COMPUTER SCIENCE AND ENGINEERING   CSE

Department of Computer Science and Engineering
College of Engineering

100   Computer Science as a Profession
Fall, Spring. 1(1-0) RB: High school algebra; ability to use a computer for browsing, email, and report preparation.
The computing and programming profession. Professionalism and ethics. Industry practice. Experiments with programming.

101   Computing Concepts and Competencies
Fall, Spring, Summer. 3(2-2) SA: CPS 100, CPS 130
Core concepts in computing including information storage, retrieval, management, and representation. Applications from specific disciplines. Applying core concepts to design and implement solutions to various focal problems, using hardware, multimedia software, communication and networks.

131   Technical Computing and Problem Solving
Spring. 3(1-3) P: (MTH 124 or concurrently) or (MTH 132 or concurrently) or (MTH 152H or concurrently) or (LB 118 or concurrently) SA: CPS 131
Use of computing systems for technical problem solving in engineering and science.

201   Fundamentals of Information Technology
Fall, Spring. 3(3-0) P: (CSE 101 or CSE 131) and (MTH 103 or MTH 116 or MTH 124 or MTH 132 or MTH 152H or LB 118) RB: high school algebra; literacy in web and computer tools, such as editor and browser. SA: CSE 240
Digital representation of objects such as numbers, signals, and 3-dimensional shapes. Algorithms that operate on digital objects. Computer communications and the Internet. Computer security and web services.

220   Programming in C
Fall, Spring. 3(2-2) P: (EGR 100 or ECE 101) and ((MTH 132 or concurrently) or (MTH 152H or concurrently) or (LB 118 or concurrently)) R: Open to undergraduate students. Not open to students with credit in CSE 251.
Basics of programming in C. Data types, operators, control, functions, arrays, pointers, file processing, testing and debugging.

231   Introduction to Programming I
Fall, Spring, Summer. 4(3-2) P: (LB 118 or concurrently) or (MTH 124 or concurrently) or (MTH 132 or concurrently) or (MTH 152H or concurrently) SA: CSE 230
Introduction to programming using Python. Design, implementation and testing of programs to solve problems such as those in engineering, mathematics and science. Programming fundamentals, functions, objects, and use of libraries of functions.

232   Introduction to Programming II
Fall, Spring. 4(3-2) P: (CSE 231 or CMSE 202) and (LB 118 or MTH 124 or MTH 132 or MTH 152H) SA: CSE 330
Continuation of object-centered design and implementation in C++. Building programs from modules. Data abstraction and classes to implement abstract data types. Static and dynamic memory allocation. Data structure implementation and algorithm efficiency. Lists, tables, stacks, and queues. Templates and generic programming.

251   Programming in C
Fall, Spring. 1(0-2) P: CSE 231 or CSE 131 or EGR 102 RB: Students are expected to have experience in programming in some language other than C R: Open to undergraduate students or graduate students.
Programming in the C language. Data and control. Compiling and linking.

260   Discrete Structures in Computer Science
Fall, Spring. 4(4-0) P: MTH 133 or MTH 126 or MTH 153H or LB 119 SA: CPS 260
Propositional and first order logic. Equivalence and methods of proof. Basics of counting. Set operations, relations, functions. Grammars and finite state automata. Discrete probability. Applications to computer science and engineering.

290   Independent Study in Computer Science
Fall, Spring. 1 credit. A student may earn a maximum of 3 credits in all enrollments for this course. R: Approval of department; application required. SA: CPS 290
Supervised individual study in an area of computer science.

291   Selected Topics in Computer Science
Fall, Spring. 1 to 4 credits. A student may earn a maximum of 8 credits in all enrollments for this course. R: Approval of department. SA: CPS 291
Topics selected to supplement and enrich existing courses and lead to the development of new courses.

320   Computer Organization and Architecture
Fall, Spring. 3(3-0) P: CSE 232 and CSE 260 R: Open to students in the Department of Computer Science and Engineering or in the Computer Engineering Major or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major or in the Computer Science Disciplinary Teaching Minor. SA: CPS 320 Not open to students with credit in ECE 331.
Boolean algebra and digital logic. Combinational and sequential circuits. Representations of data and instructions. Architecture and major components of computer systems. Assembly language programming and interfacing to high level languages. Assembler and linker processing.

331   Algorithms and Data Structures
Fall, Spring. 3(3-0) P: CSE 232 and CSE 260 R: Open to students in the Department of Computer Science and Engineering or in the Computer Engineering Major or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major or in the Computer Science Disciplinary Teaching Minor.
Linear data structures, trees, graphs and algorithms which operate on them. Fundamental algorithms for searching, sorting, string matching, graph problems. Design and analysis of algorithms.

335   Object-oriented Software Design
Fall, Spring. 4(4-0) P: CSE 232 and CSE 260 R: Open to students in the Department of Computer Science and Engineering or in the Computer Engineering Major or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major or in the Computer Science Disciplinary Teaching Minor. SA: CSE 370
Development of large software products, libraries, and product families. Object-oriented programming using inheritance and polymorphism. Design methods. Specification and the use of contracts to design reliable software. Configuration management and life-cycle issues.

402   Biometrics and Pattern Recognition
Fall. 3(3-0) P: CSE 331 and STT 351 R: Open to juniors or seniors in the College of Engineering or in the Computer Science Minor or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major.
Automated techniques used for feature extraction and pattern matching focusing on face, fingerprint and iris recognition.

410   Operating Systems
Fall, Spring. 3(3-0) P: (CSE 232 and CSE 260) and (CSE 320 or ECE 331) R: Open to juniors or seniors in the College of Engineering or in the Computer Science Minor or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major or in the Computer Science Disciplinary Teaching Minor. SA: CPS 410
Principles and evolution of operating systems. Process and processor management. Concurrent processes and threads. Primary and secondary storage management. Case studies of modern operating systems.

415   Introduction to Parallel Computing
Spring. 3(3-0) P: CSE 320 and CSE 331 R: Open to juniors or seniors in the College of Engineering or in the Computer Science Minor or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major.
Core principles and techniques of parallel computing. Parallel architectures. Parallel programming models. Principles of parallel algorithm design. Performance analysis and optimization. Use of parallel computers.

420   Computer Architecture
Spring. 3(3-0) P: (CSE 232 and CSE 260) and (CSE 320 or ECE 331) R: Open to juniors or seniors in the College of Engineering or in the Computer Science Minor or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major or in the Computer Science Disciplinary Teaching Minor. SA: CPS 420
Organization and architecture of computer systems. Arithmetic Logic Unit and control unit implementations. Hardwired and microprogrammed control. Pipelined processors; data and branch hazards. Memory hierarchy and storage devices. Input-output and peripheral devices. Advanced architectures.

Computer Science and Engineering—CSE

422 Computer Networks
Fall, Spring. 3(3-0) P: (STT 351 or ECE 280) and (CSE 410 or concurrently) R: Open to juniors or seniors in the College of Engineering or in the Computer Science Minor or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major. SA: CPS 422

Computer network architectures and models. Physical media and signaling. Data link protocols. Medium access control. Routing and IP. Transport services including TCP/UDP. Network applications. Local-area and wide-area networks.

425 Introduction to Computer Security
Spring. 3(3-0) P: CSE 422 or concurrently R: Open to juniors or seniors in the College of Engineering or in the Computer Science Minor or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major.

Theory and practice of security engineering. Security protocols. Cryptography and cryptanalysis. Smartcards. Network security and intrusion detection. Common system attacks.

429 Interdisciplinary Topics in CyberSecurity
Spring. 3(3-0) Interdepartmental with Criminal Justice. Administered by Computer Science and Engineering. P: CSE 101 or CSE 131 or CSE 231 R: Open to juniors or seniors or graduate students.

Technical, legal, criminal, medical business, and communication aspects of CyberSecurity.

431 Algorithm Engineering
Fall, Spring. 3(3-0) P: CSE 331 R: Open to juniors or seniors in the College of Engineering or in the Computer Science Minor or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major.

Algorithm analysis, design, implementation, and optimization for a broad range of problem categories including techniques to recognize and cope with intractable problems.

435 Software Engineering
Fall. 3(3-0) P: (CSE 331 and CSE 335) and completion of Tier I writing requirement R: Open to juniors or seniors in the College of Engineering or in the Computer Science Minor or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major.

Software lifecycle including specification, design, coding, testing, and verification of a software product. Stepwise refinement and traceability. Software maintenance and documentation.

440 Introduction to Artificial Intelligence
Fall. 3(3-0) P: CSE 331 R: Open to juniors or seniors in the College of Engineering or in the Computer Science Major or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major. SA: CPS 440

Fundamental issues in intelligent systems. Knowledge representation and mechanisms of reasoning. Search and constraint satisfaction. Agents. Application areas of AI and current topics.

444 Information Technology Project Management
Spring. 3(3-0) Interdepartmental with Information Technology Management and Media and Information. Administered by Information Technology Management. P: ITM 311 R: Open to students in the Information Technology Minor.

Practical training and experiences in design, testing, and launch of new information technologies and systems.

450 Translation of Programming Languages
Fall. 3(3-0) P: CSE 331 and (CSE 320 or ECE 331) R: Open to juniors or seniors in the College of Engineering or in the Computer Science Minor or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major. SA: CPS 450

Theory and practice of programming language translation. Languages, grammars and parsing. Lexical, syntactic and semantic analysis. Compile-time error handling. Code optimization and code generation.

460 Computability and Formal Language Theory
Fall. 3(3-0) P: CSE 331 R: Open to juniors or seniors in the College of Engineering or in the Computer Science Minor or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major or in the Computer Science Disciplinary Teaching Minor. SA: CSE 360

Formal models of computation such as finite state automata, pushdown automata and Turing machines. Formal definitions of languages, problems, and language classes including recursive, recursively enumerable, regular, and context free languages. The relationships among various models of computation, language classes, and problems. Church's thesis and the limits of computability. Proofs of program properties including correctness.

471 Media Processing and Multimedia Computing
Spring. 3(3-0) P: CSE 320 or CSE 331 or CSE 335 R: Open to juniors or seniors in the College of Engineering or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major.

Basic operations for processing images, video, and audio. Devices for input and output. Data formats and compression. Tools for processing images and sound. Multimedia authoring tools. Applications.

472 Computer Graphics
Spring. 3(3-0) P: CSE 331 or CSE 335 R: Open to juniors or seniors in the College of Engineering or in the Computer Science Minor or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major. SA: CPS 472

Graphics systems. Two- and three-dimensional imaging geometry and transformations. Curve and surface design. Rendering, shading, color, and animation. Graphics programming.

473 Fundamentals of 3D Game Development
Fall. 3(3-0) P: CSE 331 or CSE 335 R: Open to students in the Computer Engineering Major or in the Computer Science Major or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major or in the Computer Science Disciplinary Teaching Minor.

Fundamental algorithms and techniques for 3D computer game development including geometric transformations, procedural and keyframe animation, models and scene graphs, skeletal animation and skinned characters, illuminations and shading, collision detection, and level of detail.

476 Mobile Application Development
Spring. 3(3-0) P: CSE 320 or CSE 331 or CSE 335 R: Open to juniors or seniors in the College of Engineering or in the Computer Science Minor or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major.

Software development techniques for mobile devices such as smart phones and tablet computers.

477 Web Application Architecture and Development
Spring. 3(3-0) P: CSE 320 or CSE 331 or CSE 335 R: Open to juniors or seniors in the College of Engineering or in the Computer Science Minor or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major.

Fundamentals of World Wide Web (WWW) programming, including protocols, client-server interaction, markup languages, client- and server-side programming, databases, and remote procedure calls. Development of a WWW server and WWW sites with browser-based interfaces to remote databases. Students will incorporate scaling, throughput, and latency considerations in the development of widely-distributed systems.

480 Database Systems
Spring. 3(3-0) P: CSE 331 or CSE 335 R: Open to juniors or seniors in the College of Engineering or in the Computer Science Minor or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major. SA: CPS 480

Storage of and access to physical databases including indexing, hashing, and range accesses. Relational data models, database design principles, query languages, query optimization, transaction processing and recovery techniques. Object-oriented and distributed databases.

482 Big Data Analysis
Spring. 3(3-0) P: CSE 331 and CSE 335 and STT 351 R: Open to juniors or seniors in the College of Engineering or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major.

Data collection, storage, and preprocessing, and analysis techniques. Programming for large-scale data analysis. Case studies and applications.

484   Information Retrieval
Fall. 3(3-0) P: CSE 331 RB: STT 351 R: Open to students in the Computer Engineering Major or in the Computer Science Major or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major or in the Computer Science Disciplinary Teaching Minor.

Retrieval models including Boolean, vector space, and probabilistic models. Architecture of information retrieval systems. Text clustering, categorization and filtering. Recommendation systems. Natural language processing for text retrieval. Information extraction, question answering. Multimedia retrieval. Digital libraries.

490   Independent Study in Computer Science
Fall, Spring. 1 to 3 credits. A student may earn a maximum of 3 credits in all enrollments for this course. R: Open to students in the Computer Engineering Major or in the Computer Science Major. Approval of department; application required. SA: CPS 490

Supervised individual study in an area of computer science.

491   Selected Topics in Computer Science
Fall, Spring. 1 to 4 credits. A student may earn a maximum of 9 credits in all enrollments for this course. R: Open to students in the Computer Engineering Major or in the Computer Science Major or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major or in the Computer Science Disciplinary Teaching Minor. Approval of department. SA: CPS 491

Topics selected to supplement and enrich existing courses and lead to the development of new courses.

498   Collaborative Design (W)
Fall, Spring. 4(2-4) P: {(CSE 420 or CSE 422 or CSE 425 or CSE 435 or CSE 440 or CSE 450) or (CSE 460 or CSE 471 or CSE 472 or CSE 473 or CSE 480 or CSE 484)} and ((CSE 335 and CSE 410) and completion of Tier I writing requirement) R: Open to students in the Computer Science Major or in the Lyman Briggs Computer Science Coordinate Major. SA: CSE 449, CSE 478, CSE 479

Development of a comprehensive software and/or hardware solution to a problem in a team setting with emphasis on working with a client. Participation in a design cycle including specification, design, implementation, testing, maintenance, and documentation. Issues of professionalism, ethics, and communication.

801   Introduction to Computational Science for Evolutionary Biologists
Fall. 3(3-0) RB: A strong background in molecular biology, evolution, or ecology. R: Not open to graduate students in the College of Engineering or in the Department of Computer Science and Engineering. Approval of department.

Introductory and intermediate programming and scripting for data analysis and modeling. Algorithmic considerations. Scientific controls, workflows, and reproducibility.

802   Pattern Recognition and Analysis
Spring. 3(3-0) RB: (CSE 331 and MTH 314 and STT 441) or CSE 331 and MTH 314 and STT 441 R: Open to graduate students in the Department of Computer Science and Engineering or in the Department of Electrical and Computer Engineering.

Algorithms for classifying and understanding data. Statistical and syntactic methods, supervised and unsupervised machine learning. Cluster analysis and ordination. Exploratory data analysis. Methodology for design of classifiers.

803   Computer Vision
Fall. 3(3-0) RB: CSE 331 and MTH 314 and STT 351 R: Open only to Computer Science or Electrical Engineering majors. SA: CPS 803

Visual information processing problems. Human and machine vision systems. Image formation and transforms. Encoding, enhancement, edge detection, segmentation. 2D and 3D object description and recognition. Scene analysis. Applications.

812   Distributed Systems
Spring. 3(3-0) RB: CSE 410 R: Open to students in the Electrical Engineering Major or in the Computer Science Major. SA: CPS 812

Principles, paradigms, techniques used in distributed systems. Assurance techniques for distributed systems. Fault-tolerance and security issues in distributed systems. Research issues in the design and implementation of distributed systems.

813   Advanced VLSI Design
Spring. 3(3-0) Interdepartmental with Electrical and Computer Engineering. Administered by Electrical and Computer Engineering. P: ECE 410 SA: EE 813

Advanced topics in digital integrated circuit design. Design specifications: functionality, performance, reliability, manufacturability, testability, cost. Standard cells. Design-rule checking. Circuit extraction, simulation, verification. Team-based design.

814   Formal Methods in Software Development
Fall of odd years. 3(3-0) RB: MTH 472 R: Open only to majors in the Department of Computer Science and Engineering or approval of department. SA: CPS 814

Formal specification languages, integrating verification with development. Design and the implementation of term project.

820   Advanced Computer Architecture
Fall, Spring. 3(3-0) Interdepartmental with Electrical and Computer Engineering. Administered by Computer Science and Engineering. RB: CSE 410 and CSE 420 R: Open only to Computer Science or Electrical Engineering majors. SA: CPS 820

Instruction set architecture. Pipelining, vector processors, cache memory, high bandwidth memory design, virtual memory, input and output. Benchmarking techniques. New developments related to single CPU systems.

822   Parallel Computing
Fall. 3(3-0) Interdepartmental with Computational Mathematics, Science, and Engineering. Administered by Computational Mathematics, Science, and Engineering. RB: Calculus at the level of MTH 133. Ability to program proficiently in C/C++, basic understanding of data structures and algorithms (both at the level of CSE 232). Basic linear algebra and differential equations.

Core principles, techniques, and use of parallel computation using modern supercomputers. Parallel architectures. Parallel programming models. Principles of parallel algorithm design. Performance analysis and optimization.

824   Advanced Computer Networks and Communications
Fall. 3(3-0) RB: CSE 422 R: Open only to graduate students in the Department of Computer Science and Engineering. SA: CPS 824

Advanced topics in emerging computer networking technologies, including high-speed wide area networks and local area networks, wireless and mobile computing networks, optical networks, and multimedia networking.

825   Computer and Network Security
Spring. 3(3-0) RB: CSE 410 and CSE 422

Threat assessments, secure software, intrusions and intrusion detection.

830   Design and Theory of Algorithms
Fall, Spring. 3(3-0) RB: CSE 232 and CSE 460 R: Open only to majors in the Department of Computer Science and Engineering or approval of department. SA: CPS 830

Analysis of algorithms. Algorithm design techniques. Efficient algorithms for classical problems. Intractable problems and techniques to handle them.

835   Algorithmic Graph Theory
Spring. 3(3-0) RB: (CSE 232 and CSE 460) and (MTH 309 or MTH 314) R: Open to students in the Department of Computer Science and Engineering or approval of department. SA: CPS 835

Classical concepts in Graph Theory. Algorithmic aspects of graphs such as finding paths, network flow, spanning trees and matching.

836   Probabilistic Models and Algorithms in Computational Biology
Fall. 3(3-0) P: CSE 331 RB: Basic understanding of data structures; probabilities; programming experiences (no restriction to programming language)

Canonical probabilistic models and algorithms used in important bioinformatics tools

841   Artificial Intelligence
Fall. 3(3-0) RB: CSE 440 R: Open only to Computer Science or Electrical Engineering majors. SA: CPS 841

Types of intelligence, knowledge representation, cognitive models. Goal-based systems, heuristic search and games, expert systems. Language understanding, robotics and computer vision, theorem proving and deductive systems, and learning.

Computer Science and Engineering—CSE

842 Natural Language Processing
Spring of odd years. 3(3-0) RB: Programming skills, basic probability and statistics knowledge.
Models and algorithms for natural language processing including syntax, semantics, pragmatics, and discourse. Knowledge-based and statistical approaches to a variety of language related applications.

843 Language and Interaction
Spring of even years. 3(3-0) RB: Programming skills. Basic probability and statistical knowledge. Artificial intelligence.
Introduction to foundations and the state-of-the-art technology enabling natural language communication with artificial agents. Speech recognition, acoustic modeling and language modeling, dialogue and discourse modeling, psycholinguistic studies on situated human language processing, and their applications in situated human robot dialogue.

845 Multi-disciplinary Research Methods for the Study of Evolution
Spring. 3(3-0) Interdepartmental with Microbiology and Molecular Genetics and Zoology. Administered by Computer Science and Engineering.
Techniques for engaging in multi-disciplinary research collaborations, including biology, computer science, and engineering. Students engage in group projects to answer fundamental questions about the dynamics of actively evolving systems including both natural and computational. Multi-disciplinary teams will learn to overcome discipline-specific language and conceptual issues. Experimental design, statistical analysis, data visualization, and paper and grant writing for multi-disciplinary audiences.

847 Machine Learning
Spring. 3(3-0) P: CSE 841 RB: Algorithms, programming in C or equivalent, probability and statistics, artificial intelligence. R: Open only to students in the Department of Computer Science and Engineering or approval of department.
Computational study of learning and data mining. Strengths and limitations of various learning paradigms, including supervised learning, learning from scalar reward, unsupervised learning, and learning with domain knowledge.

848 Evolutionary Computation
Fall of even years. 3(3-0) Interdepartmental with Electrical and Computer Engineering. Administered by Computer Science and Engineering. RB: CSE 841 and CSE 440 R: Open to graduate students in the Department of Computer Science and Engineering and open to graduate students in the Department of Electrical and Computer Engineering or approval of department.
Investigation of evolutionary computation from a historical, theoretical and application viewpoint. Readings from the present literature, experiments with provided software on the application of evolutionary computation principles.

860 Foundations of Computing
Spring of even years. 3(3-0) RB: CSE 460 R: Open only to majors in the Department of Computer Science and Engineering or approval of department. SA: CPS 860
Models of computation: partial recursive functions, Turing machines, alternative models of computing. Basic theory and limitations of computability. Undecidability. Resource-bounded computational complexity, non-determinism, NP-completeness.

867 Nature and Practice of Cognitive Science
Spring. 3(3-0) Interdepartmental with Integrative Biology and Linguistics and Philosophy and Psychology. Administered by Psychology. RB: Undergraduate course work in behavioral biology, cognitive psychology, philosophy, linguistics, or artificial intelligence. SA: ZOL 867
Survey of how different disciplines explore the cognitive processes underlying intelligent behavior.

870 Advanced Software Engineering
Spring. 3(3-0) RB: (CSE 470) or undergraduate software engineering course R: Open only to students in the Department of Computer Science and Engineering.
Methods and techniques supporting later lifecycle activities, including software testing and maintenance, reuse, and reverse engineering. Domain-specific software engineering methods. Human-computer interfaces, distributed systems, and visualization techniques.

872 Advanced Computer Graphics
Fall. 3(3-0) RB: CSE 472
Advanced aspects of digital image generation, geometric modeling, computer animation and rendering methods.

880 Advanced Database Systems
Fall. 3(3-0) RB: CSE 480 R: Open only to majors in the Department of Computer Science and Engineering or approval of department. SA: CPS 880
Distributed and object-oriented databases and knowledgebase systems. Design theory, query optimization, and transaction processing.

881 Data Mining
Fall. 3(3-0) RB: Programming skills in C, C++, Java and Matlab. Basic knowledge in calculus, probability and statistics.
Techniques and algorithms for knowledge discovery in databases, from data preprocessing and transformation to model validation and post-processing. Core concepts include association analysis, sequential pattern discovery, anomaly detection, predictive modeling, and cluster analysis. Application of data mining to various application domains.

885 Artificial Neural Networks
Spring. 3(3-0) Interdepartmental with Electrical and Computer Engineering. Administered by Electrical and Computer Engineering. SA: EE 885
Overview of neuro-engineering technology. Basic neural network architectures. Feedforward and feedback networks. Temporal modeling. Supervised and unsupervised learning. Implementation. Basic applications to pattern recognition.

890 Independent Study
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to Computer Science or Electrical Engineering majors. Approval of department. SA: CPS 890
Independent study of some topic, system, or language not covered in a regular course.

891 Selected Topics
Fall, Spring. 1 to 3 credits. A student may earn a maximum of 9 credits in all enrollments for this course. R: Open only to Computer Science or Electrical Engineering majors. SA: CPS 891
Selected topics in computer science of current interest and importance but not covered in a regular course.

898 Master's Project
Spring. 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open to students in the Department of Computer Science and Engineering. Approval of department.
In depth student project where the student performs original research, research replication, or survey and reporting on a topic such as system design and development, or system conversion or installation.

899 Master's Thesis Research
Fall, Spring, Summer. 1 to 8 credits. A student may earn a maximum of 24 credits in all enrollments for this course. R: Open only to Computer Science majors. Approval of department. SA: CPS 899
Master's thesis research.

902 Selected Topics in Recognition by Machine
Spring. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. RB: CSE 802 and CSE 803 R: Open only to Computer Science or Electrical Engineering majors. SA: CPS 902
Advanced topics in pattern recognition and computer vision such as Markov random fields, modeling and recognition of three dimensional objects, and integration of visual modules.

910 Selected Topics in Computer Networks and Distributed Systems
Spring of even years. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. RB: CSE 422 and CSE 812 R: Open only to Computer Science or Electrical Engineering majors. SA: CPS 910
Advanced topics and developments in high-bandwidth computer networks, protocol engineering, and distributed computer systems.

912 Advanced Topics in Distributed Computing Systems
Spring of odd years. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. RB: CSE 410 and CSE 812
Advanced topics and developments in Internet computing, distributed algorithm and operating systems, distributed middleware, high-performance distributed computing, peer-to-peer computing, security and fault tolerance of distributed systems, mobile computing, ubiquitous and pervasive computing, and distributed-data management.

914   Formal Methods in Software Development

Fall. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. P: CSE 814 RB: Undergraduate courses in software engineering and in logic. R: Open to graduate students in the Department of Computer Science and Engineering.

Current research in selected areas of software engineering such as: approaches for the incorporation of formal methods in software development; current projects using formal methods in software engineering; object-oriented analysis and development techniques; and approaches for the incorporation of user-interface analysis and design in software development.

920   Selected Topics in High Performance Computer Systems

Spring of odd years. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. Interdepartmental with Electrical and Computer Engineering. Administered by Computer Science and Engineering. R: Open to students in the Computer Science Major or approval of department. SA: CPS 920

Design of high performance computer systems. Seminar format.

941   Selected Topics in Artificial Intelligence

Fall. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. RB: CSE 841 R: Open only to Computer Science or Electrical Engineering majors. SA: CPS 941

Topic such as second generation expert systems, human factors, natural language processing, speech understanding, neural networks, genetic algorithms and opportunistic planning.

960   Selected Topics in Algorithms and Complexity

Spring of odd years. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. RB: CSE 830 and CSE 860 R: Open only to graduate students in the Department of Computer Science and Engineering. Approval of department. SA: CPS 960

Current research in the general theory of algorithms and computational complexity.

980   Selected Topics in Database Systems

Spring. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. RB: CSE 880 R: Open only to Computer Science or Electrical Engineering majors. SA: CPS 980

Recent developments in areas such as distributed and parallel database systems, object oriented database systems, knowledgebase and expert database systems.

999   Doctoral Dissertation Research

Fall, Spring, Summer. 1 to 36 credits. A student may earn a maximum of 36 credits in all enrollments for this course. R: Open to graduate students in the Computer Science major. Approval of department. SA: CPS 999

Doctoral dissertation research.