recent advances on important topics presented by renowned speakers in areas like hyperspectral imaging, laser cooling, biological manipulation, displays, laser metrology, holography and astrophysical instrumentation plus an annual site tour of local industrial optics facilities.

EECS 820. Seminar in Solid-State Electronics  
Prerequisite: Graduate Standing, permission of instructor. I (1 credit)
Advanced graduate seminar devoted to discussing current research topics in areas of solid-state electronics. Specific topics vary each time the course is offered. Course may be elected more than once.

EECS 892. Seminar in Artificial Intelligence  
Prerequisite: EECS 592 or equivalent. I, II (2 credits)
Advanced graduate seminar devoted to discussing current research papers in artificial intelligence. The specific topics vary each time the course is offered.

EECS 990. Dissertation/Pre-Candidate  
I, II, III (2-8 credits); IIIa, IIIb (1-4 credits)
Dissertation work by doctoral student not yet admitted to status as candidate. The defense of the dissertation, that is, the final oral examination, must be held under a full-term candidacy enrollment.

EECS 995. Dissertation/Candidate  
Prerequisite: Graduate School authorization for admission as a doctoral candidate. I, II, III (8 credits); IIIa, IIIb (4 credits)
Election for dissertation work by a doctoral student who has been admitted to candidate status. The defense of the dissertation, that is, the final oral examination, must be held under a full-term candidacy enrollment.