

COMPUTER ENGINEERING (CPR E)

Any experimental courses offered by CPR E can be found at:

registrar.iastate.edu/faculty-staff/courses/explistsings/ (<http://www.registrar.iastate.edu/faculty-staff/courses/explistsings/>)

Courses primarily for undergraduates:

CPR E 131: Introduction to Computer Security Literacy

(Cross-listed with CYBSC). (1-0) Cr. 1.

Basic concepts of practical computer and Internet security: passwords, firewalls, antivirus software, malware, social networking, surfing the Internet, phishing, and wireless networks. This class is intended for students with little or no background in information technology or security. Basic knowledge of word processing required. Offered on a satisfactory-fail basis only.

CPR E 166: Professional Programs Orientation

(Cross-listed with E E). Cr. R. F.S.

(1-0) Overview of the nature and scope of electrical engineering and computer engineering professions. Overview of portfolios. Departmental rules, advising center operations, degree requirements, program of study planning, career options, and student organizations. Offered on a satisfactory-fail basis only.

CPR E 184: Computer Engineering Learning Community

Cr. 1. F.

Prereq: Member of Cpr E Learning Community

Integration of first-year students into the Computer Engineering program. Assignments and activities involving teamwork, academic preparation, study skills, and preparation for entry into the Computer Engineering profession. Completed both individually and in learning teams under the direction of faculty and peer mentors.

CPR E 185: Introduction to Computer Engineering and Problem Solving I (2-2) Cr. 3.

Prereq: (MATH 143 or satisfactory scores on mathematics placement examinations); credit or concurrent enrollment in MATH 165

Introduction to Computer Engineering. Project based examples from computer engineering. Individual interactive skills for small and large groups. Computer-based projects. Solving engineering problems and presenting solutions through technical reports. Solution of engineering problems using a programming language. Satisfactory placement scores can be found at: <https://math.iastate.edu/academics/undergraduate/aleks/placement/>. Only one of ENGR 160, A B E 160, AER E 160, C E 160, CH E 160, CPR E 185, E E 185, I E 148, M E 160, and S E 185 may count towards graduation.

CPR E 186: Introduction to Computer Engineering and Problem Solving II (0-2) Cr. 1. S.

Prereq: CPR E 185

Project based examples from computer engineering. Group skills needed to work effectively in teams. Group problem solving. Computer based projects. Technical reports and presentations. Students will work on 2 or 3 self-directed team based projects that are representative of problems faced by computer engineers.

CPR E 230: Cyber Security Fundamentals

(Cross-listed with CYB E). (2-2) Cr. 3. F.

Prereq: COM S 227 or E E 285 or MIS 207.

Introduction to computer and network infrastructures used to support cyber security. Basic concepts of computer and network configuration used to secure environments. Computer virtualization, network routing and address translation, computer installation and configuration, network monitoring, in a virtual environment. Laboratory experiments and exercises including secure computer and network configuration and management.

CPR E 231: Cyber Security Concepts and Tools

(Cross-listed with CYB E). (2-2) Cr. 3. S.

Prereq: CPR E 230 or CYB E 230

Basic concepts of practical computer and Internet security and the tools used to protect and attack systems and networks. Computer and network security methods including: user authentication, access control, firewalls, intrusion detection, use of vulnerability assessment tools and methods, and penetration testing. Ethics and legal issues in cyber security will also be covered. Laboratory experiments and exercises including evaluating systems for vulnerabilities, understanding potential exploits of the systems, and defenses for the systems.

CPR E 232: Professional and Ethical Issues in Electrical and Computer Engineering

(Cross-listed with E E). (3-0) Cr. 3.

Prereq: COM S 227 or E E 285

Professional and ethical issues in electrical and computer engineering. Soft skills, including communication and leadership skills, and how they relate to the engineering profession. Case studies illustrating ethical decision making in an engineering context and differentiating between moral and professional ethics. Issues of diversity, equity, and inclusion in the engineering profession.

CPR E 234: Legal, Professional, and Ethical Issues in Cyber Systems

(Cross-listed with CYB E). (3-0) Cr. 3. S.

Prereq: COM S 227, or E E 285, or MIS 207

Emphasizes legal, ethical, and professional issues in cyber systems. Other topics include privacy, government regulation, and compliance as applied to professional practice. Guest lecturer from government and industry, as well as discussions including current legal and ethical issues found in the main stream.

CPR E 261: Transfer Orientation

(Cross-listed with E E). Cr. R.

Introduction to the College of Engineering and the engineering profession specifically for transfer students. Information concerning university and college policies, procedures, and resources. Offered on a satisfactory-fail basis only.

CPR E 281: Digital Logic

(3-3) Cr. 4. F.S.

Prereq: Sophomore classification

Number systems and representation. Boolean algebra and logic minimization. Combinational and sequential logic design. Arithmetic circuits and finite state machines. Use of programmable logic devices. Introduction to computer-aided schematic capture systems, simulation tools, and hardware description languages. Design of simple digital systems.

CPR E 288: Embedded Systems I: Introduction

(3-2) Cr. 4. F.S.

Prereq: CPR E 281; (COM S 207 or COM S 227 or E E 285)

Embedded C programming. Interrupt handling. Memory mapped I/O in the context of an application. Elementary embedded design flow/methodology. Timers, scheduling, resource allocation, optimization, state machine based controllers, real time constraints within the context of an application. Applications laboratory exercises with embedded devices.

CPR E 294: Program Discovery

(Cross-listed with E E). Cr. R.

Prereq: CPR E 166 or E E 166

The roles of professionals in computer and electrical engineering. Relationship of coursework to industry and academic careers. Issues relevant to today's world. Offered on a satisfactory-fail basis only.

CPR E 308: Operating Systems: Principles and Practice

(3-3) Cr. 4. F.S.

Prereq: COM S 321 or CPR E 381

Operating system concepts, processes, threads, synchronization between threads, process and thread scheduling, deadlocks, memory management, file systems, I/O systems, security, Linux-based lab experiments.

CPR E 310: Theoretical Foundations of Computer Engineering

(3-1) Cr. 3. F.S.

Prereq: COM S 228

Propositional logic and methods of proof; basic discrete structures; mathematical induction and recurrence relations; functions and relations; and counting; trees and graphs; applications in computer engineering.

CPR E 329: Software Project Management

(Cross-listed with S E). (3-0) Cr. 3.

Prereq: COM S 309

Process-based software development. Capability Maturity Model (CMM). Project planning, cost estimation, and scheduling. Project management tools. Factors influencing productivity and success. Productivity metrics. Analysis of options and risks. Version control and configuration management. Inspections and reviews. Managing the testing process. Software quality metrics. Modern software engineering techniques and practices.

CPR E 330: Integrated Electronics

(Cross-listed with E E). (3-3) Cr. 4.

Prereq: CPR E 281; E E 201; credit or concurrent enrollment in E E 230

Semiconductor technology for integrated circuits. Modeling of integrated devices including diodes, BJTs, and MOSFETs. Physical layout. Circuit simulation. Digital building blocks and digital circuit synthesis. Analysis and design of analog building blocks. Laboratory exercises and design projects with CAD tools and standard cells.

CPR E 331: Application of Cryptographic Concepts to Cyber Security

(Cross-listed with CYB E). Cr. 3. F.S.

Prereq: CPR E 231 or CYB E 231

Basic cryptographic underpinnings used in modern cyber security encryption suites. Encryption benefits to cyber security and its use in protocols. Topics include cryptographically secure hash functions and pseudorandom numbers, key distribution techniques, secure authentication including single sign on. Detection and prevention of security threats such as covert communication, malicious code, and other security threats in protocols are included. In addition to laboratory experiments and exercises, students complete a project focused on cyber security problem and solution. Only one of CPR E/CYB E 331 and CPR E 431 may count towards graduation.

CPR E 332: Cyber Defense Competition

(Cross-listed with CYBSC). (0-2) Cr. 1. Repeatable. S.

Participation in cyber defense competition driven by scenario-based network design. Includes computer system setup, risk assessment and implementation of security systems, as well as defense of computer and network systems against trained attackers. Team based. Offered on a satisfactory-fail basis only.

CPR E 339: Software Architecture and Design

(Cross-listed with S E). (3-0) Cr. 3.

Prereq: S E 319

Modeling and design of software at the architectural level. Architectural styles. Basics of model-driven architecture. Object-oriented design and analysis. Iterative development and unified process. Design patterns. Design by contract. Component based design. Product families. Measurement theory and appropriate use of metrics in design. Designing for qualities such as performance, safety, security, reliability, reusability, etc. Analysis and evaluation of software architectures. Introduction to architecture definition languages. Basics of software evolution, reengineering, and reverse engineering. Case studies. Introduction to distributed system software.

CPR E 381: Computer Organization and Assembly Level Programming

(3-2) Cr. 4. F.S.

Prereq: CPR E 288

Introduction to computer organization, evaluating performance of computer systems, instruction set design. Assembly level programming: arithmetic operations, control flow instructions, procedure calls, stack management. Processor design. Datapath and control, scalar pipelines, introduction to memory and I/O systems.

CPR E 388: Embedded Systems II: Mobile Platforms

(3-2) Cr. 4.

Prereq: CPR E 288

Contemporary programming techniques for event driven systems. Mobile platforms and operating systems. Location and motion sensors based user interfaces. Threading and scheduling. Resource management - measurement and control techniques - for memory and energy. Client-server application design. Distributed applications. Laboratory includes exercises based on a mobile platform.

CPR E 394: Program Exploration

(Cross-listed with E E). Cr. R.

Prereq: CPR E 294 or E E 294

Exploration of academic and career fields for electrical and computer engineers. Examination of professionalism in the context of engineering and technology with competencies based skills. Introduction to professional portfolio development and construction. Offered on a satisfactory-fail basis only.

CPR E 412: Formal Methods in Software Engineering

(Cross-listed with COM S, S E). (3-0) Cr. 3.

Prereq: COM S 311; STAT 305 or STAT 330 or STAT 341; for graduate credit: graduate standing or permission of instructor

A study of formal techniques for model-based specification and verification of software systems. Topics include logics, formalisms, graph theory, numerical computations, algorithms and tools for automatic analysis of systems. Graduate credit requires in-depth study of concepts.

CPR E 414: Introduction to Software Systems for Big Data Analytics

Cr. 4. F.

Prereq: COM S 363; or CPR E 315 or CPR E 308; or COM S 311 or COM S 352

Introduction to different perspectives of the "data universe" and trade-offs when choosing an appropriate perspective. Impact of the concept(s) of analytics – from raw data, through its storage/representation, to interacting and querying (linguistic/interface issues). Focused studies on 3-4 different domains, followed by generalization of the concepts/abstractions and preparing the students for the next course in this realm, targeting different domains/problems. Understanding the dependencies between problem-domain needs and the data properties, and their impact on choosing appropriate analytics tools (and how/why those tools were developed and exist in the manners that they do). In addition, the students will be exposed to (limited selection of) internals of such tools.

CPR E 416: Software Evolution and Maintenance

(Cross-listed with S E). (3-0) Cr. 3.

Prereq: COM S 309

Practical importance of software evolution and maintenance, systematic defect analysis and debugging techniques, tracing and understanding large software, impact analysis, program migration and transformation, refactoring, tools for software evolution and maintenance, experimental studies and quantitative measurements of software evolution. Written reports and oral presentation.

CPR E 418: High Speed System Engineering Measurement and Testing

(Cross-listed with E E). (3-2) Cr. 4. F.

Prereq: E E 230 and E E 311

Measurement of high speed systems and mixed signal systems. Measurement accuracy and error. Network analysis and spectrum analysis used in high speed measurement and testing. Test specification process and parametric measurement. Sampling and digital signal processing concepts. Design for testability. Testing equipment. Applications.

CPR E 419: Software Tools for Large Scale Data Analysis

(Cross-listed with S E). (3-3) Cr. 4.

Prereq: COM S 363 or COM S 352 or CPR E 308; COM S 228

Software tools for managing and manipulating large volumes of data, external memory processing, large scale parallelism, and stream processing, data interchange formats. Weekly programming labs that involve the use of a parallel computing cluster.

CPR E 421: Software Analysis and Verification for Safety and Security

(Cross-listed with S E). Cr. 3. F.S.

Prereq: (COM S 230 or CPR E 310); COM S 309

Significance of software safety and security; various facets of security in cyber-physical and computer systems; threat modeling for software safety and security; and categorization of software vulnerabilities. Software analysis and verification: mathematical foundations, data structures and algorithms, program comprehension, analysis, and verification tools; automated vs. human-on-the-loop approach to analysis and verification; and practical considerations of efficiency, accuracy, robustness, and scalability of analysis and verification. Cases studies with application and systems software; evolving landscape of software security threats and mitigation techniques. Understanding large software, implementing software analysis and verification algorithms.

CPR E 424: Introduction to High Performance Computing

(Cross-listed with COM S, MATH). (2-2) Cr. 3. F.

Prereq: (MATH 265; [MATH 207 or MATH 317]) or Permission of Instructor Unix, serial programming of scientific applications, OpenMP for shared-memory parallelization. No Unix, Fortran or C experience required.**CPR E 425: High Performance Computing for Scientific and Engineering Applications**

(Cross-listed with COM S). (2-2) Cr. 3.

Prereq: COM S 311; ENGL 250; SP CM 212

Introduction to high performance computing platforms including parallel computers and workstation clusters. Discussion of parallel architectures, performance, programming models, and software development issues. Sample applications from science and engineering. Practical issues in high performance computing will be emphasized via a number of programming projects using a variety of programming models and case studies. Oral and written reports.

CPR E 426: Introduction to Parallel Algorithms and Programming

(Dual-listed with CPR E 526). (Cross-listed with COM S). (3-2) Cr. 4. F.

Prereq: (CPR E 308 or COM S 321); (CPR E 315 or COM S 311)

Models of parallel computation, performance measures, basic parallel constructs and communication primitives, parallel programming using MPI, parallel algorithms for selected problems including sorting, matrix, tree and graph problems, fast Fourier transforms.

CPR E 430: Network Protocols and Security

(Dual-listed with CPR E 530). (Cross-listed with CYBSC). (3-0) Cr. 3.

Prereq: CPR E 308 OR COM S 252 OR COM S 352. E E students: CPR E 288.

Detailed examination of networking standards, protocols, and their implementation. TCP/IP protocol suite, network application protocols. Network security issues, attack and mitigation techniques. Emphasis on laboratory experiments.

CPR E 431: Basics of Information System Security

(3-0) Cr. 3. S.

Prereq: Credit or concurrent enrollment in CPR E 308 or COM S 352

Introduction to and application of basic mechanisms for protecting information systems from accidental and intentional threats. Basic cryptography use and practice. Computer security issues including authentication, access control, and malicious code. Network security mechanisms such as intrusion detection, firewalls, SSL/TLS, and related protocols. Ethics and legal issues in information security. Wireless security. Programming and system configuration assignments. This course can not be used towards any requirements for the Cyber Security Degree or Minor. Only one of CPR E/CYB E 331 and CPR E 431 may count towards graduation.

CPR E 435: Analog VLSI Circuit Design

(Cross-listed with E E). (3-3) Cr. 4. S.

Prereq: E E 330

Basic analog integrated circuit and system design including design space exploration, performance enhancement strategies, operational amplifiers, references, integrated filters, and data converters.

CPR E 440: Operating System Security

(Cross-listed with CYB E). (3-0) Cr. 3. S.

Prereq: CPR E 308 OR COM S 352.

Focus on fundamentals and advanced topics in operating system (OS) security. Design issues, principles, mechanisms, and good practice for design and implementation of secure computer/OS systems. Threat models, vulnerabilities, attacks compromise security, and advanced OS-level techniques for achieving security. Topics include OS security concepts and principles, seminal security in Multics, vulnerabilities in ordinary systems, secure capability systems, information flow control, mandatory access control, security kernels, memory protection, file system, virtual machine systems, hardware/architecture support (e.g., Intel SGX) for OS security, secure microkernel OSes (e.g., seL4, QNX), modern mobile operating systems (e.g., Android and iOS), and security from end-user perspective. Assignments include labs exploring and implementing the technologies in the context of the Linux, Android, and seL4 systems (some involving kernel programming).

CPR E 450: Distributed Systems and Middleware

(Dual-listed with CPR E 550). (3-0) Cr. 3.

Prereq: CPR E 308 or COM S 352

Fundamentals of distributed computing, software agents, naming services, distributed transactions, security management, distributed object-based systems, web-based systems, Blockchain, middleware-based application design and development, case studies of middleware and internet applications.

CPR E 454: Distributed Systems

(Dual-listed with CPR E 554). (Cross-listed with COM S). (3-1) Cr. 3.

Prereq: COM S 311; COM S 352 or CPR E 308; for graduate credit: graduate standing or permission of instructor

Theoretical and practical issues of design and implementation of distributed systems. The client server paradigm, inter-process communications, synchronization and concurrency control, naming, consistency and replication, fault tolerance, and distributed file systems. Graduate credit requires additional in-depth study of concepts. Programming projects and written reports.

CPR E 458: Real Time Systems

(Dual-listed with CPR E 558). (3-0) Cr. 3.

Prereq: CPR E 308 or COM S 352

Fundamental concepts in real-time systems. Real time task scheduling paradigms. Resource management in uniprocessor, multiprocessor, and distributed real-time systems. Energy management in real-time systems and sensor networks. Fault-tolerance and overload handling in real-time systems. Real-time channel, QoS routing, traffic policing, packet scheduling, and real-time LAN protocols. Case study of real-time and IoT applications. Term project in real-time systems and networks.

CPR E 465: Digital VLSI Design

(Cross-listed with E E). (3-3) Cr. 4. F.

Prereq: E E 330

Digital design of integrated circuits employing very large scale integration (VLSI) methodologies. Technology considerations in design. High level hardware design languages, CMOS logic design styles, area-energy-delay design space characterization, datapath blocks: arithmetic and memory, architectures and systems on a chip (SOC) considerations. VLSI chip hardware design project.

CPR E 480: Graphics Processing and Architecture

(Dual-listed with CPR E 580). (3-3) Cr. 4. S.

Prereq: CPR E 381 or COM S 321

Introduction to hardware architectures for computer graphics and their programming models. System-level view, including framebuffer, video output devices, displays, 2D and 3D graphics acceleration, and device interfacing. Architectural design of GPUs, from 2D and 3D sprite engines to 3D rendering pipelines to unified shader architectures. Computing models for graphics processors. GPGPU and GPU computing.

CPR E 487: Hardware Design for Machine Learning

(3-3) Cr. 4.

Prereq: CPR E 381 or COM S 321

Introduction to hardware architectures for machine learning. Full system view – machinelearning frameworks to hardware interface to hardware architecture. General purpose CPU extensions for machine learning. GPU extensions for machine learning. Spatial architectures for machine learning. Performance, energy, and accuracy trade-offs. Hardware design optimizations for machine learning, including quantization, data re-use, SIMD, and SIMT. Lab section will culminate with the design and evaluation of an application-specific machinelearning accelerator.

CPR E 488: Embedded Systems Design

(3-3) Cr. 4.

Prereq: CPR E 381 or COM S 321

Embedded microprocessors, embedded memory and I/O devices, component interfaces, embedded software, program development, basic compiler techniques, platform-based FPGA technology, hardware synthesis, design methodology, real-time operating system concepts, performance analysis and optimizations.

CPR E 489: Computer Networking and Data Communications

(3-2) Cr. 4. F.S.

Prereq: CPR E 288 OR COM S 327

Modern computer networking and data communications concepts. OSI reference model, TCP/IP architecture. Sockets programming. Protocols at the physical layer, data link layer, network layer, transport layer, and application layer. Software-defined networking.

CPR E 490: Independent Study

Cr. arr. Repeatable.

Prereq: Senior classification in computer engineering

Investigation of an approved topic.

CPR E 490H: Independent Study: Honors

Cr. arr. Repeatable.

Prereq: Senior classification in computer engineering

Investigation of an approved topic.

CPR E 491: Senior Design Project I and Professionalism

(Cross-listed with E E, S E). (2-3) Cr. 3. F.S.

Prereq: CPR E major: CPR E 232, cr or enrollment in CPR E 308, completion of 29 cr in the CPRE prof prog, ENGL 314. E E major: E E 232, cr or enrollment in E E 322, completion of 24 cr in the EE prof prog, ENGL 314. S E major: S E 317 and S E 339, ENGL 309 or ENGL 314. Co-req: CPR E 308 or COM S 352

Preparing for entry to the workplace. Selected professional topics. Use of technical writing skills in developing project plan and design report; design review presentation. First of two-semester team-oriented, project design and implementation experience.

CPR E 492: Senior Design Project II

(Cross-listed with E E, S E). (1-3) Cr. 2. F.S.

Prereq: CPR E 491 or E E 491 or S E 491

Second semester of a team design project experience. Emphasis on the successful implementation and demonstration of the design completed in E E 491, Cpr E 491, or S E 491 and the evaluation of project results. Technical writing of final project report; oral presentation of project achievements; project poster.

CPR E 494: Portfolio Assessment

(Cross-listed with E E). Cr. R.

Prereq: CPR E 232 or E E 232 or CYB E 234; credit or concurrent enrollment in CPR E 491 or E E 491

Portfolio update and evaluation. Portfolios as a tool to enhance career opportunities.

Courses primarily for graduate students, open to qualified undergraduates:

CPR E 511: Design and Analysis of Algorithms

(Cross-listed with COM S). (3-0) Cr. 3.

Prereq: COM S 311

A study of algorithm design and analysis techniques. Network flows and linear programming. Randomized algorithms. NP-completeness. Approximation algorithms. Fixed-parameter algorithms.

CPR E 513: Program Analysis

(Cross-listed with COM S). (3-0) Cr. 3.

Prereq: (COM S 327 or CPR E 288); COM S 342

Algorithms, AI techniques and tools for automatically reasoning about code and program executions. Theory and foundations related to control flow analysis, dataflow analysis, abstract interpretation, and symbolic execution. Applications of program analysis to bug detection, test input generation, debugging, program repair, specification inference and trustworthy AI engineering. Concepts, algorithms, tools, benchmarks, methodologies for solving problems using program analysis and for preparing research in program analysis.

CPR E 522: Cognitive Radio Networks

(Cross-listed with E E). (3-0) Cr. 3. Alt. F., offered irregularly.

Prereq: Permission of instructor

Topics on cognitive radio networks: Cognitive Radio Networks Architecture; Software Defined Radio Architecture; Spectrum Sensing; Spectrum Management; Spectrum Sharing; Spectrum Mobility; Applications of Cognitive Radio Networks.

CPR E 525: Numerical Analysis of High Performance Computing

(Cross-listed with COM S, MATH). (3-0) Cr. 3. S.

Prereq: CPR E 308 or MATH 481; experience in scientific programming; knowledge of FORTRAN or C

Introduction to parallelization techniques and numerical methods for distributed memory high performance computers. A semester project in an area related to each student's research interests is required.

CPR E 526: Introduction to Parallel Algorithms and Programming

(Dual-listed with CPR E 426). (Cross-listed with COM S). (3-2) Cr. 4. F.

Prereq: (CPR E 308 or COM S 321); (CPR E 315 or COM S 311)

Models of parallel computation, performance measures, basic parallel constructs and communication primitives, parallel programming using MPI, parallel algorithms for selected problems including sorting, matrix, tree and graph problems, fast Fourier transforms.

CPR E 527: Concurrent Systems

(Cross-listed with COM S). Cr. 3.

Prereq: COM S 352 or CPR E 308

Fundamentals and advances in concurrent systems in the context of GPUs, TPUs, multicore and HPC systems with specific focus on parallel programming models. Discussion of high-performance computing, GPGPU, scaling deep neural network training and machine learning algorithms, high-performance deep learning, engineering parallel software and parallel design patterns.

CPR E 528: Probabilistic Methods in Computer Engineering

(3-0) Cr. 3.

Prereq: CPR E 315 or COM S 311

The application of randomization and probabilistic methods in the design of computer algorithms, and their efficient implementation. Discrete random variables in modeling algorithm behavior, with applications to sorting, selection, graph algorithms, hashing, pattern matching, cryptography, distributed systems, and massive data set algorithmics.

CPR E 529: Data Analytics in Electrical and Computer Engineering

(Cross-listed with E E). (3-0) Cr. 3. S.

Prereq: E E 322 or equivalent

Introduces a variety of data analytics techniques # particularly those relevant for electrical and computer engineers # from a foundational perspective. Topics to be covered include techniques for classification, visualization, and parameter estimation, with applications to signals, images, matrices, and graphs. Emphasis will be placed on rigorous analysis as well as principled design of such techniques.

CPR E 530: Network Protocols and Security

(Dual-listed with CPR E 430). (Cross-listed with CYBSC). (3-0) Cr. 3.

Prereq: CPR E 308 OR COM S 252 OR COM S 352. E E students: CPR E 288.

Detailed examination of networking standards, protocols, and their implementation. TCP/IP protocol suite, network application protocols. Network security issues, attack and mitigation techniques. Emphasis on laboratory experiments.

CPR E 531: Information System Security

(Cross-listed with CYBSC). (3-0) Cr. 3.

Prereq: CPR E 489 or CPR E 530 or COM S 586 or MIS 535

Computer, software, and data security: basic cryptography, security policies, multilevel security models, attack and protection mechanisms, legal and ethical issues.

CPR E 532: Information Warfare

(Cross-listed with CYBSC). (3-0) Cr. 3. S.

Prereq: CPR E 430 or 530

Computer system and network security: implementation, configuration, testing of security software and hardware, network monitoring. Authentication, firewalls, vulnerabilities, exploits, countermeasures. Study and use of attack tools. Ethics in cyber security. Emphasis on laboratory experiments.

CPR E 533: Cryptography

(Cross-listed with CYBSC, MATH). (3-0) Cr. 3. S.

Prereq: MATH 301 or CPR E 310 or COM S 230

Basic concepts of secure communication, DES and AES, public-key cryptosystems, elliptic curves, hash algorithms, digital signatures, applications. Relevant material on number theory and finite fields.

CPR E 534: Legal and Ethical Issues in Cyber Security

(Cross-listed with CYBSC, POL S). (3-0) Cr. 3. S.

Prereq: Graduate classification; CPR E 531 or CYBSC 531

Legal and ethical issues in computer security. State and local codes and regulations. Privacy issues.

CPR E 535: Steganography and Digital Image Forensics

(Cross-listed with CYBSC, MATH). (3-0) Cr. 3. S.

Prereq: E E 524 or MATH 317 or MATH 407 or COM S 230

Basic principles of covert communication, steganalysis, and forensic analysis for digital images. Steganographic security and capacity, matrix embedding, blind attacks, image forensic detection and device identification techniques. Related material on coding theory, statistics, image processing, pattern recognition.

CPR E 536: Computer and Network Forensics

(Cross-listed with CYBSC). (3-0) Cr. 3.

Prereq: CPR E 489 or CPR E 530

Fundamentals of computer and network forensics, forensic duplication and analysis, network surveillance, intrusion detection and response, incident response, anonymity and pseudonymity, privacy-protection techniques, cyber law, computer security policies and guidelines, court testimony and report writing, and case studies. Emphasis on hands-on experiments.

CPR E 537: Wireless Network Security

(3-0) Cr. 3. S.

Prereq: Credit or enrollment in CPR E 489 or CPR E 530

Introduction to the physical layer and special issues associated with the security of wireless networks. The basics of wireless communication systems (antennas and propagation, modulation, multiple access, channel modeling, specific security issues of the wireless link), jamming and countermeasures (spread spectrum technologies, channel coding, interleaving), authentication and confidentiality (basics of classic cryptography, common authentication and encryption algorithms). Detailed case studies on authentication, encryption and privacy flaws, and good practices based on the most common wireless technologies, including WiFi, GSM/3G, Bluetooth, and RFID. Individual or team-based class projects.

CPR E 538: Reverse Engineering and Security Testing

(Cross-listed with CYBSC). (2-3) Cr. 3. S.

Prereq: COM S 321 or CPR E 381, COM S 352 or CPR E 308

Techniques and tools for understanding the behavior of software/hardware systems based on reverse engineering. Flaw hypothesis, black, grey, and white box testing as well as other methods for testing the security of software systems. Discussion of counter-reverse engineering techniques.

CPR E 539: Cyber Physical System Security for the Smart Grid

(3-0) Cr. 3. S.

Introduction to cyber security, cyber physical system (CPS), and smart grid automation technologies; supervisor control and data acquisition (SCADA) systems; cyber risk modeling, vulnerability analysis, impact analysis, defense and mitigation techniques; cyber security of wide-area monitoring, protection, and control; security and privacy in advanced metering infrastructure (AMI), cyber security compliance and best practices, CPS security test-beds and attack-defense hands-on laboratory experiments.

CPR E 541: High-Performance Communication Networks

(3-0) Cr. 3.

Prereq: CPR E 489 or CPR E 530

Computer architectures and protocols designed for high-performance networking environments; software defined networking (SDN) and supporting protocols; cloud and data center networks; network traffic management and congestion control strategies; quality of service; high-speed access network protocols.

CPR E 542: Optical Communication Networks

(3-0) Cr. 3. S.

Prereq: CPR E 489

Optical components and interfaces; optical transmission and reception techniques; wavelength division multiplexing; network architectures and protocol for first generation, single and multihop optical network; routing and wavelength assignment in second generation wavelength routing networks; traffic grooming, optical network control; survivability; access networks; metro networks.

CPR E 543: Wireless Network Architecture

(3-0) Cr. 3.

Prereq: Credit or enrollment in CPR E 489 or CPR E 530

Introduction to the protocol architecture of the data link layer, network layer and transport layer for wireless networking. Operation and management of Medium Access Control in Wireless Local Area Networks (WLAN) and Wireless Metropolitan Area Networks (WMAN); recent developments in IEEE 802.11 & 802.16 and Bluetooth; Mobile IP; Mobile TCP.

CPR E 544: Fundamentals of Bioinformatics

(Cross-listed with BCB, COM S, GDCB). (4-0) Cr. 4. Alt. F., offered odd-numbered years.

Prereq: MATH 165 or STAT 401 or equivalent

A practical, hands-on overview of how to apply bioinformatics to biological research. Recommended for biologists desiring to gain computational molecular biology skills. Topics include: sequence analysis, genomics, proteomics, phylogenetic analyses, ontology enrichment, systems biology, data visualization and emergent technologies.

CPR E 545: Fault-Tolerant Systems

(3-0) Cr. 3.

Prereq: CPR E 381

Faults and their manifestations, errors, and failures; fault detection, location and reconfiguration techniques; time, space, and information (coding) redundancy management; design for testability; self-checking and fail-safe circuits; system-level fault diagnosis; Byzantine agreement; stable storage and RAID; clock synchronization; fault-tolerant networks; fault tolerance in real-time systems; reliable software design; checkpointing and rollback recovery; atomic actions; replica management protocols; and reliability evaluation techniques and tools.

CPR E 546: Wireless and Sensor Networks

(3-0) Cr. 3.

Prereq: CPR E 489 or CPR E 530

Fundamental and well-known protocols for wireless ad hoc and sensor networks at various layers, including physical layer issues, MAC (medium access control) layer protocols, routing protocols for wireless ad hoc and sensor networks, data management in sensor networks, coverage and connectivity, localization and tracking, security and privacy issues. Introduction to TinyOS and the nesC language. Hands-on experiments with Crossbow Mote sensor devices.

CPR E 547: Resource Allocation in Communication Networks

(3-0) Cr. 3.

Analytical approach to resource allocation on communication networks (e.g. the Internet, multihop wireless networks, etc.). Network utility maximization and the internet congestion control algorithm. Layering as optimization decomposition: a cross-layer design approach in multihop wireless networks. Capacity of ad hoc wireless networks.

CPR E 548: Cyber-Physical Systems Networking

Cr. 3.

Prereq: CPR E 489; CPR E 530/430; COM S 486, or equivalent.

Cyber-physical systems applications in smart agriculture, transportation, power grid, manufacturing, public safety, health systems, etc.; field area and control networks; industrial Ethernet; time-triggered communication; real-time wireless networks; wireless industrial networks; safety and security of industrial networks; systems platforms for cyber-physical systems networks; team-based learning/projects.

CPR E 550: Distributed Systems and Middleware

(Dual-listed with CPR E 450). (3-0) Cr. 3.

Prereq: CPR E 308 or COM S 352

Fundamentals of distributed computing, software agents, naming services, distributed transactions, security management, distributed object-based systems, web-based systems, Blockchain, middleware-based application design and development, case studies of middleware and internet applications.

CPR E 554: Distributed Systems

(Dual-listed with CPR E 454). (Cross-listed with COM S). (3-1) Cr. 3.

Prereq: COM S 311; COM S 352 or CPR E 308; for graduate credit: graduate standing or permission of instructor

Theoretical and practical issues of design and implementation of distributed systems. The client server paradigm, inter-process communications, synchronization and concurrency control, naming, consistency and replication, fault tolerance, and distributed file systems. Graduate credit requires additional in-depth study of concepts. Programming projects and written reports.

CPR E 556: Scalable Software Engineering

(3-0) Cr. 3.

Prereq: COM S 309

Design and analysis techniques scalable to large software, project-based learning of problem solving techniques, automation tools for high productivity and reliability of software, analysis-based measurement and estimation techniques for predictable software engineering.

CPR E 557: Computer Graphics and Geometric Modeling

(Cross-listed with COM S, M E). (3-0) Cr. 3. Alt. F., offered odd-numbered years.

Prereq: ME 421 or instructor permission

Fundamentals of computer graphics technology. Data structures. Parametric curve and surface modeling. Solid model representations. Applications in engineering design, analysis, and manufacturing.

CPR E 558: Real Time Systems

(Dual-listed with CPR E 458). (3-0) Cr. 3.

Prereq: CPR E 308 or COM S 352

Fundamental concepts in real-time systems. Real time task scheduling paradigms. Resource management in uniprocessor, multiprocessor, and distributed real-time systems. Energy management in real-time systems and sensor networks. Fault-tolerance and overload handling in real-time systems. Real-time channel, QoS routing, traffic policing, packet scheduling, and real-time LAN protocols. Case study of real-time and IoT applications. Term project in real-time systems and networks.

CPR E 559: Security and Privacy in Cloud Computing

(Cross-listed with COM S). (3-0) Cr. 3.

Prereq: COM S 352 or CPR E 308

Introduction to cloud computing concepts and systems. Security and privacy threats in cloud computing. Practical techniques for cloud computing security. Theoretical and practical solutions for secure outsourcing of data and computation. Oral presentations and research projects.

CPR E 560: Data-Driven Security and Privacy

(Cross-listed with COM S, CYBSC). Cr. 3. Alt. S., offered irregularly.

Prereq: CPR E 531; COM S 474 or COM S 573

Examination of applications of machine learning and big data techniques to various security and privacy problems, as well as secure and privacy-preserving machine learning algorithms.

CPR E 562: Secure Software Engineering

(3-0) Cr. 3. F.S.

Prereq: CPR E 308 or COM S 352

Fundamentals and techniques to design and implement software systems. Assessment of security vulnerabilities in software systems, exploitation of software vulnerabilities, and methods to secure vulnerable software. Secure coding practices, data analytics for security, microservices and cloud services security. Reverse engineering and security assessment of cyber-physical systems.

CPR E 563: Advanced Data Storage Systems

(3-0) Cr. 3.

Prereq: CPR E 308 OR COM S 352

Focus on how to keep valuable digital data (e.g., scientific computations, financial transactions, family photos) safely in modern computer systems. Fundamentals of data storage technologies including state of the art. Topics include storage hardware, Linux file systems, and warehouse-scale big data storage, with an emphasis on the design tradeoffs for robustness and security. Team projects based on high-impact open-source systems.

CPR E 566: Physical Design of VLSI Systems

(3-0) Cr. 3.

Prereq: CPR E 465

Physical design of VLSI systems. Partitioning algorithms. Placement and floorplanning algorithms. Routing-global and detailed. Layout compaction. Physical design of FPGA's and MCM's. Performance-driven layout synthesis.

CPR E 567: Bioinformatics Algorithms

(Cross-listed with BCB, COM S). (3-0) Cr. 3.

Prereq: COM S 228; COM S 230; credit or enrollment in BIOL 315, STAT 430

Biology as an information science. A review of the algorithmic principles that are driving the advances in bioinformatics and computational biology.

CPR E 569: Structural Bioinformatics

(Cross-listed with BBMB, BCB, COM S, GDCB). (3-0) Cr. 3. F.

Prereq: BCB 567, BBMB 316, GEN 409, STAT 430

Molecular structures including genes and gene products: protein, DNA and RNA structure. Structure determination methods, structural refinement, structure representation, comparison of structures, visualization, and modeling. Molecular and cellular structure from imaging. Analysis and prediction of protein secondary, tertiary, and higher order structure, disorder, protein-protein and protein-nucleic acid interactions, protein localization and function, bridging between molecular and cellular structures. Molecular evolution.

CPR E 570: Systems Biology

(Cross-listed with BCB, COM S, GDCB, STAT). (3-0) Cr. 3. S.

Prereq: BCB 567 or COM S 311, COM S 228, GEN 409, STAT 430 or STAT 483 or STAT 583

Algorithmic and statistical approaches in computational functional genomics and systems biology. Analysis of high throughput biological data obtained using system-wide measurements. Topological analysis, module discovery, and comparative analysis of gene and protein networks. Modeling, analysis, and inference of transcriptional regulatory networks, protein-protein interaction networks, and metabolic networks. Dynamic systems and whole-cell models. Ontology-driven, network based, and probabilistic approaches to information integration.

CPR E 575: Computational Perception

(Cross-listed with COM S, HCI). (3-0) Cr. 3. S.

Prereq: Graduate standing or permission of instructor

Statistical and algorithmic methods for sensing, recognizing, and interpreting the activities of people by a computer. Focuses on machine perception techniques that facilitate and augment human-computer interaction. Introduce computational perception on both theoretical and practical levels. Participation in small groups to design, implement, and evaluate a prototype of a human-computer interaction system that uses one or more of the techniques covered in the lectures.

CPR E 580: Graphics Processing and Architecture

(Dual-listed with CPR E 480). (3-3) Cr. 4. S.

Prereq: CPR E 381 or COM S 321

Introduction to hardware architectures for computer graphics and their programming models. System-level view, including framebuffers, video output devices, displays, 2D and 3D graphics acceleration, and device interfacing. Architectural design of GPUs, from 2D and 3D sprite engines to 3D rendering pipelines to unified shader architectures. Computing models for graphics processors. GPGPU and GPU computing.

CPR E 581: Computer Systems Architecture

(Cross-listed with COM S). (3-0) Cr. 3. F.

Prereq: CPR E 381

Quantitative principles of computer architecture design, instruction set design, processor architecture: pipelining and superscalar design, instruction level parallelism, memory organization: cache and virtual memory systems, multiprocessor architecture, cache coherency, interconnection networks and message routing, I/O devices and peripherals.

CPR E 582: Computer Systems Performance

(3-0) Cr. 3.

Prereq: CPR E 381, CPR E 310 and STAT 330

Review of probability and stochastic processes concepts; Markovian processes; Markovian queues; renewal theory; semi-Markovian queues; queueing networks, applications to multiprocessor architectures, computer networks, and switching systems.

CPR E 583: Reconfigurable Computing Systems

(Cross-listed with COM S). (3-0) Cr. 3.

Prereq: Background in computer architecture, design, and organization

Introduction to reconfigurable computing, FPGA technology and architectures, spatial computing architectures such as systolic and bit serial adaptive network architectures, static and dynamic rearrangeable interconnection architectures, processor architectures incorporating reconfigurability.

CPR E 584: Models and Techniques in Embedded Systems

(3-0) Cr. 3.

Industry-standard tools and optimization strategies; practical embedded platforms and technology (reconfigurable platforms, multi-core platforms, low-power platforms); instruction augmentation, memory-mapped accelerator design, embedded software optimization. Students will be encouraged to compete as teams in an embedded system design competition.

CPR E 585: Developmental Robotics

(Cross-listed with HCI). (3-0) Cr. 3. Alt. S., offered odd-numbered years.

Prereq: knowledge of C/C++ programming language.

An introduction to the emerging interdisciplinary field of Developmental Robotics, which crosses the boundaries between robotics, artificial intelligence, developmental psychology, and philosophy. The main goal of this field is to create autonomous robots that are more intelligent, more adaptable, and more useful than the robots of today, which can only function in very limited domains and situations.

CPR E 586: Pervasive Computing

(3-0) Cr. 3.

Prereq: CPR E 489 or CPR E 530

Fundamentals of pervasive computing, including location and context awareness, mobile and location services, ubiquitous data access, low power computing and energy management, middleware, security and privacy issues.

CPR E 588: Embedded Computer Systems

(3-0) Cr. 3.

Prereq: CPR E 308

Hardware/software systems and codesign. Models of computation for embedded systems. System-level design. Modeling, specification, synthesis, and verification. Hardware/software implementation. Design space exploration. Performance analysis and optimization. Multiprocessor system on chip. Platform-based design. Design methodologies and tools. Case studies and design projects.

CPR E 590: Special Topics

Cr. 1-6. Repeatable.

Formulation and solution of theoretical or practical problems in computer engineering.

CPR E 592: Seminar in Computer Engineering

Cr. 1-4. Repeatable.

Prereq: Permission of instructor

Projects or seminar in Computer Engineering.

CPR E 595: Independent Study

Cr. 1-3. Repeatable, maximum of 6 credits. F.S.SS.

Investigation of an approved topic commensurate with the student's prerequisites.

CPR E 598: Electrical and Computer Engineering Learning Community Seminar

(Cross-listed with E E). Cr. R. F.S.

Prereq: Electrical and Computer Engineering Graduate Student

Introduction to graduate study in Electrical and Computer Engineering at Iowa State University. Building networks, introduction to core requirements, and tools and techniques for success. Offered on a satisfactory-fail basis only. ECpE

CPR E 599: Creative Component

Cr. arr. Repeatable.

Courses for graduate students:**CPR E 626: Parallel Algorithms for Scientific Applications**

(Cross-listed with COM S). (3-0) Cr. 3.

Prereq: CPR E 526

Algorithm design for high-performance computing. Parallel algorithms for multidimensional tree data structures, space-filling curves, random number generation, graph partitioning and load balancing. Applications to grid and particle-based methods and computational biology.

CPR E 631: Cyber Security Operations Practicum

(Cross-listed with CYBSC). Cr. 3. Repeatable.

Prereq: CPR E 532; CPR E 534; and permission of instructor

Practical experience in cyber operations. Cyber security threat analysis, malware analysis, and intrusion detection management. Cyber security data analysis methods. Pen testing tools and techniques. Weekly threat analysis briefings. Offered on a satisfactory-fail basis only.

CPR E 632: Cyber Security Capstone Design

(Cross-listed with CYBSC). (3-0) Cr. 3.

Prereq: CYBSC 531, CYBSC 532, CYBSC 534

Capstone design course which integrates the security design process. Design of a security policy. Creation of a security plan. Implementation of the security plan. The students will attack each other's secure environments in an effort to defeat the security systems. Students evaluate the security plans and the performance of the plans. Social, political and ethics issues. Student self-evaluation, journaling, final written report.

CPR E 649: Advanced Topics in Computational Biology

(Cross-listed with COM S). (3-0) Cr. 3.

Prereq: COM S 511 and COM S 531

Design and analysis of algorithms for applications in computational biology, pairwise and multiple sequence alignments, approximation algorithms, string algorithms including in-depth coverage of suffix trees, semi-numerical string algorithms, algorithms for selected problems in fragment assembly, phylogenetic trees and protein folding. No background in biology is assumed. Also useful as an advanced algorithms course in string processing.

CPR E 681: Advanced Topics in Computer Architecture

(Cross-listed with COM S). (3-0) Cr. 3. Alt. S., offered odd-numbered years.

Prereq: CPR E 581. Repeatable with Instructor permission

Current topics in computer architecture design and implementation. Advanced pipelining, cache and memory design techniques. Interaction of algorithms with architecture models and implementations. Tradeoffs in architecture models and implementations.

CPR E 697: Engineering Internship

(Cross-listed with E E). Cr. R. Repeatable.

One semester and one summer maximum per academic year professional work period. Offered on a satisfactory-fail basis only.

CPR E 699: Research

Cr. arr. Repeatable.