# COMPUTER ENGINEERING

The mission of the computer engineering program, consistent with the Missouri S&T campus mission statements, is the education of students to fully prepare them to provide leadership in the recognition and solution of society's problems in the area of computer engineering.

The computer engineering program in the department of electrical and computer engineering offers graduate programs of study that lead to graduate certificates, the M.S. degree (thesis and non-thesis options), the Ph.D. degree, and the doctor of engineering degree. All of these programs are available through distance education. The M.S. programs can be pursued both on the Rolla campus and through Missouri S&T Global-St. Louis. Most graduate programs in computer engineering normally include some specialization in one or more of the following emphasis areas of computer engineering.

## Emphasis Areas

- **Integrated circuits and logic design:** Topics include hardware/software co-design, IC design, electromagnetic compatibility, VLSI design, and secure embedded systems design.
- **Networking, security and dependability:** Topics include network analysis and synthesis, cyber-physical systems, wireless networks, sensor networks, dependability, and fault tolerance.
- **Computer architecture and embedded systems:** Topics include high performance systems, parallel processors, GPU computing, and heterogeneous systems architecture.
- **Computational intelligence:** Topics include clustering, adaptive resonance and reinforcement learning architectures, learning and adaptation, hardware and applications, neurofuzzy regression, traveling salesman problem heuristics, robotic swarms, bioinformatics, medical informatics, machine vision, and automation.

## Departmental Requirements

The graduate certificate programs offered by the ECE department are open to all persons holding a bachelor's degree in any field of engineering from an ABET-accredited undergraduate program, or a degree in a closely related technical field such as physics or mathematics. The minimum undergraduate GPA requirement varies by certificate.

Students who lack the prerequisite courses necessary to take graduate-level courses for the certificate program may be required to take foundational courses at either the undergraduate or graduate level prior to admission.

The nominal GPA requirement for admission to the M.S. degree program in this department is an undergraduate GPA of 3.3 on a 4.0 GPA system. In evaluating the academic performance from universities that may use other grading systems, the department may rely upon statistical data gathered in analyzing academic outcomes for recent graduate students to the extent that such statistical data is available. The department will not offer graduate admissions to students who do not have the equivalent of a four year baccalaureate degree in engineering. As an example, we cannot accept students who have only a diploma or engineering technology degree.

The ECE department requires ETS reported GRE scores and recommends the following:

ETS scoring: Q+V=305, Q≥ 160, A/WR≥ 3.5

This GRE requirement may be waived if the applicant has an undergraduate GPA of 3.5 obtained from the courses offered by the electrical engineering or computer engineering program at Missouri S&T (must be minimum 18 credit hours).

For international students who are required to provide TOEFL scores, the ECE department has no preference as to the computer based TOEFL (CBT), internet based TOEFL (iBT), or paper based TOEFL (PBT). Required score set by the campus is 80 (iBT) or equivalent. Where TOEFL is not available, IELTS score of ≥ 6.5 or Duolingo 105 is strictly required.

Students applying for graduate studies in this department on the basis of degrees in closely related fields may have additional conditions placed on their admission. These conditions are generally imposed to make sure that students lacking a traditional Computer Engineering degree will have sufficient background to ensure a reasonable chance for academic success.

Students seeking admission to the Ph.D. program should meet or exceed all of the above recommendations and should have a graduate GPA of 3.5 or better. All Ph.D. applicants must provide at least three letters of recommendation. Exceptional applicants may apply directly to the Ph.D. program after completing the baccalaureate degree.

## M.S. Degree Requirements

Thesis option M.S. program of study requires a minimum of 21 credit hours of coursework exclusive of credit hours earned for thesis research. The thesis option degree is based on a combination of coursework and research. This option requires the student to find a faculty member willing to serve as advisor. This should be done as soon as possible so that the student and advisor will be able to formulate both a plan of coursework and a research project.

Non-thesis option M.S. program is based entirely on coursework. This option requires a minimum of 30 credit hours of coursework. Non-thesis students are assigned an initial advisor by the department, typically the associate chair for graduate studies. M.S. degree students, both thesis and non-thesis option, may change this degree option and advisors at any time with the consent of their current and new advisors.

**M.S. Communication Requirements**

An M.S. student is required to fulfill a zero credit hour communications requirement to demonstrate a sufficient communications capability to operate effectively at an advanced level in the professional engineering and scientific community. To fulfill this requirement, the advisor will monitor the student's capability through one of the following exemplary activities during the program of study:

1. Authoring at least one accepted publication (major contribution to communication aspects)
2. Taking/transferring one graduate-level communication course
3. Possessing industrial or other professional experiences
4. Having completed example(s) listed above or equivalent before enrolling in the program
5. Other equivalent qualifications as identified by the advisor

## Doctoral Degree Requirements

The two types of doctoral degrees offered by this department are the Doctor of Philosophy (Ph.D.) and the Doctor of Engineering (D.E.) with

a strong emphasis on research with advisor. The primary difference between these two doctoral degrees is that the research portion of the D.E .degree is conducted as an internship with an industrial concern or government laboratory and is jointly supervised by an internship advisor employed by the cooperating organization and a faculty advisor employed by S&T. In contrast, the research portion of the Ph.D. degree is generally conducted on campus.

The doctoral program of study, for the Ph.D. degree or the D.E. degree, should include 90 credit hours (minimum 48 hours coursework and minimum 42 hours research) beyond the B.S. degree or 60 credit hours (minimum 24 hours coursework and minimum 36 hours research) beyond the M.S. degree.

**Doctoral Communication Requirement**
A doctoral student is required to fulfill a zero credit hour communications requirement to demonstrate a sufficient communications capability to operate effectively at an advanced level in the professional engineering and scientific community. To fulfill this requirement, the advisor will monitor the student's capability through one of the following exemplary activities during the program of study:

1. Authoring at least one accepted publication (major contribution to communication aspects)
2. Taking/transferring one graduate-level communication course
3. Possessing industrial or other professional experiences
4. Having completed example(s) listed above or equivalent before enrolling in the program
5. Other equivalent qualifications as identified by the advisor

# Research

Significant research, suitable for publication, is expected for students pursuing the thesis option M.S. or a doctoral degree. The student should work closely with their major advisor and their advisory committee to determine when these expectations are met. The length of research time and/or the number credit hours earned for thesis research will not automatically satisfy this requirement.

# Additional Information

Additional information about departmental emphasis areas, requirements, graduate handbook, faculty, research opportunities, financial aid, and facilities can be found by visiting the department's web page at http://ece.mst.edu. We can be contacted by telephone at 573-341-4519 or email at ecegrad@mst.edu. For information about the Engineering Education Center in St. Louis, visit their web page at http://eec.mst.edu.

# Graduate Certificate Programs Admissions

The graduate certificate programs are open to all persons holding a B.S. degree in any field of engineering from an ABET accredited undergraduate program or a degree in a closely related field such as physics or mathematics. A cumulative GPA of 2.5 or higher is required for admission to the certificate. Students who lack the prerequisite courses necessary to take graduate-level courses for the certificate program may be required to take foundational courses at either the undergraduate or graduate level prior to admission.

Once admitted to the program, the student must take four designated courses from the certificate curriculum given below. The student will be given three years to complete the program. In order to receive the graduate certificate, the student must earn a grade of B or better in each of the four courses taken for the certificate.

Students admitted to the certificate program will have non-degree graduate status. Completion of certificate program does not guarantee subsequent admission to the MS programs in EE or CpE at Missouri S&T. Upon application to the MS program in EE or CpE, the GRE requirement will be waived for applicants who meet all other admission requirements and have completed a certificate offered by the ECE department.

The ECE department offers two graduate certificate programs that utilize graduate-level courses in computer engineering to develop the skills of practicing engineers: computational intelligence and cyber physical systems. These programs are offered through distance education and are designed to appeal to working professionals. The four courses taken to fulfill the requirements of any of the graduate certificate programs can be counted towards an M.S. degree in EE or CpE. However, any prerequisite or foundational courses taken to provide background for one or more of the four graduate certificate program courses cannot be counted towards an M.S. degree.

## Computational Intelligence Certificate

Recent advances in information technology and the increased level of interconnectivity that society has achieved through Internet and broadband communication technology created systems that are very much different. The world is facing an increasing level of systems integration leading towards systems of systems (SoS) that adapt to changing environmental conditions. The number of connections between components, the diversity of the components and the way the components are organized can lead to different emergent system behavior. Computational Intelligence tools are an integral part of these systems in enabling adaptive capability in their design and operation.

This graduate certificate program provides practicing engineers the opportunity to develop the necessary skills in the use and development of computational intelligence algorithms based on evolutionary computation, neural networks, fuzzy logic, and complex systems theory. Engineers can also learn how to integrate common sense reasoning with computational intelligence elective courses such as data mining and knowledge discovery.

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|---|---|---|
| Core Courses | | |
| COMP ENG 5310/ ELEC ENG 5310/ SYS ENG 5211 | Computational Intelligence | 3 |
| Select one of the following: | | |
| SYS ENG 5212/ ELEC ENG 5370 | Introduction to Neural Networks and Applications | 3 |
| COMP SCI 5400 | Introduction To Artificial Intelligence | 3 |
| COMP SCI 5401 | Evolutionary Computing | 3 |
| Select two of the following not taken as a core course: | | |
| SYS ENG 5212/ ELEC ENG 5370 | Introduction to Neural Networks and Applications | 3 |
| ELEC ENG 5320 | Neural Networks Control and Applications | 3 |
| COMP SCI 5400 | Introduction To Artificial Intelligence | 3 |
| COMP SCI 5401 | Evolutionary Computing | 3 |
| COMP SCI 6400 | Advanced Topics In Artificial Intelligence | 3 |
| COMP SCI 6401 | Advanced Evolutionary Computing | 3 |
| SYS ENG 6213 | Deep Learning and Advanced Neural Networks | 3 |
| SYS ENG 6214/ COMP ENG 6330/ ELEC ENG 6340/ STAT 6239 | Clustering Algorithms | 3 |

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|---|---|---|
| SYS ENG 6215/ COMP ENG 6320/ ELEC ENG 6360 | Adaptive Dynamic Programming | 3 |
| SYS ENG 6216/ COMP ENG 6302/ COMP SCI 6402 | Advanced Topics in Data Mining | 3 |
| COMP ENG 6310/ ENG MGT 6410/ COMP SCI 6202/ MECH ENG 6447/ AERO ENG 6447 | Markov Decision Processes | 3 |

## Cyber Physical Systems Graduate Certificate

Cyber Physical Systems with different levels of implementation that entail complex logic with many levels of reasoning in intricate arrangement, organized by web of connections and demonstrating self-driven adaptability are emerging. They will impact manufacturing industry, defense, healthcare, energy, transportation, emergency response, agriculture and society overall.The graduate certificate in Cyber Physical systems is a joint effort between computer engineering and systems engineering to provide practicing engineers with the necessary skills to develop and design the operation of complex adaptive systems. These four courses count towards a M.S. degree in systems engineering or computer engineering and they address the intersection between computer engineering, systems engineering, and architecting. The requirements are the successful completion of two core courses and two elective courses from the list below. A grade of "B" or better is required in each course before the student is eligible for the master of science program.

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|---|---|---|
| Core Course: | | |
| SYS ENG 6321/ COMP ENG 6410 | Modeling Complex Systems | 3 |
| COMP ENG 5410 | Introduction to Computer Communication Networks | 3 |
| Elective Courses (Select two courses): | | |
| COMP ENG 5420 | Introduction to Network Security | 3 |
| COMP ENG 5430/ SYS ENG 5323 | Wireless Networks | 3 |
| COMP ENG 5510 | Fault-Tolerant Digital Systems | 3 |
| SYS ENG 6322/ COMP ENG 6510 | Resilient Networks | 3 |
| COMP ENG 6420/ SYS ENG 6324 | Wireless Ad hoc and Sensor Networks | 3 |
| COMP ENG 6430 | High Speed Networks | 3 |
| COMP ENG 6440/ COMP SCI 6602 | Network Performance Analysis | 3 |
| COMP SCI 6600 | Formal Methods in Computer Security | 3 |
| COMP SCI 6604 | Mobile, IoT and Sensor Computing | 3 |

**Levent Acar**, Associate Professor
PHD Ohio State University
Control and systems, intelligent control with applications to robotics, neural network and fuzzy logic systems, large-scale systems and optimization.

**Ahmad Alsharoa**, Assistant Professor
PHD Iowa State University

**Daryl G Beetner**, Professor[1]
DSC Washington University
Electromagnetic immunity and emissions at the chip and system level detection, detection and neutralization of explosive devices, skin cancer detection.

**Rui Bo**, Assistant Professor
PHD Univeristy of Tennessee-Knoxville
Computation, optimization and economics in power system operation and planning, high performance computing and its application in power systems, electricity market simulation, evaluation and design.

**Minsu Choi**, Associate Professor
PHD Oklahoma State University
Computer architecture and VLSI, embedded systems, fault tolerance testing, quality assurance, reliability modeling and analysis, configurable computing, distributed systems and dependable instrumentation and measurement.

**Kristen Marie Donnell Hilgedick**, Associate Professor
PHD Missouri Univeristy of Science & Technology
Microwave nondestructive testing, modulated antennas/scatterers and terahertz methodologies and electronics design.

**Kelvin Todd Erickson**, Professor[1]
PHD Iowa State University
Chemical process control, advanced control algorithms, digital control, programmable logic controllers, and systems identification.

**Mina Esmaeelpour**, Assistant Professor
PHD Lehigh University

**Mehdi Ferdowsi**, Professor
PHD Illinois Institute of Technology
Power electronics, power converters and electric drives.

**Jie Huang**, Assistant Professor
PHD Clemson University
Fiber optic sensors, laser machining, sensors and instrumentation for applications in harsh environments, microwave-photonic sensing imaging and spectroscopy.

**Ali Hurson**, Professor
PHD University of Central Florida
Parallel and distributed systems, databases, mobile databases, pervasive and mobile computing.

**Chulsoon Hwang**, Assistant Professor
PHD KAIST, Korea
Signal and power integrity of IC/package/PCB system, electromagnetic modeling, time/frequency domain simulation/measurement techniques.

**Chang-Soo Kim**, Professor
PHD Kyungpook National University, Korea
Micro-and nano-sensors, bio-MEMS (Micro Electro Mechanical System), microsystems, sensor engineering, biomedical/agricultural engineering.

**DongHyun (Bill) Kim**, Assistant Professor
PHD KAIST, Korea

**Jonathan William Kimball**, Professor[1]
PHD University of Illinois-Urbana
Power electronics, energy harvesting, alternative energy, and multi-phase converters.

**Kurt Louis Kosbar**, Associate Professor
PHD University of Southern California
Statistical communication theory, spread spectrum systems, computer aided design of communication systems, stochastic process theory, and digital signal processing.

**Jagannathan Sarangapani**, Professor
PHD University of Texas-Arlington
Control of networks, embedded systems, MEMS, intelligent systems/ control, diagnostics/prognostics, and biomedical applications.

**Sahra Sedigh Sarvestani**, Associate Professor
PHD Purdue University-W. Lafayette
Dependable networks and systems, cyber-physical systems, quantitative modeling and prediction for complex networked systems, critical infrastructure.

**Pourya Shamsi**, Associate Professor
PHD University of Texas-Dallas
Smart-grids, stability assessments in micro-grids, energy management, switching power converters, VHF/UHF dc-dc converters, and motor drives.

**Ronald Joe Stanley**, Professor
PHD University of Missouri-Columbia
Image and signal processing, computational intelligence, automation and medical informatics.

**Steve E Watkins**, Professor
PHD University of Texas at Austin
Fiber optic sensing, optical and electronic materials, electro-optic devices and engineering education.

**Cheng Hsiao Wu**, Professor
PHD University of Rochester
Quantum resistor network theory, semiconductor device modeling, DLTS measurement, and optical computing.

**Donald C Wunsch II**, Professor[1]
PHD University of Washington
Adaptive critic designs, neural networks, fuzzy systems, surety, nonlinear adaptive control, intelligent agents, applications and financial engineering.

**Maciej J Zawodniok**, Associate Professor
PHD University of Missouri-Rolla
Embedded systems for cyber infrastructure, wireless sensor and ad hoc networks, and general wireless communications systems.

**Jiangfan Zhang**, Assistant Professor
PHD Lehigh University
Statistical signal processing for cyber-physical systems, Internet of Things, sensor networks, cybersecurity, smart grid,radar and sonar processing.

***COMP ENG 5000 Special Problems*** (IND 1.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

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***COMP ENG 5001 Special Topics*** (LEC 1.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

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***COMP ENG 5040 Oral Examination*** (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/ comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

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***COMP ENG 5070 Teaching Engineering*** (LEC 3.0)
Introduction to teaching objectives and techniques. Topics include: using course objectives to design a course; communication using traditional and cutting-edge media; textbook selection; assessment of student learning; grading; student learning styles; cooperative/active learning; and student discipline. Prerequisite: Graduate standing. (Co-listed with Eng Mgt 5070, Env Eng 5070, Elec Eng 5070, Civ Eng 5070).

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***COMP ENG 5099 Special Research And Thesis*** (IND 1.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Prerequisite: Consent of the instructor required.

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***COMP ENG 5110 Principles of Computer Architecture*** (LEC 3.0)
Principles of performance measurement and instruction set design; advanced issues in pipelining; instruction level parallelism (dynamic scheduling, branch prediction, multi-issue processors); memory hierarchies for superscalar processors; multiprocessors; multi-threading; storage systems; and interconnection networks. Prerequisite: Comp Eng 3110. (Co-listed with Comp Sci 5803).

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***COMP ENG 5120 Digital Computer Design*** (LEC 3.0)
Organization of modern digital computers; design of processors, memory systems and I/O units, hardware-software tradeoffs in different levels of computer system design. Prerequisites: COMP ENG 3150 and COMP ENG 3151.

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***COMP ENG 5130 Advanced Microcomputer System Design*** (LEC 3.0)
The design of digital systems based on advanced microprocessors. Introduction to microcomputer logic development systems. I/0 interfaces. Assembly and high level language tradeoffs. Hardware and software laboratory projects required. Prerequisites: COMP ENG 5110.

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***COMP ENG 5151 Digital Systems Design Laboratory*** (LAB 1.0 and LEC 2.0)
Design of 32-bit microcontroller based systems. Topics include the instruction set architecture of a 32-bit microcontroller, assembly language and C programming, using microcontroller peripherals for communication, measurement and control. Student designs, programs and tests microcontroller based projects. Prerequisites: Comp Eng 3150 or Comp Eng 5110.

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***COMP ENG 5160 Embedded Processor System Design*** (LEC 3.0)
Development of hardware and software for embedded systems, including real-time operating systems, advanced programming, communication schemes, hardware peripherals and sensors, control methodologies, printed-circuit board design, interrupts, microcontrollers, and hardware-software co-design. One or more team design projects. Prerequisites: COMP ENG 3150 or equivalent or 80x51 processor experience.

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***COMP ENG 5170 Real-Time Systems*** (LEC 3.0)
Introduction to real-time (R-T) systems and R-T kernels, also known as R-T operating systems, with an emphasis on scheduling algorithms. The course also includes specification, analysis, design and validation techniques for R-T systems. Course includes a team project to design an appropriate R-T operating system. Prerequisites: COMP ENG 3150 or COMP SCI 3800. (Co-listed with Comp Sci 5205).

***COMP ENG 5210 Introduction To VLSI Design*** (LEC 3.0)
An introduction to the design and analysis of digital integrated circuits (ICs). Topics include basic manufacturing techniques, transistor-level design and analysis of logic and memory circuits, logic timing, and parasitics. Computer aided design tools are used to develop circuits in the lab. Prerequisites: Elec Eng 2200 and Comp Eng 2210.

***COMP ENG 5220 Digital System Modeling*** (LEC 3.0)
Digital system modeling for simulation, synthesis, and rapid system prototyping. Structural and behavioral models, concurrent and sequential language elements, resolved signals, generics, configuration, test benches, processes and case studies. Prerequisite: Comp Eng 2210 with a grade of "C" or better.

***COMP ENG 5230 Optical Computing*** (LEC 3.0)
Introduction to the principles, subsystems, and architectures of optical computing. Topics include characteristics of optical devices; optical implementations of memory, logic elements, and processors; and computational structures. Prerequisite: Comp Eng 2210 or equivalent. (Co-listed with Elec Eng 5250).

***COMP ENG 5310 Computational Intelligence*** (LEC 3.0)
Introduction to Computational Intelligence (CI), Biological and Artificial Neuron, Neural Networks, Evolutionary Computing, Swarm Intelligence, Artificial Immune Systems, Fuzzy Systems, and Hybrid Systems. CI application case studies covered include digital systems, control, power systems, forecasting, and time-series predictions. Prerequisite: Graduate Standing. (Co-listed with Elec Eng 5810 and Sys Eng 5211).

***COMP ENG 5410 Introduction to Computer Communication Networks*** (LEC 3.0)
Design of computer networks with emphasis on network architecture, protocols and standards, performance considerations, and network technologies. Topics include: LAN, MAN, WAN, congestion/flow/error control, routing, addressing, broadcasting, multicasting, switching, and internetworking. A modeling tool is used for network design and simulation. Prerequisites: Comp Eng 3150 or computer hardware competency and Stat 3117 or Stat 3115 or Stat 5643 or equivalent.

***COMP ENG 5420 Introduction to Network Security*** (LEC 3.0)
This course examines basic issues in network management, testing, and security; it also discusses key encryption, key management, authentication, intrusion detection, malicious attack, and insider threats. Security of electronic mail and electronic commerce systems is also presented. Prerequisite: Comp Eng 5410 or Comp Sci 5600.

***COMP ENG 5430 Wireless Networks*** (LAB 1.0 and LEC 2.0)
Introduction to wireless communications and networking. Topics include transmission fundamentals, wireless channel, coding techniques and error control, satellite and cellular networks, cordless systems, mobile IP and management, multiple access techniques and wireless protocols, wireless LAN, IEEE 802.11, and adhoc and sensor networks. Prerequisites: Hardware competency, Elec Eng 3420 or Comp Eng 3150 and graduate standing. (Co-listed with Elec Eng 5430 and Sys Eng 5323.).

***COMP ENG 5450 Digital Image Processing*** (LEC 3.0)
Fundamentals of human perception, sampling and quantization, image transforms, enhancement, restoration, channel and source coding. Prerequisites: Elec Eng 3430. (Co-listed with Elec Eng 5450).

***COMP ENG 5460 Machine Vision*** (LEC 3.0)
Image information, image filtering, template matching, histogram transformations, edge detection, boundary detection, region growing and pattern recognition. Complementary laboratory exercises are required. Prerequisites: Elec Eng 3430. (Co-listed with Elec Eng 5460).

***COMP ENG 5510 Fault-Tolerant Digital Systems*** (LEC 3.0)
Design and analysis of fault-tolerant digital systems. Fault models, hardware redundancy, information redundancy, evaluation techniques, system design procedures. Prerequisites: Comp Eng 2210 and Comp Eng 2211.

***COMP ENG 5610 Real-Time Digital Signal Processing*** (LAB 1.0 and LEC 2.0)
Introduction to the use of programmable DSP chips. Includes real-time data acquisition, signal generation, interrupt-driven programs, high-level language, and assembly level routines. Applications to real-time systems are also presented. Prerequisite: Elec Eng 3400 or Elec Eng 3410.

***COMP ENG 5620 Signal Integrity in High-Speed Digital & Mixed Signal Design*** (LEC 3.0)
Signal integrity ensures signals transmitted over a propagation path maintain sufficient fidelity for proper receiver operation. Compromised signal integrity is often associated with parasitics (e.g. unintentional inductance, capacitance). Theory and CAD tools used for signal integrity analysis of functioning designs. Prerequisites: Elec Eng 3600 or Comp Eng 3150, and Senior standing. (Co-listed with Elec Eng 5620).

***COMP ENG 5803 Mathematical Logic I*** (LEC 3.0)
A mathematical introduction to logic with some applications. Functional and relational languages, satisfaction, soundness and completeness theorems, compactness theorems. Examples from Mathematics, Philosophy, Computer Science, and/or Computer Engineering. Prerequisite: Philos 3254 or Math 5105 or Comp Sci 2500 or Comp Eng 2210. (Co-listed with Comp Sci 5203, Philos 4354 and Math 5154).

***COMP ENG 5820 Mechatronics*** (LAB 1.0 and LEC 2.0)
This course will introduce students to the basics of mechatronics (i.e., the integration of mechanical, electrical, computer, and control systems). Students will learn the fundamentals of sensors and actuators for mechanical systems, computer interfacing, microcontrollers, real-time software, and control. Prerequisite: Mech Eng 4479 or equivalent. (Co-listed with Mech Eng 5478, Aero Eng 5478 and Elec Eng 5870).

***COMP ENG 5880 Introduction to Robotics*** (LEC 3.0)
This course provides an introduction to robotics, covering robot hardware, fundamental kinematics, trajectories, differential motion, robotic decision making, and an overview of current topics in robotics. Prerequisite: A grade of "C" or better in both Math 3108 and Comp Sci 1575. (Co-listed with Comp Sci 5403 and Elec Eng 5880).

***COMP ENG 6000 Special Problems*** (IND 1.0-6.0)
Problems or readings on specific subjects or projects in the department. Prerequisite: Consent of the instructor.

***COMP ENG 6001 Special Topics*** (LAB 0.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title. Prerequisite: Consent of the instructor.

***COMP ENG 6040 Oral Examination*** (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/ comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

***COMP ENG 6050 Continuous Registration*** (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except for the dissertation, and are away from the campus, must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

***COMP ENG 6099 Special Research and Thesis*** (IND 1.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Prerequisite: Consent of the instructor required.

***COMP ENG 6110 Advanced Computer Architecture I*** (LEC 3.0)
Advanced topics in computer structures, parallel processors, and computer networks. Emphasis on their design, applications, and performance. Prerequisite: Comp Eng 5110 or Comp Eng 5120. (Co-listed with Comp Sci 6801).

***COMP ENG 6120 Advanced Computer Architecture II*** (LEC 3.0)
Continuation of Computer Engineering 6110. Prerequisites: COMP ENG 6110.

***COMP ENG 6210 Digital Logic*** (LEC 3.0)
Digital logic analysis, synthesis and simulation. Design automation of digital systems. Prerequisites: Comp Eng 2210 and Comp Eng 2211.

***COMP ENG 6230 Advanced VLSI Design*** (LEC 3.0)
Advanced topics in chip-level VLSI design, including issues related to high-performance, low-power, analog and mixed-signal circuits, reliability, noise and coupling mechanisms, computer aided design tools, and recent advances and trends in the field. Prerequisite: Comp Eng 5210 is required.

***COMP ENG 6302 Advanced Topics in Data Mining*** (LEC 3.0)
Advanced topics of current interest in the field of data mining. This course involves reading seminal and state-of-the-art papers as well as conducting topical research projects including design, implementation, experimentation, analysis, and written and oral reporting components. Prerequisite: A "C" or better grade in Comp Sci 301 Introduction to Data Mining. (Co-listed with Comp Sci 6402 and Sys Eng 6216).

***COMP ENG 6310 Markov Decision Processes*** (LEC 3.0)
Introduction to Markov Decision Processes and Dynamic Programming. Application to Inventory Control and other optimization and control topics. Prerequisite: Graduate standing in background of probability or statistics. (Co-listed with Mech Eng 6447, Aero Eng 6447, Eng Mgt 6410, Comp Sci 6202 and Sys Eng 6217).

***COMP ENG 6320 Adaptive Dynamic Programming*** (LEC 3.0)
Review of Neurocontrol and Optimization, Introduction to Approximate Dynamic Programming (ADP), Reinforcement Learning (RL), Combined Concepts of ADP and RL - Heuristic Dynamic Programming (HDP), Dual Heuristic Programming (DHP), Global Dual Heuristic Programming (GDHP), and Case Studies. Prerequisites: Elec Eng 5370 or Comp Eng 5310. (Co-listed with Elec Eng 6360, Mech Eng 6458, Aero Eng 6458 and Sys Eng 6215).

***COMP ENG 6330 Clustering Algorithms*** (LEC 3.0)
An introduction to cluster analysis and clustering algorithms rooted in computational intelligence, computer science and statistics. Clustering in sequential data, massive data and high dimensional data. Students will be evaluated by individual or group research projects and research presentations. Prerequisite: At least one graduate course in statistics, data mining, algorithms, computational intelligence, or neural networks, consistent with student's degree program. (Co-listed with Elec Eng 6830, Sys Eng 6214, Comp Sci 6405, Stat 6239).

***COMP ENG 6410 Modeling Complex Systems*** (LEC 3.0)
Engineering Systems of today are non-linear, distributed, global, and adaptive to their environment in both space and time, thereby creating emergent behaviors. This course covers the current modeling tools and techniques used in modeling and architecting these complex systems. Prerequisites: Graduate Standing. (Co-listed with SYS ENG 6321).

***COMP ENG 6420 Wireless Ad hoc and Sensor Networks*** (LEC 3.0)
Introduction to ad hoc and sensor networks, IEEE standards, heterogeneity, quality of service, wireless channel issues, energy awareness, power and topology control, routing, scheduling, rate adaptation, self-organization, admission and flow control, energy harvesting, security and trust levels, hardware and applications. Prerequisite: Comp Eng 5430 or Comp Eng 5420 or equivalent. (Co-listed with Elec Eng 6430 and Sys Eng 6324).

***COMP ENG 6430 High Speed Networks*** (LAB 1.0 and LEC 2.0)
A state-of-the-art survey of high-speed networks, modeling and simulation, quality of service (QoS) for multimedia applications and management schemes, TCP congestion control, ATM and Internet traffic management, Internet Service Architecture (ISA), and Internet routing protocols. Prerequisites: Comp Eng 5410 and hardware competency for ECE students, Comp Sci 4600 for computer science students, or consent of the instructor.

***COMP ENG 6440 Network Performance Analysis*** (LEC 3.0)
Provides an introduction to performance modeling and analysis of computer networks. Topics include stochastic processes; performance measurement and monitoring; quantitative models for network performance, e.g., Markovian models for queues; simulation; and statistical analysis of experiments. Prerequisites: Comp Eng 5410 or Comp Sci 4600; Stat 3117 or 5643. (Co-listed with Comp Sci 6602).

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***COMP ENG 6510 Resilient Networks*** (LEC 3.0)
This course presents reliability and fault tolerance for network-centric systems, including models, metrics, and analysis techniques. This course also concentrates on security, including technical tools and methods for audit and assessment as well as management and policy issues. Prerequisites: Sys Eng 6410, Comp Eng 6410, or Comp Eng 5420. (Co-listed with SYS ENG 6322).

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