232 Introduction to Programming II
Fall, Spring. 4(3-2) P: CSE 231 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. 10(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

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 undergraduate students in the Department of Computer Science and Engineering or in the Lyman Briggs Computer Science Coordinating Major or in the Lyman Briggs Computer Science major or in the Computer Science Disciplinary Teaching Minor. SA: CPS 320
Organization and architecture of computer systems. Arithmetic Logic Unit and control unit implementation. Hardwired and microprogrammed control. Pipelined processors; data and branch hazards. Memory hierarchy and storage devices. Input-output and peripheral devices. Advanced architectures.

335 Object-oriented Software Design
Fall, Spring. 3(3-0) P: CSE 232 and CSE 260 R: Open only to students in Computer Science or Computer Engineering or the LBS Computer Science field of concentration or the LBS Computer Science coordinate major or the Computer Science disciplinary minor. SA: CSE 370
Interdisciplinary Topics in CyberSecurity
Fall. 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.

Software Engineering
Fall. 3(3-0) P: CSE 320 and CSE 331 and CSE 335 R: Open only to students in the Department of Computer Science or the Computer Engineering or LBS Computer Science major or the LBS Computer Science coordinate major or the Computer Science disciplinary teaching minor. SA: CSE 470
Software lifecycle including specification, design, coding, testing, and verification of a software product. Stepwise refinement and traceability. Software maintenance and documentation.

Introduction to Artificial Intelligence
Fall. 3(3-0) P: CSE 331 or CSE 335 R: Open only to students in the Department of Computer Science and Engineering or the Computer Engineering major or the LBS Computer Science field of concentration or the LBS Computer Science coordinate major or the Computer Science disciplinary teaching minor. SA: CPS 440

Information Technology Project Management
Spring. 3(3-0) Interdepartmental with Information Technology Management and Telecommunication. Administered by Information Technology Management. P: ITM 311 R: Open to students in the Information Technology Specialization. Practical training and experiences in design, testing, and launch of new information technologies and systems.

Translation of Programming Languages
Spring. 3(3-0) P: (CSE 331 or CSE 335) and (CSE 320 or ECE 331) R: Open only to students in the Department of Computer Science and Engineering or the Computer Engineering major or the LBS Computer Science field of concentration or the LBS Computer Science coordinate major or the Computer Science disciplinary teaching minor. SA: CPS 450

Organization of Programming Languages
Fall. 3(3-0) P: (CSE 331 or CSE 335) and (CSE 320 or ECE 331) R: Open only to students in the Department of Computer Science and Engineering or the Computer Engineering major or the LBS Computer Science field of concentration or the LBS Computer Science coordinate major or the LBS Computer Science field of concentration or the Computer Science disciplinary teaching minor. SA: CPS 452

Computability and Formal Language Theory
Fall, Spring. 3(3-0) P: CSE 331 R: Open only to students in the Department of Computer Science and Engineering or the Computer Engineering major or the LBS Computer Science field of concentration or 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, recursive-ly 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.

Media Processing and Multimedia Computing
Fall. 3(3-0) P: CSE 320 or CSE 331 or CSE 335 R: Open only to students in the Department of Computer Science and Engineering or in the Computer Engineering major or in the Lyman Briggs Computer Science Coordinator or in the Lyman Briggs Computer Science major or in the Computer Science Disciplinary Teaching Minor.

Computer Graphics
Spring. 3(3-0) P: (MTH 234 or LB 220) and (CSE 331 or CSE 335) R: Open to juniors or seniors or graduate students in the Department of Computer Science and Engineering or open to juniors or seniors in the Computer Engineering major or in the Lyman Briggs Computer Science Coordinator or in the Lyman Briggs Computer Science major or in the Computer Science Disciplinary Teaching Minor.
SA: CPS 472

Fundamentals of 3D Game Development
Fall. 3(3-0) P: MTH 234 and (CSE 320 or CSE 331 or CSE 335) R: Open to juniors or seniors or graduate students in the Department of Computer Science and Engineering or in the Computer Engineering major or in the Lyman Briggs Computer Science Coordinator or in the Lyman Briggs Computer Science major.
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.

Database Systems
Spring. 3(3-0) P: CSE 331 and (CSE 320 or CSE 331) R: Open only to students in the Department of Computer Science and Engineering or the Computer Engineering major or in the LBS Computer Science field of concentration or the LBS Computer Science coordinate major or the LBS Computer Science disciplinary teaching minor. 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.

Information Retrieval
Fall. 3(3-0) P: CSE 331 RB: STT 351 R: Open only to students in Computer Science or Computer Engineering or Lyman Briggs Computer Science major.

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 only to students in the Department of Computer Science or the Computer Engineering major. Approval of department; application required. SA: CPS 490
Supervised individual study in an area of computer science.

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: Open only to students in the Department of Computer Science or the Computer Engineering major. Approval of department. SA: CPS 491
Topics selected to supplement and enrich existing courses and lead to the development of new courses.

Collaborative Design (W)
Fall, Spring. 4(2-4) P: (CSE 335 and CSE 410) and completion of Tier I writing requirement) and (CSE 420 or CSE 422 or CSE 435 or CSE 440 or CSE 450 or CSE 452 or CSE 460 or CSE 471 or CSE 472 or CSE 480) R: Open only to students in the Department of Computer Science and Engineering. 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.

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.


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


812 Advanced Operating Systems
Spring. 3(3-0) RB: CSE 410 and CSE 420 R: Open only to Computer Science or Electrical Engineering majors. SA: CPS 812

Parallel and distributed operating systems. Load sharing, scheduling, reliability, recovery, memory management. Distributed file systems, distributed agreement, and object-oriented operating 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


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.

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 R: 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.

842 Natural Language Processing
Spring of odd years. 3(3-0) RB: Programming skills. Basic probability and statistical 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) P: CSE 440 RB: Programming skills. Basic probability and statistical knowledge.

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 R: 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


867 Nature and Practice of Cognitive Science
Spring. 3(3-0) Interdepartmental with Linguistics and Philosophy and Psychology and Zoology. Administered by Zoology. RB: Undergraduate course work in behavioral biology, cognitive psychology, philosophy, linguistics, or artificial intelligence.

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.
Selected Topics in Recognition by Master's Thesis Research

899

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

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.

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) 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 614 RB: Undergraduate courses in software engineering and in logic. R: Open only 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. P: CSE 822 R: Open only to students in the Computer Science and Engineering major or approval of department. SA: CPS 920
Design of high performance computer systems. Seminar format.

921

Advanced Topics in Digital Circuits and Systems
Fall, Spring. 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course. Interdepartmental with Electrical and Computer Engineering. Administered by Electrical and Computer Engineering. SA: EE 921
Topics vary each semester.

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 24 credits. A student may earn a maximum of 99 credits in all enrollments for this course. R: Open only to Computer Science majors. Approval of department. SA: CPS 999
Doctoral dissertation research.