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.

101  Computing Concepts and Competencies
Fall, Spring, Summer. 3(2-2) SA: CSE 100, CSE 130
Core concepts in computing including information storage, retrieval, pattern, 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: CSE 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 200) 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(5-0) P: MTH 133 or MTH 126 or MTH 153H or LB 119 SA: CSE 260

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: CSE 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 6 credits in all enrollments for this course.
R: Approval of department. SA: CSE 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 and Engineering Major or in the Computer Science Disciplinary Teaching Minor. SA: CSE 320
Computer and processor management. Concurrent and parallel processing. 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 and Engineering 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 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 and Engineering Major.
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, Spring. 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.

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 and Engineering Major.

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 and Engineering Major.
222 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

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.

432 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

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

460 Computability and Formal Languages 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.
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 Computer Science Minor 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

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 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 Minor 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 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 R: STT 351  
Open to students in the Computer Engineer-
ning 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 informa-
tion retrieval systems. Text clustering, categorization
 and filtering. Recommendation systems. Natural lan-
guage processing for text retrieval. Information ex-
 traction, 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 enroll-
 ments for this course. R: Open to students in
 the Computer Engineering Major or in the
 Computer Science Major. Approval of de-
 partment; 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 enroll-
 ments 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 Discipli-
nary Teaching Minor. Approval of depart-
 ment. SA: CPS 491
 Topics provided 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 stu-
 dents in the Computer Science Major or in
 the Lyman Briggs Computer Science Coordi-
 nate 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, imple-
m entation, testing, maintenance, and documentation.
 Issues of professionalism, ethics, and communica-
tion.

801 Introduction to Computational Science  
for Evolutionary Biologists  
Fall. 3(3-0) R: A strong background in mo-
l ecular biology, evolution, or ecology. R: Not
 open to graduate students in the College of
 Engineering or in the Department of Com-
 puter Science and Engineering. Approval of de-
 partment.
 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) R: (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 Engi-
 neering majors. SA: CPS 802
 Algorithms for classifying and understanding data.
 Statistical and syntactic methods, supervised and un-
supervised machine learning. Cluster analysis and
 ordination. Exploratory data analysis. Methodology
 for design of classifiers.

803 Computer Vision  
Fall. 3(3-0) R: 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 tran-
sforms. Encoding, enhancement, edge detection, seg-
 mentation. 2D and 3D object description and recog-
nition. Scene analysis. Applications.

812 Distributed Systems  
Spring. 3(3-0) R: CSE 410 R: Open to stu-
 dents in the Electrical Engineering Major or in
 the Computer Science Major. SA: CPS 812
 Principles, paradigms, techniques used in distrib-
 uted systems. Algorithms and techniques for distrib-
 uted systems. Fault-tolerance and security issues in distrib-
 uted systems. Research issues in the design and im-
plementation of distributed systems.

813 Advanced VLSI Design  
Spring. 3(3-0) Interdepartmental with Elec-
trical 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, re-
l iability, manufacturability, testability, cost. Standard
 cells. Design-rule checking. Circuit extraction, simu-
l ation, verification. Team-based design.

814 Formal Methods in Software Development  
Fall of odd years. 3(3-0) R: MTH 472 R: Open
 only to majors in the Department of
 Computer Science and Engineering or ap-
p roval of department. SA: CPS 814
 Formal specification languages, integrating verifica-
tion with development. Design and the implementa-
tion of term project.

820 Advanced Computer Architecture  
Fall, Spring. 3(3-0) Interdepartmental with Elec-
trical and Computer Engineering. Administered
 by Computer Science and Engi-
 neering. RB: CSE 410 and CSE 420 R: Open
 only to Computer Science or Electrical Engi-
 neering majors. SA: CPS 820
 Instruction set architecture. Pipelining, vector proces-
sors, 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 Compu-
tational Mathematics, Science, and Engineer-
ing. Administered by Computational Mathe-
 matics, Science, and Engineering. RB: Cal-
culus at the level of MTH 133. Ability to pro-
gram proficiently in C/C++, basic under-
 standing 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 com-
 putation using modern supercomputers. Parallel ar-
 chitectures. Parallel programming models. Princi-
ples of parallel algorithm design. Performance anal-
ysis and optimization.

824 Advanced Computer Networks and
 Communications  
Fall. 3(3-0) R: CSE 422 R: Open only to
 graduate students in the Department of Com-
 puter Science and Engineering. SA: CPS 824
 Advanced topics in emerging computer networking
 technologies, including high-speed wide area net-
 works and local area networks, wireless and mobile
 computing networks, optical networks, and multimedi-
a networking.

825 Computer and Network Security  
Spring. 3(3-0) R: CSE 410 and CSE 422
 Threat assessment, secure software, intrusions and
 intrusion detection.

830 Design and Theory of Algorithms  
Fall, Spring. 3(3-0) R: CSE 232 and CSE
 480 R: Open only to majors in the Depart-
 ment 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) R: (CSE 232 and CSE 460)
 and (MTH 309 or MTH 314) R: Open to
 students in the Department of Computer Sci-
 ence and Engineering or approval of depart-
 ment. SA: CPS 835
 Classical concepts in Graph Theory. Algorithmic as-
 pects 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 R: Basic under-
 standing of data structures; probabilities; pro-
gramming experiences (no restriction to pro-
gramming language)
 Canonical probabilistic models and algorithms used
 in important bioinformatics tools

841 Artificial Intelligence  
Fall. 3(3-0) R: CSE 440 R: Open only to
 Computer Science or Electrical Engineering
 majors. SA: CPS 841
 Types of intelligence, knowledge representation, cog-
native models. Goal-based systems, heuristic search
 and games, expert systems. Language understand-
ing, robotics and computer vision, theorem proving
 and deductive systems, and learning.
### CSE—Computer Science and Engineering

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>842</td>
<td>Natural Language Processing</td>
<td>Spring of odd years. 3(3-0) RB: Programming skills, basic probability and statistics knowledge. Models and algorithms for natural language processing, including syntactic analysis, semantic analysis, pragmatic analysis, and discourse. Knowledge-based and statistical approaches to a variety of language-related applications.</td>
</tr>
<tr>
<td>843</td>
<td>Language and Interaction</td>
<td>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.</td>
</tr>
<tr>
<td>845</td>
<td>Multi-disciplinary Research Methods for the Study of Evolution</td>
<td>Spring. 3(3-0) Interdepartmental with Integrative Biology and Molecular Genetics. 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.</td>
</tr>
<tr>
<td>847</td>
<td>Machine Learning</td>
<td>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.</td>
</tr>
<tr>
<td>848</td>
<td>Evolutionary Computation</td>
<td>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.</td>
</tr>
<tr>
<td>860</td>
<td>Foundations of Computing</td>
<td>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.</td>
</tr>
<tr>
<td>867</td>
<td>Nature and Practice of Cognitive Science</td>
<td>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.</td>
</tr>
<tr>
<td>870</td>
<td>Advanced Software Engineering</td>
<td>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.</td>
</tr>
<tr>
<td>872</td>
<td>Advanced Computer Graphics</td>
<td>Fall. 3(3-0) RB: CSE 472. Advanced aspects of digital image generation, geometric modeling, computer animation and rendering methods.</td>
</tr>
<tr>
<td>880</td>
<td>Advanced Database Systems</td>
<td>Fall. 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 880. Distributed and object-oriented databases and knowledgebase systems. Design theory, query optimization, and transaction processing.</td>
</tr>
<tr>
<td>881</td>
<td>Data Mining</td>
<td>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.</td>
</tr>
<tr>
<td>890</td>
<td>Independent Study</td>
<td>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.</td>
</tr>
<tr>
<td>891</td>
<td>Selected Topics</td>
<td>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.</td>
</tr>
<tr>
<td>898</td>
<td>Master's Project</td>
<td>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.</td>
</tr>
<tr>
<td>902</td>
<td>Selected Topics in Recognition by Machine</td>
<td>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.</td>
</tr>
<tr>
<td>910</td>
<td>Selected Topics in Computer Networks and Distributed Systems</td>
<td>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.</td>
</tr>
<tr>
<td>912</td>
<td>Advanced Topics in Distributed Computing Systems</td>
<td>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.</td>
</tr>
</tbody>
</table>
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 Computer Science or Electrical Engineering majors. 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.