SIU Southern Illinois University
CARBONDALE

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Cybersecurity and Cyber Systems.....1

Cybersecurity and Cyber Systems

The Master of Science degree in Cybersecurity and Cyber Systems is an interdisciplinary program offered through the School of Computing and the School of Electrical, Computer, and Biomedical Engineering.

Master of Science (M.S.) in Cybersecurity and Cyber Systems

Admission

Applicants with a bachelor's degree in Computer Science, Engineering, Physics, Mathematics, Information Systems or equivalent degrees will be admitted directly as long as their GPA satisfies Graduate School requirements. The M.S. in Cybersecurity and Cyber Systems requires 30 credit hours. Students can select an area of study in cybersecurity or in cyber systems. For applicants lacking the required specific background, we offer conditional admission status until completing prerequisite courses.

Admission to the M.S. in Cybersecurity and Cyber Systems program is based on the following factors: grade point average of 2.75 or higher on a scale of 4.0 on the entire last undergraduate GPA earned at the time of application, class ranking, and faculty recommendation letters. Although GRE scores are not required for admission, they are important to qualify for the High Achievers Tuition Rate. See also tuition.siuc.edu/highachievers2.html. The minimum TOEFL iBT score for international applicants is 80 prior to January 21, 2026, or 4.5 on or after January 21, 2026.

The program requires a nonrefundable $65 application fee that must be submitted with the application for admissions to the M.S. program in Cybersecurity and Cyber Systems. Students must apply online and pay this fee by credit card. Please address any correspondence to “Master of Science Program in Cybersecurity and Cyber Systems,” 1230 Lincoln Drive, Southern Illinois University Carbondale, Carbondale, Illinois 62901, Mailcode 6603 or Mailcode 4511. Inquiries can be addressed to cyberms@siu.edu. For telephone inquiries please call 618-536-2364 or 618-536-2327, and refer to the Master of Cybersecurity and Cyber Systems Program. The facsimile numbers are 618-453-7972 and 618-453-6044.

Retention

Any student whose cumulative grade point average falls below 3.0 on courses that count towards the degree will be placed on academic probation. Any graduate student on academic probation whose grade point average remains below 3.0 on courses that count towards the degree for two consecutive semesters in which she or he is enrolled will be permanently suspended from the program, unless the program grants an exception.

Curriculum

The degree requires 3 courses from 3 key areas that will ascertain understanding of fundamentals and help build a solid foundation for the remainder of the program. These courses are listed below.

1. **Fundamentals in computer security**. This requirement will be completed by either CS 510A or ECE 508. Only one of these courses will count towards the degree.
2. **Fundamentals in systems programming**. This requirement will be completed by either CS 512A or ECE 536. Only one of these courses will count towards the degree.

3. **Fundamentals in network systems**. This requirement will be completed by either CS 540A or ECE 553. Only one of these courses will count towards the degree.

A student should then seek an area of study in either cybersecurity or cyber systems by selecting at least 5 elective courses in these areas. The lists of these courses are given below. A maximum of six credit hours from academic units outside the School of Computing and the School of Electrical, Computer, and Biomedical Engineering can be applied towards the degree.

In the area of cybersecurity, students must complete 4 courses in cybersecurity and 1 course in cyber systems. In the area of cyber systems, students must complete 4 courses in cyber systems and 1 course in cybersecurity. A fundamental area may be satisfied by a course that was taken prior to admission or a documented record of accomplishment in the subject matter content. In this case, the student must select an additional elective course either in cybersecurity or in cyber systems for each satisfied fundamental area. Students must take at least two CS/ECE five-hundred-level courses not cross listed to a four-hundred-level course. Students must take at least three ECE and at least three CS courses. Only three credit hours of ECE 592 or CS 598 can count towards the degree.

MS Thesis option: 6 credit hours of thesis in ECE or CS (ECE 599 or CS 599) may substitute for 6 credit hours in an area of study (cybersecurity or cyber systems).

The Master of Science degree program in Cybersecurity and Cyber Systems has an online option for the non-thesis track.

List of cybersecurity courses for the MS degree: CS 508A, CS 509A, CS 513A, CS 515A, CS 548, CS 531B, ECE 502, ECE 517, ECE 518, ECE 519.

List of cyber system courses for the MS degree: CS 525A, CS 540B, CS 541A, ECE 512, ECE 509, ECE 528, ECE 536, ECE 541, ECE 575A.

For program courses and faculty, refer to Electrical and Computer Engineering and Computer Science.

Cybersecurity and Cyber Systems Courses

CS501A - Computer Architecture Review of logical circuit design. Hardware description languages. Algorithms for high-speed addition, multiplication and division. Pipelined arithmetic. Implementation and control issues using PLA?s and microprogramming control. Cache and main memory design. Input/ Output. Introduction to interconnection networks and multiprocessor organization. Students who have completed CS 401 are ineligible to enroll. Prerequisite: CS 320 with a grade of C or better or graduate standing. Credit Hours: 3

CS501B - Advanced Computer Architecture Hardware and software elements of multiprocessors, multicomputers, pipeline and array machines, data flow architecture and other state-of-the-art architectures. Design principles related to machine structures, interconnection networks, control software and hardware, data storage and access. Prerequisite: CS 401. Credit Hours: 3

CS503 - Fault-Tolerant Computing Systems An introduction to different aspects of fault-tolerance in computing systems. Redundancy techniques with an emphasis on information redundancy, software fault-tolerance, coding techniques, algorithm-based fault-tolerance, fault-tolerant interconnection network architecture, DFT techniques, and quantitative evaluation methods. Prerequisite: CS 401. Credit Hours: 3

CS504A - Autonomous Mobile Robots This course is a comprehensive introduction to modern robotics with an emphasis on autonomous mobile robotics. Fundamental of sensors and actuators as well as algorithms for top level control are discussed. Multi-robotics and human-robot interaction issues are explored. A group project is an integral part of this course. Students who have completed CS 404 are ineligible to enroll. Prerequisite: CS 330 with a grade of C or better or graduate standing. Credit Hours: 3

CS508A - Applied Cryptography This course is a comprehensive introduction to modern cryptography, with an emphasis on the application and implementation of various techniques for achieving message confidentiality, integrity, authentication and non-repudiation. Applications to Internet security and electronic commerce will be discussed. All background mathematics will be covered in the course.

Prerequisite: CS 330 with a grade of C or better and MATH 221 or graduate standing. Students who have completed CS 408 are ineligible to enroll. Credit Hours: 3

CS509A - Ethical Hacking This course will explore the various means that an intruder has available to gain access to computer resources. We will investigate weaknesses by discussing the theoretical background, and whenever possible, actually performing the attack. We will then discuss methods to prevent/reduce the vulnerabilities. This course is targeted specifically for Certified Ethical Hacking (CEH) exam candidates, matching the CEH exam objectives with the effective and popular Cert Guide method of study. Prerequisite: CS 202 or equivalent with a grade of C or better. Students who have completed CS 409 are ineligible to enroll. Credit Hours: 3

CS510A - Computer Security A broad overview of the principles, mechanisms, and implementations of computer security. Topics include cryptography, access control, software security and malicious code, trusted systems, network security and electronic commerce, audit and monitoring, risk management and disaster recovery, military security and information warfare, physical security, privacy and copyrights, and legal issues. Prerequisite: CS 306 with a grade of C or better or graduate standing. Students who have completed CS 410 are ineligible to enroll. Credit Hours: 3

CS511 - Formal Specification of Programming Languages A survey of modeling techniques and Meta languages for the formal specification of the syntax and semantics of high-level programming languages. Prerequisite: CS 311. Credit Hours: 3

CS512A - Programming Distributed Applications This course uses advanced features of the Java programming language to develop networked, distributed, and web-based applications. Topics covered include, but are not limited to, sockets, datagrams, the Java security model, threads, multi-tier architectures, Java RMI, Java database connectivity, and Java-based mobile agents. Prerequisite: CS 306 with a grade of C or better or graduate standing. Students who have completed CS 412 are ineligible to enroll. Credit Hours: 3

CS513A - Digital Forensics Cybersecurity has become a ubiquitous concern well beyond finding solutions to post-mortem threat analysis. The course provides a broad overview of security objectives and will cover fundamentals in confidentiality, integrity, and availability. Lectures will offer a broad range of topics on digital forensics. Students will be trained for an investigation mindset. Contemporary tools and techniques for digital forensics and investigations are reviewed. Security for stationary and mobile platforms are foci of current course in both forensic and active modes. There will be multiple hands-on homework and laboratories as well as a practical project as integral part of this course. Students who have completed CS 413 are ineligible to enroll. Prerequisite: CS 330 with a grade of C or better or graduate standing. Credit Hours: 3

CS514 - Advanced Operating Systems Rigorous treatment of advanced topics in operating systems. Multiprocessors and distributed operating systems. Highly concurrent machines. Performance analysis of memory management and scheduling algorithms. Recovery techniques in distributed computation. Security in operating systems. Prerequisite: CS 335 with a grade of C or better. Credit Hours: 3

CS515A - Network Forensics With the proliferation of wireless networks, security is at odds with privacy and integrity. The course provides a broad overview of security strategies for wireless networks. Topics will range from intrusion detection and network security protocols to collaborative computing. Contemporary tools and techniques for wireless network security are reviewed. A hands-on project will be an integral part of this course. Students who have completed CS 415 are ineligible to enroll. Prerequisite: CS 330 with a grade of C or better or graduate standing. Credit Hours: 3

CS516A - Compiler Construction Introduction to compiler construction. Design of a simple complete compiler, including lexical analysis, syntactical analysis, type checking, and code generation. Students who have completed CS 416 are ineligible to enroll. Prerequisites: CS 306 and 311 each with a grade of C or better or graduate standing. Credit Hours: 3

CS516B - Advanced Compilers A continuation of 416 including advanced topics in lexical and syntax analysis, error recovery, sematic analysis, code optimization and compiler compilers. Prerequisite: CS 416. Credit Hours: 3

CS520A - Distributed Systems A top-down approach addressing the issues to be resolved in the design of distributed systems. Concepts and existing approaches are described using a variety of methods including case studies, abstract models, algorithms and implementation exercises. Students who have completed CS 420 are ineligible to enroll. Prerequisite: CS 335 with a grade of C or better or graduate standing. Credit Hours: 3

CS525A - Principles of Virtualization and Cloud Computing Cloud Computing (CC) represents a recent major strategic shift in computing and Information Technology. This course explores fundamental principles, foundational technologies, architecture, design, and business values of CC. Understanding will be reinforced through multiple angles including: analysis of real world case studies, hands-on projects and in-depth study of research developments. Students who have completed CS 425 are ineligible to enroll. Prerequisite: CS 330 with a grade of C or better or graduate standing. Credit Hours: 3

CS529 - Natural Language Processing This course combines essential ideas from linguistics and artificial intelligence to for machine understanding and generation of language. We will cover language syntax, semantics, and pragmatics and discuss the applications such as information extraction, question answering and dialog systems. Machine learning is the main computational tool to solve NLP problems and will devote a part of the course to discussing ML approaches that model NLP tasks. Deep Neural Networks and their ability in learning representations are also part of our approach to NLP problems. We will discuss learning representations and learn about transformer-based architectures that help in learning rich representations. This course is suitable for students who are willing and able to learn abstract concepts, complete programming assignments, develop a project, and produce a term paper. Prerequisite: CS 330 with a grade of C or better. Credit Hours: 3

CS530A - Database Systems The course concentrates on the relational model, database design, and database programming. Topics include relational model, relational algebra, SQL, constraints and integrity, transaction support, concurrency control, database design, normalization, backup, recovery, and security. A comprehensive product-like project is an integral part of the course. Prerequisite: CS 330 with a grade of C or better or graduate standing. Students who have completed CS 430 are ineligible to enroll. Credit Hours: 3

CS530B - Advanced Database Systems A detailed treatment of advanced topics in data base systems including, but not limited or restricted to, relational database theory, query optimization, recovery techniques, concurrency control, distributed database systems, security and integrity and database machines. Prerequisite: CS 430. Credit Hours: 3

CS531A - Cyber-Physical Systems The goal of this course is to introduce and develop an understanding of the computing and communication for Internet of Things as a subset of Cyber-Physical systems. Connectivity among devices in our daily lives such as WiFi-enabled thermostats, smarts grids, and driverless cars is ushering in an era of sociality that transcends human social networks to machine to machine networks. Prerequisite: CS 306 with a grade of C or better or graduate standing. Students who have completed CS 431 are ineligible to enroll. Credit Hours: 3

CS531B - Security in Cyber-Physical Systems The course covers introductory topics in cyber-physical systems security. The goal is to expose students to fundamental security primitives specific to cyber-physical systems and to apply them to a broad range of current and future security challenges. Various tools and techniques used by hackers to compromise computer systems or otherwise interfere with normal operations are explored using tools that are unique to interacting with cyber-physical systems. Restricted to graduate standing or consent of the instructor. Credit Hours: 3

CS533 - Data Mining and Big Data Analysis This course provides a series of comprehensive and in-depth lectures on the core techniques in data mining and knowledge discovery; addresses the unique issues of big data; and discusses potential applications of data mining particularly on big data analysis. Major topics include: data preparation, association mining, classification (and prediction), clustering, characteristics and challenges of big data, and strategies of big data mining and analysis. Prerequisites: CS 330 and CS 430 with grades of C or better or consent of instructor. Credit Hours: 3

CS534A - Learning from Data An introduction to classical machine learning theory and practical techniques. Topics to be covered include computational learning theory (VC theory), linear classification and regression models, SVMs and kernel methods, decision trees, the bias-variance tradeoff, overfitting,

and regularization. Prerequisite: CS 330 with a grade of C or better or graduate standing. Students who have completed CS 434 are ineligible to enroll. Credit Hours: 3

CS535A - Software Engineering Principles, practices and methodology for development of large software systems. Object-oriented principles, design notations, design patterns and coping with changing requirements in the software process. Experiences with modern development tools and methodologies. A team project is an integral part of this course. Prerequisite: CS 330 with a grade of C or better or graduate standing. Students who have completed CS 435 are ineligible to enroll. Credit Hours: 3

CS536A - Artificial Intelligence I Search and heuristics, problem reduction. Predicate calculus, automated theorem proving. Knowledge representation. Applications of artificial intelligence. Parallel processing in artificial intelligence. Students who have completed CS 436 are ineligible to enroll. Prerequisites: CS 311 and CS 330 each with a grade of C or better or graduate standing. Credit Hours: 3

CS536B - Artificial Intelligence II Theorem proving, the Resolution Principle, strategies, and achievements. Program verification. Natural language processing. Other selected topics. Prerequisite: CS 436. Credit Hours: 3

CS537A - Machine Learning and Soft Computing An introduction to the field of machine learning and soft computing. It covers rule-based expert systems, fuzzy expert systems, artificial neural networks, evolutionary computation, and hybrid systems. Students will develop rule-based expert systems, design a fuzzy system, explore artificial neural networks, and implement genetic algorithms. Prerequisite: CS 330 with a grade of C or better or graduate standing. Students who have completed CS 437 are ineligible to enroll. Credit Hours: 3

CS537B - Advanced Machine Learning The purpose of this course is for students to acquire in-depth knowledge of advanced aspects of machine learning. This course will cover topics including classification, clustering, the foundation of deep learning, convolutional Neural Networks, recurrent Neural Networks, and some other advanced topics-deep reinforcement learning and deep generative models. Students will learn the foundations of machine learning, deep learning, and develop skills for performing research to advance the state of knowledge in machine learning. Prerequisites: CS 434 or CS 437 with a grade of C or better. Concurrent enrollment in CS 434 or CS 437 is allowed. Credit Hours: 3

CS538A - Bioinformatics Algorithms This course is an introductory course on bioinformatics algorithms and the computational ideas that have driven them. The course includes discussions of different techniques that can be used to solve a large number of practical problems in biology. Prerequisite: CS 330 with a grade of C or better or graduate standing. Students who have completed CS 438 are ineligible to enroll. Credit Hours: 3

CS539 - Agents and Multiagent Systems This is an advanced treatment of fundamental concepts in the design of intelligent autonomous agents and agent systems. Classic agent theories, architectures, algorithms, and languages are discussed. An agent-based project is an integral part of this course. Restricted to graduate standing or consent of instructor. Credit Hours: 3

CS540A - Computer Networks Design and analysis of computer communication networks. Topics to be covered include queuing systems, data transmission, data link protocols, topological design, routing, flow control, security and privacy, and network performance evaluation. Prerequisite: CS 330 with a grade of C or better or graduate standing; CS 306 recommended. Students who have completed CS 440 are ineligible to enroll. Credit Hours: 3

CS540B - Advanced Computer Networks Topics include routing protocols used in internet; data compression techniques; telecommunication systems - its services, architecture and protocols; high speed networks; routing protocols in mobile ad-hoc networks; and a detailed performance analysis of different window flow control and congestion control mechanisms using queuing theory. Prerequisite: CS 440 with a grade of C or better, or consent of the instructor. Credit Hours: 3

CS541A - Mobile and Wireless Computing Concepts of mobile and wireless systems are presented. These concepts include, but are not limited to, Routing and Medium Access for Mobile Ad hoc and Wireless Sensor Networks, Mobile IP, Wireless LAN and IEEE 802.11. Hands-on group lab experience is an integral component in the course. Prerequisite: CS 330 with a grade of C or better or graduate

standing, or consent of the instructor. Students who have completed CS 441 are ineligible to enroll. Credit Hours: 3

CS543 - Wireless and Network Security Advanced security concepts of distributed systems and wireless networks are presented. Topics include IEEE 802.11 security, Wireless Encryption and Authentication, Key Management in Networks, Distributed Denial of Service Attacks, Routing Security, Intrusion Detection and Mobile Code Security. Prerequisite: CS 410 with a grade of C or better or consent of the instructor. Credit Hours: 3

CS544 - Game Theory in Networks Game theoretic concepts apply whenever actions of several players are interdependent. This course will provide an introduction to classic game theory and strategic thinking including dominance, Nash equilibrium, and stability. Social choice, social learning, and online mechanism design are then discussed. We will examine how game theoretic concepts can be used in developing reasoning strategies, i.e., algorithms. Application of game theoretic framework to telecommunication and human networks is an integral part of this course. Restricted to graduate standing or consent of instructor. Credit Hours: 3

CS547A - Introduction to Graph Theory Graph theory is an area of mathematics which is fundamental to future problems such as computer security, parallel processing, the structure of the World Wide Web, traffic flow and scheduling problems. It also plays an increasingly important role within computer science. Topics include: trees, coverings, planarity, colorability, digraphs, depth-first and breadth-first searches. Prerequisite: MATH 349 with a grade of C or better. Students who have completed CS 447 are ineligible to enroll. Credit Hours: 3

CS548 - Security Issues in Cloud Computing This course offers a survey of security and privacy issues in Cloud Computing systems along with an overview of current best practices and available technologies. Threat model as well as practical applications of secure Cloud Computing are explored. Prerequisite: CS 410 or graduate standing. Credit Hours: 3

CS549A - Introduction to Combinatorics This course will introduce the student to various basic topics in combinatorics that are widely used throughout applicable mathematics. Possible topics include: elementary counting techniques, pigeonhole principle, multinomial principle, inclusion and exclusion, recurrence relations, generating functions, partitions, designs, graphs, finite geometry, codes and cryptography. Prerequisite: MATH 349 with a grade of C or better. Students who have completed CS 449 are ineligible to enroll. Credit Hours: 3

CS550 - Advanced Topics in Parallel & Distributed Computing An advanced treatment of parallel and distributed computing; review of hardware and software considerations for parallel computation; development and analysis of parallel algorithms (with particular attention to the communication and synchronization costs associated with parallel algorithms); effect of granularity on performance; a comparison of the parallel and distributed programming paradigms including a detailed study of the central features of each approach; software systems for distributed computing including exposure to one or more distributed programming environments; the direction of parallel computing as suggested by recent, high level parallel languages; parallelizing serial programs; parallelizing compilers; future directions of parallel and distributed computing systems. The course will include a student project. Prerequisite: CS 420. Credit Hours: 3

CS551A - Theory of Computing The fundamental concepts of the theory of computation including finite state acceptors, formal grammars, Turing machines, and recursive functions. The relationship between grammars and machines with emphasis on regular expressions and context-free languages. Prerequisites: CS 311 and CS 330 each with a grade of C or better or graduate standing. Students who have completed CS 451 are ineligible to enroll. Credit Hours: 3

CS553 - Formal Languages and Automata The Chomsky hierarchy of formal grammars and the corresponding classes of automata. Turing machines and basic concepts of computability. Recursive and recursively enumerable languages. Closure properties. Undecidable problems about Turing machines and context-free languages. Deterministic context-free languages and the construction of LR parsers. Prerequisite: CS 451. Credit Hours: 3

CS554 - Computational Blockchain This course introduces fundamentals of modern blockchain-based systems as well as cryptocurrency applications. Topics for discussion include consensus and distributed

computing, smart contracts, privacy and secrecy, and other relevant computational platforms. Non-currency applications of blockchains, and legal and social implications will be outlined. Students will be required to develop a term project. Prerequisites: CS 330 with grade of C or better or CS 410 or graduate standing. Credit Hours: 3

CS555A - Advanced Algorithm Design and Analysis An in-depth treatment of the design, analysis and complexity of algorithms with an emphasis on problem analysis and design techniques. Prerequisite: CS 330 with a grade of C or better or graduate standing. Students who have completed CS 455 are ineligible to enroll. Credit Hours: 3

CS556 - Computability and Complexity Turing machines and other models of computation. Computable functions. Church's thesis. Solvable and unsolvable problems. Introduction to complexity theory including the classes P and NP. Polynomial time approximation algorithms for NP-complete problems. Prerequisite: CS 451. Credit Hours: 3

CS557 - Advanced Topics in Expert Systems This course is designed to provide students with advanced topics in expert systems theory. Topics covered include: knowledge representation, methods of inference, reasoning under uncertainty, and inexact reasoning (fuzzy logic). A practical introduction to expert systems programming serves to reinforce and clarify the theoretical concepts. Prerequisite: CS 330 or consent of instructor. Credit Hours: 3

CS571A - Optimization Techniques Introduction to algorithms for finding extreme values of nonlinear multivariable functions with or without constraints. Topics include: convex sets and functions; the arithmetic-geometric mean inequality; Taylor?s theorem for multivariable functions; positive definite, negative definite, and indefinite matrices; iterative methods for unconstrained optimization. Prerequisites: MATH 221 and MATH 250 with a grade of C or better. Students who have completed CS 471 are ineligible to enroll. Credit Hours: 3

CS572A - Linear Programming Introduction to finding extreme values of linear functionals subject to linear constraints. Topics include: recognition, formulation, and solution of real problems via the simplex algorithm; development of the simplex algorithm; artificial variables; the dual problem and duality theorem; complementary slackness; sensitivity analysis; and selected applications of linear programming. Prerequisite: MATH 221 with a grade of C or better. Students who have completed CS 472 are ineligible to enroll. Credit Hours: 3

CS575A - Numerical Analysis I Introduction to theory & techniques for computation with digital computers. Topics include: solution of nonlinear equations; interpolation & approximation; solution of systems of linear equations; numerical integration. Students will use MATLAB to study the numerical performance of the algorithms introduced in the course. Prerequisites: MATH 221 and MATH 250 with grades of C or better. Students who have completed in CS 475 are ineligible to enroll. Credit Hours: 3

CS575B - Advanced Topics in Numerical Analysis (Same as MATH 572) Selected advanced topics in Numerical Analysis chosen from such areas as: approximation theory; spline theory; special functions; wavelets; numerical solution of initial value problems; numerical solution of boundary value problems; numerical linear algebra; numerical methods of optimization; and functional analytic methods. Special approval needed from the instructor. Credit Hours: 1-12

CS580A - Computational Statistics II This course utilizes computational and graphical approaches to solve statistical problems. A comprehensive coverage on modern and classical methods of statistical computing will be given. Case studies in various disciplines such as science, engineering, and education will be discussed. Various topics such as numerical integration and simulation, optimization and maximum likelihood estimation, density estimation and smoothing as well as re-sampling will be presented. Students will be able to create graphical and numerical display based on their data analysis results using R programming language. Prerequisites: MATH 250 and CS 306 or CS 330 with a grade of C or better or graduate standing. Students who have completed CS 480 are ineligible to enroll. Credit Hours: 3

CS584A - User Interface Design and Development Problems and processes in the design of highly usable systems. Understanding stakeholders, requirements, tasks, prototyping, evaluation, guidelines and design process and heuristics. Interactive software concepts and implementation considerations. A group

project is an integral part of this course. Prerequisite: CS 306 with a grade of C or better or graduate standing. Students who have completed CS 484 are ineligible to enroll. Credit Hours: 3

CS585A - Computer Graphics Principles and techniques of computer graphics. Interactive graphics software development using a modern graphics standard such as OpenGL. Topics include: primitives, transforms, clipping, modeling, viewing, texture, lighting and shading. Advanced rendering and modern graphics hardware. Prerequisite: CS 306 with a grade of C or better or graduate standing; MATH 150 and MATH 221 are recommended. Students who have completed CS 485 are ineligible to enroll. Credit Hours: 3

CS585B - Advanced Topics in Computer Graphics Study of computer graphics for realistic image synthesis. Object modeling and associated date structures. Advanced rendering techniques such as raytracing and radiosity. Efficiency considerations. Image composition and compression. Current advances and research problems in realistic computer graphics. Prerequisite: CS 485. Credit Hours: 3

CS586 - Pattern Recognition An introduction to the area of pattern recognition and data science. This course will cover basic and advanced theories, algorithms, and practical solutions of statistical pattern recognition. It covers bayesian learning, parametric and non-parametric learning, data clustering, component analysis, boosting techniques, sequential data, reinforcement learning, and deep learning with neural networks. Credit Hours: 3

CS587A - Software Aspects of Game Development This course focuses on software implementation and development aspects of game production including: software process, system architecture, frameworks, entity management and interaction design, game design, production and business issues as well as technical foundations in graphics modeling and rendering, collision detection, physics, artificial intelligence, and multiplayer techniques. Prerequisite: CS 330 with a grade of C or better or graduate standing. Students who have completed CS 487 are ineligible to enroll. Credit Hours: 3

CS590 - Readings Supervised readings in selected subjects. Graded S/U only. Special approval needed from the instructor. Credit Hours: 1-6

CS591 - Special Topics Selected advanced topics from the various fields of computer science. Repeatable on different topics toward degree credit. Credit Hours: 1-3

CS593 - Seminar Preparation and presentation of reports. Graded S/U only. Special approval needed from the instructor. Credit Hours: 1-4

CS598 - Graduate Project A practical exercise in the design, implementation, documentation and deployment of a project. A project may be completed through internship, work/study, or a supervised project. For Ph.D. students only, an internship could include face-to-face or online teaching. Credit Hours: 3-9

CS599 - Thesis Special approval needed from the instructor. Credit Hours: 3-9

CS600 - Doctoral Dissertation Dissertation research. Hours and credit to be arranged by the student's academic advisor. Graded S/U only. Restricted to admission to Ph.D. in computer science program. Credit Hours: 1-9

CS601 - Continuing Enrollment For those graduate students who have not finished their degree programs and who are in the process of working on their dissertation, thesis, or graduate project. The student must have completed a minimum of 24 hours of dissertation research, or the minimum thesis or graduate project hours before being eligible to register for this course. Concurrent enrollment in any other course is not permitted. Graded S/U or DEF only. Credit Hours: 1

ECE501 - Data Mining with R R programming language: Vectors, Matrices, Lists, Data Frames, Factors, Tables. Review of machine learning techniques: Numerical Regression, Logistic Regression, k-Nearest Neighbors, Decision Trees. ROC curves. Various application case studies. Restricted to graduate standing and consent of instructor. Students who have completed ECE 435 or BME 435 will not receive credit for this course. Credit Hours: 3

ECE502 - Network System Security Principles, design, and implementation of network systems security. Network security basics (computer networks and network security module), packet sniffing and

spoofing, network security systems (firewall, virtual private network, and instruction detection systems), security tools (AES, Hash, RSA, and public key infrastructure), and advanced topics such as bitcoin and block chain. Students who have completed ECE 433 will not receive credit for this course. Restricted to graduate standing and consent of instructor. Credit Hours: 3. Credit Hours: 3

ECE503 - Modern Cryptography Probability and basic number theory, block ciphers and key-recovery security, pseudorandom functions, symmetric encryption, hash functions, message authentication codes, authenticated encryption, asymmetric encryption, digital Signatures, key distribution, lattice-based cryptography, identity-based encryption, zero-knowledge e techniques, introduction to quantum cryptography. Credit Hours: 3

ECE504 - Hardware and Software Aspects in the Internet of Things Fundamentals and importance of the Internet of Things (IoT). Sensors and hardware components of IoT systems. Design of energy-efficient IoT systems from circuit to system level. Connectivity in IoT, off-loading strategies, and federated learning concepts. Applications of IoT in smart cities, healthcare, agriculture, and augmented/virtual Reality. Prerequisites: ECE 329 and ECE 321 (or equivalent) with a grade of C or better or consent of instructor. Credit Hours: 3

ECE505 - Surgical Technologies Overview of the ordinary physiology of cells and tissues and the abnormal physiology associated with cancer and/or other major diseases. Role of surgeries in the practice of modern medicine with a special focus on cancer treatment and/or other important procedures. Environment of and people inside the operating room. Therapeutic and diagnostic tools and techniques available in the operating room. Open and minimally invasive surgeries. Introduction to image-guided surgeries. Imaging systems and contrast agents for image-guided surgeries. Introduction to robotic surgeries. Preclinical research, clinical research, and FDA-approval process. Prerequisite: ECE 355 (or equivalent). Credit Hours: 3

ECE506 - Biomedical Optics (Same as BME 506) Fundamental theories of light, including the wave theory of light and the particle theory of light; Fundamental interactions between light and matter, including reflection, refraction, absorption, scattering, fluorescence, and polarization; Biology of cells and tissues; Tissue optical properties; Tissue-targeted contrast agents; Coherence and interference; Light transport in turbid media; Diagnostic applications of light, including microscopy, spectroscopy, fluorescence imaging, fluorescence-lifetime imaging, optical coherence tomography, diffuse optical tomography, and/or biosensors; Therapeutic applications of light, including photodynamic therapy, photothermal therapy, and/or laser ablation. Prerequisites: ECE 355, MATH 251, and PHYS 205B, or equivalent, with a grade of C or better, or consent of instructor. Students who are taking or have taken BME 431 or ECE 451 are ineligible to enroll. Credit Hours: 3. Credit Hours: 3

ECE507 - Image Sensors (Same as BME 507) Fundamentals of semiconductor physics, including the use of doping and biasing to control electronic potentials in devices; Fundamentals of integrated circuits, including the design and fabrication of diodes, transistors, and interconnects; Fundamental interactions between light and matter, including reflection, refraction, and absorption; Structure and operating modes of photodiodes; Architectures and operating principles for charge coupled device (CCD) image sensors and complementary metal-oxide-semiconductor (CMOS) image sensors; Performance metrics for image sensors, including the noise floor, the full-well capacity, the quantum efficiency, and fixed pattern noise; Construction of color image sensors; Signal processing for image sensors, including color interpolation and color correction. Prerequisite: ECE 355 and PHYS 205B, or equivalent, with a grade of C or better, or consent of instructor. Students who are taking or have taken BME 453 or ECE 453 are ineligible to enroll. Credit Hours: 3. Credit Hours: 3

ECE508 - Computer Systems Security Principles of computer systems security. Vulnerabilities, attacks and defenses, cryptographic primitives, authentication, digital signature, access control. Software systems security: buffer overflow, virus, SQL injection. Networking security: denial of service attack, firewall and IDS, Wi-fi security. Hardware systems security: secure processing and secure co-processor. Cloud, edge and IoT security. Students who have completed ECE 434 will not receive credit for this course. Restricted to graduate standing in ECE or consent of instructor. Credit Hours: 3

ECE509 - Systems Reliability Combinatorial aspects of system reliability. Parallel, standby, n-modular redundancy. Common cause failures. Information coding techniques. Reliability optimization and apportionment. Fault-tolerant computer design techniques. Students who have completed ECE 419 will

not receive credit for this course. Restricted to graduate standing and consent of instructor. Credit Hours: 3

ECE510 - Hardware Designs and Architectures for AI Artificial intelligence (AI) is currently widely used in many advanced Machine learning (ML) applications. This course covers the fundamentals of design and implementation of hardware architectures for AI algorithms. Basic hardware building blocks will be introduced. It will also introduce the emerging memristor-crossbar array (MCA) as a computing platform for implementing neural network architectures. Students will gain hands-on experience through mixed-signal simulations and validation techniques. Students will be assigned a team project which applies concepts and tools learned from this course. Prerequisites: ECE 327 and ECE 345 with grades of C or better. Students who have completed ECE 410 will not receive credit for this course. Project-based fee: $35 to help defray cost of software licenses and computers in the lab. Credit Hours: 3

ECE511 - Software Hardware Co-design for Deep Neural Networks This course explores deep learning architectures with a focus on convolutional neural networks (CNNs), recurrent neural networks (RNNs), sequence models, and transformers. Students will also focus on generative AI techniques. The course covers mapping techniques for deep learning workloads on TPUs and systolic arrays, emphasizing memory hierarchies and parallel execution strategies. Design space exploration for TPU architectures will be introduced, allowing students to evaluate trade-offs in performance, power, and efficiency. Practical implementation using TensorFlow and PyTorch will reinforce software-hardware co-design principles. Students will also work on a semester-based project utilizing the latest advancements in deep neural networks. Students that have completed ECE 411 are not eligible to enroll in ECE 511 as the courses cover similar topics to an extent. Credit Hours: 3

ECE512 - Wireless Networks Compared to infrastructure based wireless communication systems, ad hoc wireless networks present several unique advantages. Thus, it has been widely studied as an important wireless communication paradigm. This graduate level course first introduces several widely adopted wireless communication technologies and then presents the concept, structure, and principles of ad hoc wireless networks. The course also introduces the details of several popular ad hoc wireless networks including mobile ad hoc networks, delay tolerant networks, wireless sensor networks, and connected vehicle networks. Novel applications in those networks will also be introduced. The course work will include paper and literature review, presentations, assignments, and a project that will enable students to be familiar with ad hoc wireless networks. NS2 will be used for student project in this course. Students can gain experience on NS2. Students who have taken ECE 412 are ineligible to enroll. Project-based fee: $10 to help defray cost of equipment. Credit Hours: 3

ECE513 - Digital VLSI Design Principles of the design and layout of Very Large Scale Integrated (VLSI) circuits concentrating on the CMOS technology. MOS transistor theory and the CMOS technology. Characterization and performance estimation of CMOS gates, CMOS gate and circuit design. Layout and simulation using CAD tools. CMOS design of datapath subsystems. Design of finite state machines. Examples of CMOS system designs. Laboratory experience in CMOS VLSI design. Restricted to enrollment in ECE program. Students who have taken ECE 423 are ineligible to enroll. Project-based fee: $35 to help defray cost of software licenses and equipment. Credit Hours: 3

ECE514 - Design of Intelligent Embedded Systems This course covers the fundamental concepts of embedded systems including models of sensors and actuators, processors, memory architectures, and I/O. Concepts of multi-tasking and scheduling methods will be also covered. Different methods of modeling and analyzing embedded systems will be also discussed. Finally, applications of AI in embedded systems and efficient ways of executing AI workloads on resource-constrained embedded devices will be investigated. Students who have completed ECE 424 will not receive credit for this course. Prerequisites: Courses equivalent to ECE 296 and ECE 321 with grades of C or better. Lab fee: $10 to help defray cost of equipment. Credit Hours: 3

ECE515 - Three Dimensional Integration Systems This course introduces the design of three dimensional VLSI integration systems, including through-silicon-via (TSV) process, characterization and modeling, 3D IC systems design, mixed signal simulation, data management, testing, process, variation, thermal and reliability challenges, as well as review of 3D system design examples. Laboratory experience in design tools (Cadence Virtuoso and Liberate, AMS simulator). Prerequisite: ECE 345 and ECE 423 with a grade of C or better. Restricted to enrollment in ECE program. Credit Hours: 3

ECE516 - Implementation of VLSI Systems with HDL This course is dedicated for advanced Digital VLSI architecture and system implementation for high performance and low power digital signal processing applications. Application-specific processors and architectures to support real time processing of signal processing systems will be studied. Hands-on experience of using state-of-the-art CAD tools on designing such kind of VLSI architecture and systems. Upon completion of this course, students will entail large HDL-based implementation of a complete VLSI system. Students who have taken ECE 426 are ineligible to enroll. Prerequisite: ECE 327 with a grade of C or better. Project-based fee: $35 to help defray cost of software licenses and equipment. Credit Hours: 3

ECE517 - Edge Computing Analysis of IoT architectures and core IoT modules, integration of sensors and data acquisition systems, power-aware optimizations, and embedded operating systems. Investigation of cloudlet topologies and services, edge to cloud protocols, and security. Special focus will be given on data analytics and machine learning in the cloud and the edge. Credit Hours: 3

ECE518 - Advanced Hardware Security and Trust Cryptographic systems and hardware. Advances in physically unclonable functions. Random number generators. Watermarking. Hardware metering. Side channel attacks including fault injection and power analysis. Types of hardware Trojan attacks (forms and sizes). Detection of hardware Trojans. Hardware tampering and obfuscation. Countermeasures against hardware attacks and hardware authentication. Counterfeit circuits: detection and avoidance. Trust issues in FPGAs. JTAG security and trust. SoC security requirements and secure design. Prerequisite: ECE 418 or graduate standing. Credit Hours: 3

ECE519 - Advanced Computer Security with Machine Learning This course covers the principles and practices of advanced computer systems security using machine learning. The principles encompass topics such as machine learning for computer security, cryptography, software and network security, as well as security and privacy in machine learning applications. The practical component consists of a series of hands-on labs aimed at achieving data confidentiality, authenticity, and integrity, along with exploring various attacks and their countermeasures. Restricted to graduate standing in ECE or consent of instructor. Credit Hours: 3

ECE520 - VLSI Design and Test Automation Principles of the automated synthesis, verification, testing and layout of Very Large Scale Integrated (VLSI) circuits concentrating on the CMOS technology. Resource allocation and scheduling in high-level synthesis. Automation of the logic synthesis for combinational and sequential logic. The physical design automation cycle and CMOS technology considerations. Fault modeling and testing. Timing analysis. Laboratory experience using commercial tools for synthesis and layout. Students who completed ECE 425 can't take ECE 520. They are similar. Prerequisite: ECE 327 with a C- or better or enrollment in ECE graduate programs. Project-based fee: $30 to help defray cost of software licenses and equipment. Credit Hours: 3

ECE521 - Fault-Tolerant Computer Design Concepts of error detection, location and correction in digital systems. Codes for error detection and correction. Models and simulations of faults. Design of tests for combinatorial and sequential circuits. Testability. Design of digital systems with testability. Prerequisite: ECE 423, ECE 425 or consent of instructor. Restricted to enrollment in ECE program. Credit Hours: 3

ECE522 - VLSI Circuit Testing Theoretical and practical aspects of production testing of VLSI circuits. Relations between physical defects and fault models. Procedures for generating test inputs. Design modifications for test application and theory of built-in self-test. Prerequisite: ECE 425 or ECE 520 with a minimum grade of C or consent of instructor. Restricted to enrollment in ECE program. Project-based fee: $25 to help defray cost of software licenses. Credit Hours: 3

ECE523 - Low Power VLSI Design Source of power dissipation, technology impact on power dissipation, low power circuit techniques, energy recovery, synthesis of low power circuits, low power components. Prerequisite: ECE 423 or ECE 513 with a minimum grade of C or consent of instructor. Restricted to enrollment in ECE program. Project-based fee: $35 to help defray cost of software licenses and equipment. Credit Hours: 3

ECE524 - Synthesis and Verification of Digital Circuits Binary decision diagrams, finite state machines and finite automata. Design automation concepts in logic level synthesis, optimization and verification for combinational as well as sequential logic. Technology mapping. Prerequisite: ECE 425 or ECE 520 with a

minimum grade of C or consent of instructor. Restricted to enrollment in ECE program. Project-based fee: $35 to help defray cost of software licenses and equipment. Credit Hours: 3

ECE525 - Advances in Physical Design Automation Advances in the automation of VLSI layouts with emphasis on recent developments in deep submicron, FPGA and MCM technologies. Floor planning, placement, routing objectives in high performance designs using deep submicron technology. Timing analysis in the presence of crosstalk. FPGA architectures and design with dynamically reconfigurable FPGAs. Physical design automation for MCMs. Prerequisite: ECE 425 or ECE 520 with a minimum grade of C or consent of instructor. Restricted to enrollment in ECE program. Project-based fee: $35 to help defray cost of software licenses and equipment. Credit Hours: 3

ECE526 - Network Processing Systems Design Protocol processing, packet processing algorithms, classification and forwarding, queuing theory, switching fabrics, network processors, network systems design tradeoffs. Prerequisite: ECE 422 and ECE 429 or consent of the instructor. Restricted to enrollment in ECE program. Credit Hours: 3

ECE527 - Integrated Interconnection Networks Importance of interconnection networks and networks-on-chip (NOCs). Specifications and constraints. Topology, routing, flow control, deadlock, livelock, arbitration, allocation, performance analysis, simulation. Restricted to enrollment in ECE program. Credit Hours: 3

ECE528 - Programmable ASIC Design Principle and practice of designing and implementing Application-Specific Integrated Circuits (ASIC). Field Programmable Gate Arrays (FPGA). Timing analysis, timing closure and managing difference clock domains in ASIC design. Complex arithmetic circuits. Digital signal processing (DSP) circuits. FPGA microprocessors. Students who have taken ECE 428 are ineligible to enroll. Project-based fee: $50 to help defray cost of equipment and consumable items. Credit Hours: 3

ECE529 - Computer Systems Architecture Principles of performance evaluation, processor microarchitecture, instruction-level parallelism, static and dynamic pipeline considerations. Superscalar processors. Multiprocessor systems. Memory hierarchy design, cache design. Mutual exclusion and synchronization mechanisms. Students who have taken ECE 429 are ineligible to enroll. Restricted to enrollment in ECE program. Credit Hours: 3

ECE530 - Engineering Data Acquisition (Same as ENGR 530) Theory of data acquisition and measurement systems. Criteria for selection of data acquisition hardware and software, instruments, sensors and other components of scientific and engineering experimentation. Methods for sampled data acquisition, signal conditioning, interpretation, analysis and error estimation. Restricted to enrollment in ECE program. Project-based fee: $60 to help defray cost of software licenses and equipment. Credit Hours: 3

ECE531 - Mixed-Signal VLSI Design Analysis and design of mixed-signal integrated circuits. Digital to analog converter (DAC). Analog to digital converter (ADC). Sigma-delta data converters. Performance analysis of signal chains containing both analog and digital signal processing functions. Prerequisite: ECE 446 with a minimum grade of C. Restricted enrollment in ECE program. Project-based fee: $60 to help defray cost of software licenses and equipment. Credit Hours: 3

ECE532 - GPU Programming This course provides an advanced study of GPU architectures and high-performance parallel programming using CUDA C/C++. Students will explore many-core design principles in depth, focusing on low-level architectural features such as warp schedulers, SIMT execution, shared memory banks, and memory access patterns. Emphasis is placed on performance-critical optimizations, including instruction-level parallelism, occupancy tuning, register pressure analysis, and efficient tensor core usage for AI and scientific computing. The course also covers profiling and fine-grained performance analysis using tools such as Nsight Compute and CUDA Profiler. Students will work with advanced CUDA libraries such as cuDNN, cuBLAS, and CUTLASS to implement and optimize compute-intensive kernels. Design trade-offs in cache hierarchy, memory bandwidth, and interconnects will be examined in the context of throughput, scalability, and energy efficiency. Students that have completed ECE 432 are not eligible to enroll in ECE 532 as the courses cover similar topics to an extent. Project-based fee: $20 to help defray cost of equipment. Credit Hours: 3

ECE533 - Speech Processing (Same as BME 533) Fundamentals of speech production system, signal analysis of speech, speech coding, linear prediction analysis, speech synthesizing, and speech recognition algorithms. Students who have taken ECE 474 are ineligible to enroll. Prerequisite: MATH 250, ECE 355 with grades of C or better or consent of instructor. Credit Hours: 3

ECE534 - Biomedical Signal Analysis (Same as BME 536) The nature of biomedical signals. Electricity in living tissue. Biomedical signal processing and modeling. Modeling and simulation of biomedical systems. Prerequisite: MATH 250, ECE 355 with a grade of C or better or consent of instructor. Project-based fee: $20 to help defray cost of software licenses. Credit Hours: 3

ECE535 - CMOS Radio-Frequency Integrated Circuit Design Introduction of RF IC, passive RLC Networks, passive IC components, MOS Transistors, distributed systems, Smith Chart and S-Parameters, introduction to Band-width estimation, biasing and voltage reference, basic High Frequency Amplifiers, introduction to: noise in RF IC, Low Noise Amplifiers, Power Amplifiers, Phase-Locked Loops and Oscillators. Lecture and laboratory. Students who have taken ECE 440 are ineligible to enroll. Lab fee: $35 to defray the cost of software licenses and equipment. Credit Hours: 3

ECE536 - Embedded Systems Programming Advanced software concepts and techniques to develop complex software projects on embedded systems. Concepts and techniques include system calls, structure of operating systems, advanced dynamic memory management, cross-compilation, scheduling techniques, and resource management. Students who have completed ECE 430 cannot take ECE 536. They are similar. Credit Hours: 3

ECE537 - Integrated Photonics Fundamentals of electromagnetic theory, waveguides, photonic structures including photonic crystals and integrated micro-ring resonator, numerical simulations of photonic integrated circuits using the beam propagation method, finite-difference time-domain method, rate equations, and fabrication processes. Prerequisite: ECE 441 or consent of instructor. Restricted to enrollment in ECE program. Credit Hours: 3

ECE538 - Medical Instrumentation: Application and Design (Same as BME 518) This course introduces ECE graduate students to the field of medical instrumentation. Medical instrumentation is the application of advanced engineering technology to problems in biology and medicine. The course focuses on fundamentals of instrumentation systems, sensors, amplifiers, and signal precondition. In addition, the course also includes design and applications of medical instrumentation, biopotential measurement, biomedical signal processing, and other related topics. Students who have completed ECE 438 or BME 438 will not receive credit for this course. Prerequisite: MATH 305 and ECE 355 with a grade of C or better, or consent of instructor. Restricted to enrollment in ECE programs. Project-based fee: $45 to help defray cost of software licenses and equipment. Credit Hours: 3

ECE539 - Diagnostic Ultrasound Diagnostic ultrasound is an ultrasound-based medical imaging technique used to visualize muscles, tissue, and many internal organs, to capture their size, structure and any pathological lesions. This course is an introduction to the principles and applications of biomedical ultrasound. This course will focus on fundamentals of acoustic theory, principles of ultrasonic detection and imaging, design and use of currently available tools for performance evaluation of diagnostic devices, and biological effects of ultrasound. Students who have taken ECE 494 or BME 439 will not receive credit for this course. Prerequisite: MATH 305 and ECE 355 or equivalent courses with a grade of C or consent of instructor. Restricted to enrollment in ECBE programs. Project-based fee: $30 to help defray cost of software licenses and equipment. Credit Hours: 3

ECE540 - CMOS Radio-Frequency Integrated Circuit Design II High frequency amplifier design techniques, noise in RF IC and CMOS low noise amplifiers (LNA), mixers, oscillators, PLLs, frequency synthesizers, power amplifiers, an overview of wireless architectures. Prerequisite: ECE 440 or ECE 535 or equivalent. Lab fee: $50 to defray the cost of software licenses and equipment. Credit Hours: 3

ECE541 - Quantum Information Processing and Devices Fundamentals of information theory: uncertainty and information, thermodynamics of information. Quantum information processing: essential quantum mechanics of states, measurements and Bell's theorem, operations, and their representations as matrices; quantum Shannon theory (von Neumann entropy); quantum entanglement. Quantum cryptography. Various quantum algorithms and computational complexity. Building blocks: qubits and qubit operations, quantum machines. Decoherence, quantum error correction, and fault tolerance. Physical realization and quantum devices: double quantum dot charge qubit, Rabi oscillations of an

excitonic qubit, Quantum dot spin-qubits, Photonic quantum computing, Superconducting qubits. Prerequisite: Familiarity with electronic and photonic devices, information theory, theoretical computer science, or quantum mechanics will be beneficial. Credit Hours: 3

ECE542 - Photonics and Devices Ray optics, wave optics, beam optics, polarization of light, Fourier optics, fiber optics, electro-optics, nonlinear optical media, acousto-optics, and photonic switching. Students who have completed ECE 441 cannot receive credit for this course. Prerequisite: ECE 375 (or equivalent) with a grade of C or better or consent of instructor. Project-based fee: $50 to help defray the cost of equipment and consumables. Credit Hours: 3

ECE543 - Advanced Analog Integrated Circuit Design Analysis and design of CMOS analog integrated circuits. Circuit noise analysis. Low-voltage high-performance operational amplifiers. Voltage and current reference circuits. Integrated analog filter circuits. Micropower circuits. Prerequisite: ECE 446 or ECE 546 with a minimum grade of C or consent of instructor. Restricted to enrollment in ECE program. Project-based fee: $35 to help defray cost of software licenses and equipment. Credit Hours: 3

ECE543A - Bioelectronics and Biosensors (Same as BME 528) The sources of electrical signals in biological systems. Methods and types of sensors for sensing bioelectrical signals, including amperometric, potentiometric, piezo-electric, impedance, and FET based biosensors. Interface between biosensors and electronics for sensor signal condition and data acquisition. Precision electronics for biosensor signal acquisition, including potentiostat, current, charge, capacitance and impedance sensing circuit, lock-in amplifier. Prerequisite: ECE 345 or equivalent with a grade of C or better. Students who have completed ECE 442 or BME 418 will not receive credit for this course. Credit Hours: 3. Credit Hours: 3

ECE544 - Optical Imaging and Photonics (Same as BME 544) Geometrical optics, including refraction and reflection; Physical optics, including interference, diffraction, and polarization; Optical aberrations, including causes and effects; Fourier optics, with applications to imaging; Light sources, including LEDs and lasers; Photodetectors, including photodiodes and image sensors; Lens systems; Microscopes. Students who are taking or have taken ECE 448 or BME 448 are ineligible to enroll. Prerequisites: ECE 355, MATH 251, and PHYS 205B, or equivalent, with a grade of C or better, or consent of instructor. Lab fee: $125 to help defray the cost of equipment, supplies, and software packages. Credit Hours: 3. Credit Hours: 3

ECE544A - Computer Vision This course covers fundamental and advanced topics in computer vision. Computer vision applications, image formation, image processing and filtering, deep learning, computer recognition and matching, 3D computer vision, motion and video. Students who have taken ECE 444 or BME 444 will not receive credit for this course. Prerequisite: ECE 355 with a minimum grade of C- or consent of instructor. Restricted to enrollment in ECE program. Credit Hours: 3. Credit Hours: 3

ECE545 - Advanced Semiconductor Devices Technology drivers: Moore, More-Moore, and More-than-Moore trends. Case Study: Integrated health monitoring systems, 3-D SoCs. Review of Solid-State Theory: electronic, magnetic, optical and thermal properties of semiconductors. Energy Related Devices: solid-state lighting, solar cells, thermoelectric devices, piezoelectric devices, energy storages and supercapacitors. Optoelectronic and Photonic Devices: Imagers, LEDs, OLEDs, Lasers, LCDs, thin-film transistors (TFTs). Sensors and Detectors. Microwave and Terahertz Devices. Prerequisite: ECE 447 or ECE 423 or ECE 446 or PHYS 425 or PHYS 430 or instructor consent. Credit Hours: 3

ECE545A - VLSI Design for Manufacturability and Process Control VLSI manufacturing: oxidation, photolithography, etching, doping; process integration and monitoring; Yield modeling. Design for manufacturability (DFM): Sources and impact of variability; Lithography aware design; Stress and related variations in FinFETs and beyond; Design solutions for analog systems, parametric fluctuations in digital systems, interconnects, compensation and limiting the degrees of freedom; Criticality-aware DFM. Process control: patterns, multivariate and supervisory control; Statistical experimental design; Process modeling and equipment diagnosis. Prerequisite: familiarity with physics of semiconductor devices (e.g., ECE 447 or ECE 423 or PHYS 425 with a grade of C or better, or instructor consent). Credit Hours: 3

ECE546 - Analog Circuit Design Analysis and design of electronic circuits, both discrete and integrated. Computer-aided circuit design and analysis. Design of amplifier and filter circuits. Circuit stability analysis and frequency compensation techniques. Restricted to enrollment in ECE program. Students who have

taken ECE 446 are ineligible to enroll. Project-based fee: $10 to help defray cost of equipment. Credit Hours: 3

ECE547 - Semiconductor Devices Semiconductor industry and Moore's law. Review of quantum mechanics of atoms. From atoms to crystals: energy bands, effective mass and density-of-states. Semiconductor statistics. Carrier transport phenomena. PN junctions. Schottky junctions. Bipolar junction transistors (BJTs). MOSFETs: capacitance-voltage and current-voltage characteristics, threshold voltage, scaling and short-channel effects, SPICE models. CMOS process integration. Basic optoelectronic devices: LEDs and solar cells. Lecture and laboratory. Students who have taken ECE 447 are ineligible to enroll. Prerequisite: ECE 345 or equivalent. Project-based fee: $25 to help defray cost of software licenses. Credit Hours: 3

ECE548 - Quantum Phenomena and Devices Introduction: Classical Phenomena and Devices. Why Quantum Devices? Current Picture: Academia and Industry. Essential Statistical Mechanics. Essential Quantum Mechanics. Quantum Theory of Electrons: Quantization, Tunneling, Quantum Interference, Quantum Hall Effect, Scattering and Broadening, Dephasing and Shot Noise. Coulomb Blockade. Quantum Optics. Collective Phenomena and Spin. Relativistic Quantum Phenomena. Quantum Phase Transition. Quantum Computation. Prerequisite: ECE 447 or ECE 423 or ECE 446 or PHYS 425 or PHYS 430 with C or better or instructor consent. Credit Hours: 3

ECE549 - Fiber Optic Communications Fundamentals of step index and graded index fiber waveguides using geometrical optics and Maxwell's equations. Other topics include design criteria, practical coupling techniques, discussion of optical sources and detectors used in light-wave communications, system examples, characterization and measurement techniques. Prerequisite: ECE 447 or ECE 448 or consent of instructor. Restricted to enrollment in ECE program. Credit Hours: 3

ECE550 - Nanoscale VLSI Devices Review of fundamental principles of semiconductor devices. NanoTransistor: Charge-based devices-MOSFETs, non-ideal, atomistic, and quantum effects in nanoscale MOSFETs, charge-coupled devices. Advanced MOSFETs: FinFETs, SOI, SiGe and III-Vs, carbon nanotubes, graphene and 2-D semiconductors, nanowires. High electron mobility transistors (HEMTs), HBTs, and power MOSFETs. Compact and SPICE models for MOS devices. VLSI interconnects, parasitic elements, 3-D integration and reliability issues. Non-charge based devices-tunnel FETs, spin-based devices. NanoMemory: EEPROM and Flash, phase change memory, memristors, magnetic and ferroelectric, spin-torque devices, DRAM and ZRAM cells. TCAD simulation of semiconductor devices. Prerequisite: ECE 447 or ECE 423 or ECE 446 or PHYS 425 or PHYS 430 with a C or better or instructor consent. Project-based fee: $25 to help defray cost of software licenses. Credit Hours: 3

ECE551 - Probability and Stochastic Processes for Engineers Axioms of probability, random variables and vectors, joint distributions, correlation, conditional statistics, sequences of random variables, stochastic convergence, central limit theorem, stochastic processes, stationarity, ergodicity, spectral analysis, and Markov processes. Restricted to graduate student status. Students who have taken BME 351 or ECE 351 cannot receive credit for this course. Restricted to enrollment in ECBE. Project-based fee: $20 to help defray cost of software licenses. Credit Hours: 3

ECE552 - Signal Detection and Estimation Estimation theory: parameter estimation, minimum variance unbiased estimators, sufficient statistics, Cramer-Rao lower bound, best linear unbiased estimators, maximum likelihood estimators, least squares, Bayesian estimation, maximum a posteriori estimators, minimum mean square error estimators, linear minimum mean square error estimators, Wiener filtering. Detection theory: hypothesis testing, likelihood ratios, Neyman-Pearson detection, Bayesian hypothesis testing, matched filtering, multiple hypothesis testing, sequential detection, composite hypothesis testing, uniformly most powerful tests, generalized likelihood-ratio tests. Prerequisite: ECE 551 or consent of instructor. Restricted to enrollment in ECE program. Credit Hours: 3

ECE553 - Computer Network System Architecture Principles of Computer Networks. Protocols and system level implementations. Socket programming, router and switching fabric architecture, security and packet classification techniques, multimedia networking and QoS. Restricted to enrollment in ECE program. Students who have taken ECE 422 are ineligible to enroll. Project-based fee: $10 to help defray cost of equipment. Credit Hours: 3

ECE554 - Broadband Wireless Communications and Sensing Statistical channel models for broadband communications and sensing: Doppler, delay, angular, and spatial domain characterizations, radiative near-field and far-field propagation characteristics, spatial non-stationary propagation, spatial wide-band fading, target response matrices, radar cross-sections, radar equation, and clutter models. Broadband channel estimation, localization, and radar sensing techniques, hybrid beamforming/ combining, waveform designs, and resource optimization. Antenna array techniques for communications and sensing: massive multiple-input multiple-output (MIMO), extremely large aperture arrays (ELAAs), holographic surfaces, and reconfigurable intelligent surfaces (RISs). Sub-6 GHz, mid-range, millimeter-wave, and sub-terahertz frequency spectrum usage for communications and sensing. Broadband modulation and orthogonal/non-orthogonal multiple access techniques. Prerequisites: ECE 315 and ECE 355 or consent of instructor. Restricted to EE or CEGR majors or consent of instructor. Credit Hours: 3

ECE555 - Introduction to Information Theory and Channel Coding Entropy and Mutual Information. Channel Capacity. Gaussian Channel. Linear Block Codes. Convolutional Codes. Advance Channel Coding Techniques. Students who have taken ECE 476 are ineligible to enroll. Restricted to enrollment in ECE program. Credit Hours: 3

ECE556 - Digital Communications Digital communication signals and systems characterization. Deterministic receiver design. Probabilistic receiver design. Error control coding. Communication over band limited channels. Prerequisite: ECE 551 or consent of the instructor. Restricted to enrollment in ECE program. Credit Hours: 3

ECE557 - Computational Electronics Elements of computational science/engineering. High-performance clusters and software tools for HPCs. Essential numerical methods. Review of solid-state theory. Fundamental physics of charge transport in semiconductor VLSI devices. Numerical solution of Poisson's and carrier continuity equations in semiconductor devices. Boltzmann transport equation and Monte Carlo solutions. Electronic bandstructure calculations using the tight-banding formalism. Introduction to NEGF formalism. Commercial and non-commercial semiconductor device modeling tools. Prerequisite: Familiarity with physics of semiconductor devices (e.g., ECE 447 or ECE 423 or PHYS 425 with a grade of C or better, or instructor consent). Project-based fee: $25 to help defray cost of software licenses. Credit Hours: 3

ECE558 - Digital Image Processing I (Same as BME 558) Scope and applications of digital image processing, digital image fundamentals, intensity transformations and spatial filtering, filtering in the frequency domain, image segmentation, basics of color image processing. Students who have completed ECE 458 or BME 558 will not receive credit for this course. Prerequisite: ECE 355 with a minimum grade of C- or consent of instructor. Project-based fee: $30 to help defray cost of equipment. Credit Hours: 3. Credit Hours: 3

ECE558A - Magnetic Resonance Imaging This course provides a comprehensive overview of Magnetic Resonance Imaging (MRI), covering fundamental principles, technology, and clinical applications. Students will explore MRI physics, pulse sequences, hardware components, safety protocols, and imaging techniques. The graduate-level course includes a final project. The graduate-level course includes a final project. Students who have completed ECE 458A, BME 458A, or BME 558A will not receive credit for this course. Prerequisite: ECE 355 with a grade of C or better. Credit Hours: 3

ECE559 - Reinforcement Learning A graduate level course on the theory and practice of Reinforcement Learning. The course covers topics such as finite and infinite horizon Markov decision processes, multi-armed bandit problem, dynamic programming, approximate dynamic programming, value and policy iteration, Q-learning, Monte Carlo methods, and stochastic approximation. Prior knowledge of machine learning and optimal control is helpful but not required. Credit Hours: 3

ECE559A - Biomedical Microelectromechanical Systems The course is designed to introduce students with fundamentals of MEMS and its applications. The emphasis will be on physical principle in sensors and corresponding fabrication techniques, with supplemental discussion of the state-of-art applications in industry and research. Students will learn to analyze and design systems by solving regular homework problems and active participation during lectures and in-class examples. Topics: Introduction of MEMS (Chapter 1), fundamentals of microfabrication and nanofabrication, fundamentals of physics in sensors, a case study of electrostatic sensing, microfluidics and biomedical applications, projects. Prerequisites: MATH 251, PHYS 205A, PHYS 205B each with a grade of C or better, or consent

of instructor. Students who have completed BME 419 or ECE 459 will not receive credit for this course. Project-based fee: $50 to help defray cost of equipment and commodities. Credit Hours: 3

ECE560 - VLSI Material and Device Characterization Introduction to semiconductors. Materials for modern VLSI: crystals, tubular and monolayer materials, organic materials, heterostructures, wafers and notations. VLSI unit processes, contacts and interconnects, integration and packaging. Spontaneous formation and ordering of nanostructures. VLSI device characterization: wafer mapping, line width and contact resistance, measurement of MOS parameters, defect characterization using DLTS, carrier mobility and lifetime measurements. Optical characterization, electron beam microscopy, particle and X-ray techniques. Reliability and lifetime measurements: failure statistics and modes, hot carriers, NBTI, oxide integrity, electromigration and electrostatic discharge. Power dissipation and cooling. Prerequisite: Familiarity with physics of semiconductor devices (e.g., ECE 447 or ECE 423 or PHYS 425 with a grade of C or better, or instructor consent). Credit Hours: 3

ECE561 - Mechatronics and Embedded Control Components of mechatronics systems, mathematical modeling, system identification, numerical tools for design and analysis, single-loop controller design, embedded systems, data acquisition and signal conditioning, sensors, actuators, networked control. This course includes lab session. Students who have taken ECE 456 are ineligible to enroll. Lab fee: $35 to help defray the cost of software licenses. Credit Hours: 3

ECE562 - Microwave Engineering I Electromagnetic theory, analysis, design, fabrication, measurement and CAD applied to passive networks at microwave frequencies. Topics include: Transmission lines, Waveguides, Impedance matching, Tuning, Resonators, Scattering parameters, the Smith Chart. Lecture and Laboratory. Students who have taken ECE 479 are ineligible to enroll. Prerequisite: ECE 375 or equivalent. Restricted to enrollment in ECE program. Project-based fee: $100 to help defray cost of software licenses. Credit Hours: 3

ECE563 - Advanced Image Sensors Pixel- and system-level design of charge coupled device (CCD) and complementary metal-oxide-semiconductor (CMOS) image sensors; Image processing pipelines for CCD and/or CMOS image sensors; Sources of nonlinearity and non-uniformity in image sensors, including photodiodes and amplifiers; Sources of noise in image sensors, including photon shot noise, dark shot noise, reset (kTC) noise, flicker (1/f) noise, and quantization noise; Materials used in image sensors, including silicon and indium gallium arsenide; Sources of resolution loss in image sensors, including crosstalk; Methods for evaluating image sensors; Technologies and techniques for moving beyond intensity-based imaging, including spectral imaging, polarization imaging, volumetric imaging, temporal imaging, and/or light-field imaging. Prerequisite: BME 453 or ECE 453 with a grade of C or better, or consent of instructor. Credit Hours: 3

ECE564 - Optimal Control Optimization techniques for linear and nonlinear systems. Variational calculus. Dynamic programming. Pontryagin's maximum principle. Hamilton-Jacobi theory. Linear regulator. Bang Bang control, minimum time control, singular control. Discrete variational calculus. Combined estimation and control. Computational methods in optimal control. Prerequisite: ECE 456 or consent of instructor. Restricted to enrollment in ECE program. Credit Hours: 3

ECE565 - Nonlinear Control Systems Analysis and design of nonlinear dynamical systems. Topics include: nonlinear differential equations, stability, Lyapunov stability analysis, stability of perturbed systems, linearization, and central manifold theorem. Stabilization, feedback linearization, and controller design methods such as backstepping and sliding mode control. Credit Hours: 3

ECE566 - Linear Systems Theory Introduction to the structure and analysis of linear dynamical systems in time domain. Linear algebra review, solutions of linear differential equations, state-space representations, state transition matrix, and time varying systems. Introduction to fundamental mathematics of linear spaces and linear operator theory. Structural properties of linear systems such as controllability, observability, and stability. Design and synthesis of controllers and state observers for linear systems. Linear quadratic regulatory theory and Kalman filter. Credit Hours: 3

ECE567 - Modern Biomedical Imaging (Same as BME 567) Diagnostic x-ray imaging. Tomographic imaging. Ultrasound imaging. Magnetic resonance imaging (MRI). Optical imaging. Signal and noise characteristics. Image quality evaluation. Three-dimensional image reconstruction algorithms. Students who have taken ECE 467 or BME 467 cannot receive credit for this course. Prerequisite: MATH 305 and ECE 355 with a grade of C- or better, or consent of instructor. Restricted to enrollment in ECE program.

Project-based fee: $30 to help defray cost of software licenses and equipment. Credit Hours: 3. Credit Hours: 3

ECE568 - Introduction to Machine Learning for Engineering Applications Basic machine learning concepts: Model selection, feature scaling, bias-variance trade-off, regularization, Performance metrics and validation techniques, Probability and statistics review. Supervised learning: Linear/non-linear regression and logistic regression, Generalized linear models, Generative learning models, Bayes decision theory, Naive Bayes classifier, Nearest neighbor classifiers, Hidden-Markov models, Support vector machines, Kernel methods, Bagging, Boosting. Unsupervised Learning: Clustering: K-means, Expectation-maximization, Anomaly detection, Dimensionality Reduction: Principal components analysis, transform techniques. Basics of reinforcement learning and deep learning. Restricted to 4th Year or graduate standing. Students who have taken ECE 469 cannot receive credit for this course. They are similar. Credit Hours: 3

ECE568A - Digital Signal Processing This course introduces graduate students to the field of digital signal processing, which is an area of science and engineering that has developed rapidly. The course topics include discrete-time signals and systems analysis, z-transform, discrete Fourier transform, fast Fourier transform algorithms, digital filter design, and other related topics. Students who have completed ECE 468A will not receive credit for this course. Prerequisite: ECE 355 with a grade of C or better, or consent of instructor. Project-based fee: $20 to help defray cost of equipment. Credit Hours: 3

ECE569 - Biomedical Instrumentation (Same as BME 538) Basic concept of Medical instrumentation, basic sensors and principles, amplifiers, biopotential electrodes, blood pressure and sound, measurement of respiratory system, chemical biosensors, Cellular measurements, Nervous system measurements, magnetic resonance imaging. Prerequisites: PHSL 410A or CHEM 444 or consent of instructor. Restricted to enrollment in ECE program. Lab fee: $45 to help defray cost of software licenses and equipment. Credit Hours: 3

ECE570 - Principles of Communication Systems This course covers principles of communication systems. Topics include representation of signals and systems, amplitude modulation, angle modulation, probability theory and random processes for communication system designs, transition from analog to digital and pulse code/delta modulation, baseband digital transmission, digital band-pass transmission techniques, introduction to information theory and coding, wireless channel modeling, cellular systems and performance analysis. Lectures and laboratory projects. Prerequisites: ECE 315 and ECE 355 or consent of instructor. Students having passed ECE 478 are not eligible to enroll. Credit Hours: 3

ECE570A - Wireless Communication Systems This course covers fundamentals of wireless communication systems. Topics include wireless system architectures, channel modeling, introduction to cellular systems, digital modulation and multiple-access techniques, introduction to multiantenna techniques, performance analysis, wireless physical layer security, future trends in wireless communications. Prerequisites: ECE 315 and ECE 355 with a grade of C or better or consent of instructor. Students who have completed ECE 471 will not receive credit for this course. Project-based fee: $20 to help defray cost of software and equipment. Credit Hours: 3

ECE571 - Advanced Wireless Communication This course covers advanced topics in wireless communications. Topics include wireless system architectures, wireless channel modeling, cellular systems and co-channel interference, advanced digital modulation and multiple-access techniques, massive MIMO, mm-wave communications, performance analysis, radio resource allocation and optimization, wireless physical layer security, enabling technologies for 5G. Restricted to enrollment in ECE program or consent of instructor. Project-based fee: $20 to help defray cost of software licenses. Credit Hours: 3

ECE572 - Neural Networks (Same as BME 572) Anatomy and physiology of the cerebral cortex, Feed-forward Networks, Linear Associator, Multilayer Perceptrons, Feedback Networks, Hopfield Networks, ART. Applications to pattern recognition, robotics, image processing, and speech processing. Optical and electronic implementations. Students who have taken BME 470 or ECE 470 cannot receive credit for this course. Prerequisite: MATH 305 with a C or better or consent of instructor. Credit Hours: 3

ECE573 - Field and Waves II Time-harmonic electromagnetic fields in dielectric and lossy media, transmission lines, antennas and resonators. Techniques include duality, image theory, reciprocity and

integral equations. Boundary value problems solved for several frequently encountered symmetries. Prerequisite: ECE 477. Restricted to enrollment in ECE program. Credit Hours: 3

ECE574 - Nonlinear Optics Coupled-mode-analysis applied to nonlinear wave interactions, harmonic generation, parametric amplification, backward wave amplifiers, backward oscillation in laser systems, phase conjugation and multiple-wave mixing systems, Pockel and Kerr effects, and electro-optical modulations in optical communication systems. Prerequisite: ECE 375 or consent of instructor. Restricted to enrollment in ECE program. Credit Hours: 3

ECE575 - Antennas I Analysis, design, fabrication, measurement and CAD applied to basic antenna types. Fundamental parameters. Friis transmission equation. Impedance and pattern measurements. Resonant microstrip and wire antennas. Arrays and line sources. Lecture and laboratory. Students who have taken ECE 472 are ineligible to enroll. Prerequisite: ECE 375 or equivalent. Restricted to enrollment in ECE program. Project-based fee: $120 to help defray cost of software licenses. Credit Hours: 3

ECE575A - Cyber Security for Digital Health This course introduces students to cyber security for digital health applications. Introduction to cyber security and cyber-attack surface, cyber security for electronic health records, cyber security for medical information, security and identity based on characteristics of face recognition and fingerprint recognition, cyber security for networked medical devices and healthcare facilities, cyber security for wearable or implantable devices. Students who have competed ECE 475 will not receive credit for this course. Prerequisite: MATH 251 with a minimum grade of C- or consent of instructor. Credit Hours: 3. Credit Hours: 3

ECE576 - Numerical Electromagnetics Numerical solution of electromagnetic problems by methods that include finite element, integral equation, moment, spectral domain and finite difference. Examination of electromagnetic problems and their solutions in current literature. Prerequisite: ECE 573. Restricted to enrollment in ECE program. Credit Hours: 3

ECE577 - Antennas II Analysis, design and CAD of antennas. Numerical methods. Broadband, traveling-wave, frequency independent, electrically-small, aperture and microstrip antenna types. Prerequisite: ECE 472. Restricted to enrollment in ECE program. Credit Hours: 3

ECE578 - Digital Image Processing II Full-color image processing, image noise and degradation models, image restoration, inverse filtering, Wiener filtering, geometric transformations, image compression models, error-free compression, lossy compression, compression standards, dilation and erosion, opening and closing operations, morphological filtering, boundary descriptors, regional descriptors, principal components, vision-based pattern recognition. Prerequisite: ECE 558. Restricted to enrollment in ECE program. Credit Hours: 3

ECE579 - Microwave Engineering II Analysis and design of passive and active devices at microwave frequencies. Topics include: power dividers, couplers, filters, ferrite devices, noise, noise effects in detectors, mixers, modulators, amplifier and oscillator design, and an introduction to microwave systems. Prerequisite: ECE 479. Restricted to enrollment in ECE program. Credit Hours: 3

ECE579A - Terahertz Devices and Applications THz band. Interaction of THz with matter, THz system components. Generation and detection of THz signals: photoconductive antenna, optical rectification, electro-optical sampling, quasi-phase-matching crystals, photo-mixers. Terahertz quantum cascade lasers: intersubband transitions, quantum dots photodetector, thermal detectors, device design and modeling. THz in 2D materials: Graphene and TMDs. Terahertz optics: metamaterials, photonic crystals, plasmonics. THz imaging: tomography, medical diagnostics. Spectroscopy: atoms, molecules, nanostructures. Nondestructive evaluation and security checks. THz wireless systems and THz in space. Prerequisite: familiarity with physics of semiconductor devices (e.g., ECE 447 or ECE 423 or PHYS 425 with a grade of C or better, or instructor consent). Credit Hours: 3

ECE580 - Seminar Study and formal presentation by students of selected research in electrical and computer engineering. Restricted to students in the graduate program in Electrical and Computer Engineering. Special approval needed from the instructor. Credit Hours: 1

ECE581 - Wind and Solar Energy Power Systems The course introduces students to wind and solar energy power systems. Planning of wind generation; and operation of wind generators, mechanical and electrical design, power conditioning, control and protection. Planning, operation and design of electric

solar plants; power conditioning, control and protection. Students who have taken ECE 481 are ineligible to enroll. Credit Hours: 3

ECE582 - Power Electronics This course offers a comprehensive overview of power electronics devices and circuits, covering both foundational and advanced concepts. The primary objective is to equip students with design methodologies and analytical tools crucial for the efficient conditioning and management of electrical power. Topics include semiconductor power materials and devices, power converters, converter dynamics and control, switched mode power supply, and the use of machine learning for design optimization. Real-world applications in clean energy, electrification, electric vehicles, computing, display, and solid-state lighting will be covered. Fabrication and packaging of power electronics modules will also be discussed. Students will also engage in hands-on design projects using industry-standard TCAD software. Students who have received credit for ECE 482 will not receive credit for this course. Prerequisite: ECE 345 with a grade of C or better, or instructor consent. Project/design fee: $65 to help defray cost of software licenses. Credit Hours: 3

ECE583 - Electric Drive Systems Course content is roughly 1/3 power electronics, 1/3 applied control and 1/3 electric machinery and focuses on analysis, simulation, and control design of electric drive based speed, torque, and position control systems. Advanced topics depending on the semester are taught. Students who have taken ECE 483 are ineligible to enroll. Project-based fee: $65 to help defray cost of software licenses and equipment. Credit Hours: 3

ECE584 - Electric and Hybrid Vehicles This course provides a comprehensive overview of modern all electric vehicles. It also touches on hybrid and plug-in hybrid vehicles. Topics include design analysis of vehicle components, trends in state-of-the-art power electronics materials, devices, and converters, battery and energy storage technologies, and the interaction of vehicles with the power grid. Key technical aspects with appropriate level of mathematical formulations and engineering design guidelines will be discussed. Essential features of autonomous driving system architecture and the associated hardware and software requirements will also be covered. Using industry-standard TCAD design software, students will work on a comprehensive design project or research paper on a topic of interest such as: i) emerging electric motors, ii) high-performance lithium ion batteries, iii) high-breakdown voltage power electronic converters. Students who have completed ECE 484 will not receive credit for this course. Prerequisite: Familiarity with electronic devices and circuits and electric motors or instructor consent. Project/design fee: $65 to help defray cost of software licenses. Credit Hours: 3

ECE585 - Power Systems Stability and Control Fundamentals of power system stability, synchronous machine modeling and simulation, transient and small signal stability, control and protection, power system stabilizers, voltage stability, voltage collapse, concepts and devices of flexible ac transmission, mid-term and long-term stability. Credit Hours: 3

ECE586 - Computational Methods in Power Systems The course covers advanced methods for the computation and analysis of power systems. Topics: circuit graph theory and network matrices, computation of electromagnetic transients, computation of power flows and faults, computation of system stability, stochastic methods in power systems, load forecasting, state estimation, unit dispatch. The course uses power system software. Lecture. Restricted to enrollment in the ECE program. Credit Hours: 3

ECE586A - Clean Electric Energy History and future of energy resources and their use as a component of electrical systems. Fossil fuels and renewable energy sources. Environmental and economical impacts of various energy sources. Electric energy generating plants and distributed generation. Design of hybrid renewable energy systems. Students who have completed ECE 486 will not receive credit for this course. Prerequisite: ECE 385 with a grade of C or better, or consent of instructor. Credit Hours: 3. Credit Hours: 3

ECE587 - Modern Power Systems Operation This course provides students with a comprehensive picture of the techniques used in modern power systems operation. The course introduces central "terminal" characteristics for thermal and hydroelectric power generation systems, along with new optimization techniques for tackling "real-world" power systems operating problems. The topics include: analysis of different bidding strategies in competitive electricity markets, prediction of load and price, analysis of power systems security, different methods of optimal power flow, analysis of power systems

uncertainty and reliability, economic dispatch, and unit commitment analysis. Project-based fee: $65 to help defray cost of software licenses and equipment. Credit Hours: 3

ECE587A - Power Systems Analysis Modeling and analysis of electric power systems. Topics covered: AC power, generators, power transformers, transmission line parameters and steady state operation, computation of power flows. The course uses power system analysis software. Students who have completed ECE 487 will not receive credit for this course. Prerequisite: ECE 385 with a grade of C or better, or consent of instructor. Credit Hours: 3. Credit Hours: 3

ECE588 - Power System Engineering The course covers topics involving the design and operation of a power system. Topics: symmetrical and unsymmetrical power system faults, power system protection design, transient stability of power generators, power system economic operation, power system control, transient operation of transmission lines. The course uses power system software. Lecture. Students who have taken ECE 488 are ineligible to enroll. Credit Hours: 3

ECE588A - Introduction to Cyber-Physical Power Systems This course introduces the interdisciplinary field of cyber-physical power systems (CPPS), focusing on the integration of electrical power networks with modern sensing, communication, computing, and control technologies. Students will learn how the cyber layer interacts with the physical grid to enable intelligent, secure, and resilient operation. Core topics include system architectures, IoT-enabled monitoring, cyber-physical interdependency modeling, vulnerability and risk assessment, and AI-driven situational awareness. The course features hands-on projects using simulation tools such as OpenDSS, MATLAB/Python, and NS-3, along with exposure to real-time testbed environments such as OPAL-RT. Students who have completed ECE 488A will not receive credit for this course. Prerequisite: ECE 235; concurrent enrollment allowed in ECE 385. Credit Hours: 3

ECE589 - Electric Power Distribution Design of primary and secondary distribution networks. Load characteristics. Voltage regulation. Metering techniques and systems. Protection of distribution systems. Special topics related to power distribution. Students who have taken ECE 489 are ineligible to enroll. Prerequisite: ECE 235. Credit Hours: 3

ECE592 - Special Investigations in Electrical Engineering Individual advanced projects and problems selected by student or instructor. Restricted to graduate standing. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593A - Advanced Topics in Electrical Engineering-Antennas and Propagation Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593B - Advanced Topics in Electrical Engineering-ASIC Design Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593C - Advanced Topics in Electrical Engineering-Communications Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593D - Advanced Topics in Electrical Engineering-Computer Architecture Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593E - Advanced Topics in Electrical Engineering-Control Systems Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593F - Advanced Topics in Electrical Engineering-Design Automation Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593G - Advanced Topics in Electrical Engineering-Digital Design Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593H - Advanced Topics in Electrical Engineering-Digital Testing and Verification Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593I - Advanced Topics in Electrical Engineering-Electromagnetic Fields and Waves Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593J - Advanced Topics in Electrical Engineering-Embedded Systems Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593K - Advanced Topics in Electrical Engineering-Medical Imaging Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593L - Advanced Topics in Electrical Engineering-Mixed-Signal Testing and Design Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593M - Advanced Topics in Electrical Engineering-Nanotechnology Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593N - Advanced Topics in Electrical Engineering-Network Systems Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593O - Advanced Topics in Electrical Engineering-Photonics Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593P - Advanced Topics in Electrical Engineering-Physical Design Automation Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593Q - Advanced Topics in Electrical Engineering-Power Electronic Converters and Drive Systems Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593R - Advanced Topics in Electrical Engineering-Power Quality Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is

designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593S - Advanced Topics in Electrical Engineering-Power System Control and Protection Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593T - Advanced Topics in Electrical Engineering-Renewable Energy Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593U - Advanced Topics in Electrical Engineering-RF and Microwave Systems Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593V - Advanced Topics in Electrical Engineering-Signal Processing Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593W - Advanced Topics in Electrical Engineering-Software Engineering Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE593X - Advanced Topics in Electrical Engineering-Wireless Systems Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor. Credit Hours: 1-3

ECE595 - Communication Skills for Engineering Graduate Students This course prepares graduate engineering students to communicate technical information to various audiences and for various purposes. Principles and strategies are applied to theses, dissertations, scholarly presentations, and other engineering documents such as lab reports, user manuals, business correspondences, job application materials, and engineering ethics. Research tools and software programs prepare students to deliver oral presentations on current engineering topics. Restricted to graduate standing. Does not count toward the hours required for graduation in the ECE program. Restricted to enrollment in ECE program. Credit Hours: 3

ECE596 - Principles of Biomedical Engineering (Same as BME 596) Principles of biomechanics, biomaterials, electrophysiology, modeling, instrumentation, biosignal processing, medical imaging, and biomedical optics. Professional moral and ethical issues in biomedical research and development. Students who have taken ECE 460 are ineligible to enroll. Prerequisite: MATH 250 with a grade of C or better or consent of instructor. Credit Hours: 3

ECE599 - Thesis Credit Hours: 1-6

ECE600 - Doctoral Dissertation Dissertation research. Hours and credit to be arranged by director of graduate studies. Graded S/U only. Restricted to Admission to PhD program in Electrical and Computer Engineering. Credit Hours: 1-16

ECE601 - Continuing Enrollment For those graduate students who have not finished their degree programs and who are in the process of working on their dissertation, thesis, or research paper. The student must have completed a minimum of 24 hours of dissertation research, or the minimum thesis, or research hours before being eligible to register for this course. Concurrent enrollment in any other course is not permitted. Graded S/U or DEF only. Credit Hours: 1

Cybersecurity and Cyber Systems Faculty

Computer Science Faculty

Ahmed, Khaled, Associate Professor, Computer Science, Ph.D., Tokyo Institute of Technology, 2004; 2019. Deep learning, big data, computer vision, parallel and distributed computing.

Bhattacharya, Ansuman, Assistant Professor, Radio Physics and Electronics, Ph.D., University of Calcutta, 2016; 2024. Broad areas of Networks and Network Security, especially, Next Generation Networks, Internet-of-Things, Cognitive Radio Networks, Software Defined Networks, Green Communication and Wireless Network Security.

Chen, Zhong, Assistant Professor, Mathematics and Computer Science, Ph.D., Wuhan University of Technology, 2015; 2023. Development, analysis, implementation, and experimental evaluation of big streaming data mining algorithms, deep learning techniques, and applications in healthcare and medical physics.

Gupta, Bidyut, Professor, Computer Science, Ph.D., University of Calcutta, 1986; 1988. Fault-tolerant computing, routing algorithms in computer networks, architecture design of P2P networks, P4P networks, Fog P2P networks.

Hexmoor, Henry, Professor, Computer Science, Ph.D., University of Buffalo, 1996; 2006. Artificial intelligence, Multi-agent systems, cognitive science, knowledge representation and reasoning, cybersecurity, blockchain.

Hossain, Md Belayat, Assistant Professor, Electronic & Computer Science, Ph.D., University of Hyogo, 2018; 2024. Machine Learning, Artificial Intelligence, Generative AI, Computer Vision, Medical Image Processing, and Healthcare Analytics.

Huang, Chun-Hsi, Professor and Director School of Computing, Computer Science, Ph.D., State University of New York at Buffalo, 2001; 2019. Extreme-scale computing and data analytics, computational biology, security and applied algorithmics.

Huang, Xiaolan, Assistant Professor, Computer Science, Ph.D., Southern Illinois University, 2017; 2019. Bioinformatics, big data analytics, machine learning, high performance computing.

Imteaj, Ahmed, Assistant Professor, Computer Science, Ph.D., Florida International University, 2022; 2022. Machine learning and optimization algorithms, distributed algorithms, federated learning, Internet-of-Things, blockchain and cybersecurity.

Jiang, Xiaopeng, Assistant Professor, Computer Science, Ph.D., New Jersey Institute of Technology, 2024; 2024. Machine Learning, Mobile Computing, Artificial Intelligence, Internect of Things.

Liu, Xiaoqing, Professor and Dean College of Engineering, Computing, Technology, and Mathematics, Computer Science, Ph.D., Texas A&M University, 1995; 2020. Cyber argumentation based social media and networking, data analytics based recommendation systems, service computing, cyber physical systems, software engineering, applied artificial intelligence, advanced computing and data applications.

Shahid, Abdur Rahman Bin, Assistant Professor, Computer Science, Florida International University, 2019; 2023. Cybersecurity, artificial intelligence, adversarial machine learning, cyber-physical systems, Internet of Things, Digital Twin, and blockchain.

Sinha, Koushik, Associate Professor, Computer Science, Ph.D., Jadavpur University, 2007; 2015. Mobile computing, wireless ad hoc and sensor networks, complex networks, social computing, crowdsourcing systems.

Tsatsoulis, Constantinos, Professor and Vice Chancellor for Research and Graduate School Dean, Electrical Engineering, Ph.D., Purdue University, 1987; 2022. Multiagent systems, case based reasoning, machine learning, and intelligent image analysis.

Electrical, Computer, and Biomedical Engineering Faculty

Ahmed, Shaikh S., Professor, Ph.D., Arizona, 2005; 2007. Nanotechnology, semiconductor devices and circuit design, simulation and characterization.

Anagnostopoulos, Iraklis, Associate Professor, Ph.D., National Technical University of Athens, 2014; 2015. Many-core architectures, run-time resource management, embedded systems.

Aruma Baduge, Gayan, Associate Professor, University of Alberta, 2013; 2016. Communications theory, wireless communications, massive MIMO systems, millimeter-wave communications, cooperative relay networks, wireless energy harvesting for IoTs, physical-layer security.

Asrari, Arash, Assistant Professor, Ph.D., University of Central Florida, 2015; 2017. Power systems operation and planning, power systems optimization, smart grid.

Chen, Kang, Associate Professor, Ph.D., Clemson University, 2014; 2015. Software-defined networking (SDN), network function virtualization (NFV), vehicular networks, mobile opportunistic/ad hoc networks.

Chen, Ying (Ada), Associate Professor, Ph.D., Duke, 2007; 2007. Biomedical imaging, image reconstruction, digital tomosynthesis, image quality analysis, signal and image processing, simulation and computing.

Chilman, Bae, Assistant Professor, Ph.D., Pennsylvania State University, 2009; 2019. Bioelectrical engineering, neuroscience, mechanobiology.

Chowdhury, Farhan, Associate Professor, Ph.D., University of Illinois at Urbana-Champaign, 2011; 2015. Mechanobiology, single-molecule cell mechanics, biomaterials.

Haniotakis, Themistoklis, Associate Professor, Ph.D., University of Athens, 2008; 2013. Digital VLSI design and test, RF IC design and test, low power VLSI design, and fault-tolerant systems.

Kagaris, Dimitrios, Professor, Ph.D., Dartmouth College, 1994; 1995. VLSI design automation, digital circuit testing, communications networks, biostatistics, bioinformatics.

Komaee, Arash, Associate Professor, Ph.D., University of Maryland, College Park, 2008; 2015. Control systems, microrobotics, signal processing, estimation theory.

Lu, Chao, Associate Professor, Ph.D., Purdue University, 2012; 2015. VLSI system design, device-circuit co-design, 3D IC.

Qin, Jun, Associate Professor, Ph.D., Duke University, 2008; 2012. Sensors and instrumentation, data acquisition, medical devices, therapeutic ultrasound, haptics.

Sayeh, Mohammad R., Professor, Ph.D., Oklahoma State University, 1985; 1986. Neural networks, optical computing, image processing, stochastic modeling, quantum electronics.

Tragoudas, Spyros, Professor and Director, Ph.D., University of Texas at Dallas, 1991; 1999. Design and test automation for VLSI, embedded systems, computer networks.

Wang, Haibo, Professor, Ph.D., University of Arizona, 2002; 2002. Bioelectronics, biosensors.

Weng, Ning, Professor, Ph.D., University of Massachusetts at Amherst, 2005; 2005. High performance routers, network processors, system-on-a-chip, computer architectures.

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