COMPUTER SCIENCE (CS)

CS Class Schedule (https://courses.illinois.edu/schedule/DEFAULT/DEFAULT/CS)

Courses

CS 100 Freshman Orientation credit: 1 Hour. (https://courses.illinois.edu/schedule/terms/CS/100)
Introduction to Computer Science as a field and career for computer science majors. Overview of the field and specific examples of problem areas and methods of solution.

CS 101 Intro Computing: Engrg & Sci credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/101)
Fundamental principles, concepts, and methods of computing, with emphasis on applications in the physical sciences and engineering. Basic problem solving and programming techniques; fundamental algorithms and data structures; use of computers in solving engineering and scientific problems. Intended for engineering and science majors. Prerequisite: MATH 220 or MATH 221.
This course satisfies the General Education Criteria for: Quantitative Reasoning I

CS 102 Little Bits to Big Ideas credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/102)
Same as INFO 102. See INFO 102.

CS 105 Intro Computing: Non-Tech credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/105)
Computing as an essential tool of academic and professional activities. Functions and interrelationships of computer system components: hardware, systems and applications software, and networks. Widely used application packages such as spreadsheets and databases. Concepts and practice of programming for the solution of simple problems in different application areas. Intended for non-science and non-engineering majors. Prerequisite: MATH 112.
This course satisfies the General Education Criteria for: Quantitative Reasoning I

CS 107 Data Science Discovery credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/107)
Same as IS 107 and STAT 107. See STAT 107.
This course satisfies the General Education Criteria for: Quantitative Reasoning I

CS 125 Intro to Computer Science credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/125)
Basic concepts in computing and fundamental techniques for solving computational problems. Intended as a first course for computer science majors and others with a deep interest in computing. Prerequisite: Three years of high school mathematics or MATH 112.
This course satisfies the General Education Criteria for: Quantitative Reasoning I

CS 126 Software Design Studio credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/126)
Fundamental principles and techniques of software development. Design, documentation, testing, and debugging software, with a significant emphasis on code review. Credit is not given for both CS 242 and CS 126. Prerequisite: CS 125. For majors only.

CS 127 Computing Systems credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/127)
Basic concepts in computing and fundamental techniques for solving computational problems. Intended as a first course for computer science majors and others with a deep interest in computing. Prerequisite: Three years of high school mathematics or MATH 112.
This course satisfies the General Education Criteria for: Quantitative Reasoning I

CS 128 Operating Systems credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/128)
Basics of operating systems and process control. Fundamentals of process management, inter-process communication, and security. Prerequisite: CS 125.

CS 129 Data Structures credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/129)
Data abstractions: elementary data structures (lists, stacks, queues, and trees) and their implementation using an object-oriented programming language. Solutions to a variety of computational problems such as search on graphs and trees. Elementary analysis of algorithms. Prerequisite: CS 125 or ECE 220; CS 173 or MATH 213. This course satisfies the General Education Criteria for: Quantitative Reasoning I

CS 130 Intro to Software Engineering credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/130)
Basics of software engineering. Topics include software requirements, project planning, modeling, project organization, software quality, design, implementation, and testing. Prerequisite: CS 125.

CS 131 Computer Organization and Architecture credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/131)
Basics of computer organization and architecture, including registers, instruction formats, instruction sets, addressing modes, and memory system. Prerequisite: CS 125.

CS 132 Architecture of Modern Computers credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/132)
Basics of computer architecture and system design, including instruction set architecture, processor design, memory management, and I/O systems. Prerequisite: CS 125.

CS 133 Discrete Structures credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/133)
Discrete mathematical structures frequently encountered in the study of Computer Science. Sets, propositions, Boolean algebra, induction, recursion, relations, functions, and graphs. Credit is not given for both CS 173 and MATH 213. Prerequisite: One of CS 125, ECE 220; one of MATH 220, MATH 221.

CS 134 Software Engineering credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/134)
Basics of software engineering. Topics include software requirements, project planning, modeling, project organization, software quality, design, implementation, and testing. Prerequisite: CS 125.

CS 135 Computer Architecture credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/135)
Basics of computer architecture and system design, including instruction set architecture, processor design, memory management, and I/O systems. Prerequisite: CS 125.

CS 136 Data Structures and Algorithms credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/136)
Basics of data structures and algorithms. Topics include basic data structures, algorithm analysis, sorting, searching, and recursion. Prerequisite: CS 125.

CS 137 Programming Concepts credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/137)
Basics of computer programming. Topics include programming languages, control structures, data types, algorithms, and problem solving. Prerequisite: CS 125.

CS 138 Computer Organization and Architecture credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/138)
Basics of computer organization and architecture, including registers, instruction formats, instruction sets, addressing modes, and memory system. Prerequisite: CS 125.

CS 139 Software Engineering credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/139)
Basics of software engineering. Topics include software requirements, project planning, modeling, project organization, software quality, design, implementation, and testing. Prerequisite: CS 125.

CS 140 Introduction to Computer Systems credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/140)
Basics of computer systems. Number representations, assembly/machine language, abstract models of processors (fetch/execute, memory hierarchy), processes/process control, simple memory management, file I/O and directories, network programming, usage of cloud services. Prerequisite: CS 225 or both CS 205 and CS 110C++.

CS 141 System Programming credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/141)
Basics of system programming, including POSIX processes, process control, inter-process communication, synchronization, signals, simple memory management, file I/O and directories, shell programming, socket network programming, RPC programming in distributed systems, basic security mechanisms, and standard tools for systems programming such as debugging tools. Credit is not given for both CS 241 and ECE 391. Prerequisite: CS 225 and CS 233.

Information listed in this catalog is current as of 05/2019
CS 242  Programming Studio  credit: 3 Hours. ([link](https://courses.illinois.edu/schedule/terms/CS/242))
Intensive programming lab intended to strengthen skills in programming. Prerequisite: CS 241.

CS 296  Honors Course  credit: 1 Hour. ([link](https://courses.illinois.edu/schedule/terms/CS/296))
Group projects for honors credit in computer science. Sections of this course are offered in conjunction with other 200-level computer science courses taken concurrently. A special examination may be required for admission to this course. May be repeated. Prerequisite: Concurrent registration in another 200-level computer science course (see Schedule).

CS 357  Numerical Methods I  credit: 3 Hours. ([link](https://courses.illinois.edu/schedule/terms/CS/357))
Fundamentals of numerical methods for students in science and engineering: floating-point computation, systems of linear equations, approximation of functions and integrals, the single nonlinear equation, and the numerical solution of ordinary differential equations; various applications in science and engineering; programming exercises and use of high quality mathematical library routines. Same as MATH 357. Credit is not given for both CS 357 if credit for CS 450 has been earned. (Counts for advanced hours in LAS). Prerequisite: One of CS 101, CS 105 or CS 125; MATH 241; one of MATH 225, MATH 415, MATH 416 or ASRM 406.

CS 361  Probability & Statistics for Computer Science  credit: 3 Hours. ([link](https://courses.illinois.edu/schedule/terms/CS/361))
Introduction to probability theory and statistics with applications to computer science. Topics include: visualizing datasets, summarizing data, basic descriptive statistics, conditional probability, independence, Bayes theorem, random variables, joint and conditional distributions, expectation, variance and covariance, central limit theorem. Markov inequality, Chebyshev inequality, law of large numbers, Markov chains, simulation, the PageRank algorithm, populations and sampling, sample mean, standard error, maximum likelihood estimation, Bayesian estimation, hypothesis testing, confidence intervals, linear regression, principal component analysis, classification, and decision trees. Same as STAT 361. Credit is not given for both CS 361 and ECE 313. Prerequisite: MATH 220 or MATH 221; credit or concurrent registration in one of MATH 225, MATH 415 or MATH 416. For majors only.

CS 374  Introduction to Algorithms & Models of Computation  credit: 4 Hours. ([link](https://courses.illinois.edu/schedule/terms/CS/374))
Analysis of algorithms, major paradigms of algorithm design including recursive algorithms, divide-and-conquer algorithms, dynamic programming, greedy algorithms, and graph algorithms. Formal models of computation including finite automata and Turing machines. Limitations of computation arising from fundamental notions of algorithm and from complexity-theoretic constraints. Reductions, undecidability and NP-completeness. Same as ECE 374. Prerequisite: CS 241. Credit is not given for both CS 374 and CSE 307.

CS 397  Individual Study  credit: 1 to 3 Hours. ([link](https://courses.illinois.edu/schedule/terms/CS/397))
May be repeated. Prerequisite: Consent of instructor.

CS 398  Special Topics  credit: 1 to 4 Hours. ([link](https://courses.illinois.edu/schedule/terms/CS/398))
Subject offerings of new and developing areas of knowledge in computer science intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. May be repeated in the same or separate terms if topics vary.

CS 410  Text Information Systems  credit: 3 or 4 Hours. ([link](https://courses.illinois.edu/schedule/terms/CS/410))
Theory, design, and implementation of text-based information systems. Text analysis, retrieval models (e.g., Boolean, vector space, probabilistic), text categorization, text filtering, clustering, retrieval system design and implementation, and applications to web information management. 3 or 4 graduate hours. Prerequisite: CS 225.

CS 411  Database Systems  credit: 3 or 4 Hours. ([link](https://courses.illinois.edu/schedule/terms/CS/411))
Examination of the logical organization of databases: the entity-relationship model; the hierarchical, network, and relational data models and their languages. Functional dependencies and normal forms. Design, implementation, and optimization of query languages; security and integrity; concurrency control, and distributed database systems. 3 or 4 graduate hours. Prerequisite: CS 225.

CS 412  Introduction to Data Mining  credit: 3 or 4 Hours. ([link](https://courses.illinois.edu/schedule/terms/CS/412))
Concepts, techniques, and systems of data warehousing and data mining. Design and implementation of data warehouse and on-line analytical processing (OLAP) systems; data mining concepts, methods, systems, implementations, and applications. 3 or 4 graduate hours. Prerequisite: CS 225.

CS 413  Intro to Combinatorics  credit: 3 or 4 Hours. ([link](https://courses.illinois.edu/schedule/terms/CS/413))
Same as MATH 413. See MATH 413.

CS 414  Multimedia Systems  credit: 3 or 4 Hours. ([link](https://courses.illinois.edu/schedule/terms/CS/414))
Organization and structure of modern multimedia systems; audio and video encoding; quality of service concepts; scheduling algorithms for multimedia within OS and networks multimedia protocols over high-speed networks; synchronization schemes, user-interface design; multimedia teleservices. 3 or 4 graduate hours. Prerequisite: CS 241 or ECE 391.

CS 418  Interactive Computer Graphics  credit: 3 or 4 Hours. ([link](https://courses.illinois.edu/schedule/terms/CS/418))
Basic mathematical tools and computational techniques for modeling, rendering, and animating 3-D scenes. Same as CSE 427. 3 or 4 graduate hours. Prerequisite: CS 225; MATH 225 or MATH 415; MATH 416.

CS 419  Production Computer Graphics  credit: 3 or 4 Hours. ([link](https://courses.illinois.edu/schedule/terms/CS/419))
Advanced methods for representing, displaying, and rendering two-, three-, and four-dimensional scenes. General algebraic curves and surfaces, splines, Gaussian and bump-function representation, fractals, particle systems, constructive solid geometry methods, lighting models, radiosity, advanced ray-tracing methods, surface texture animation techniques, data visualization methods. 3 or 4 graduate hours. Prerequisite: CS 418.

CS 420  Parallel Progrmng: Sci & Engrg  credit: 3 or 4 Hours. ([link](https://courses.illinois.edu/schedule/terms/CS/420))
Fundamental issues in design and development of parallel programs for various types of parallel computers. Various programming models according to both machine type and application area. Cost models, debugging, and performance evaluation of parallel programs with actual application examples. Same as CSE 402 and ECE 492. 3 or 4 graduate hours. Prerequisite: CS 225.
CS 421 Programming Languages & Compilers  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/421)
Structure of programming languages and their implementation. Basic language design principles; abstract data types; functional languages; type systems; object-oriented languages. Basics of lexing, parsing, syntax-directed translation, semantic analysis, and code generation. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 223 or CS 240; CS 374.

CS 422 Programming Language Design  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/422)
Exploration of major language design paradigms using imperative and functional programming as unifying themes. Tools include both practical language processor construction and theoretical models. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 421.

CS 423 Operating Systems Design  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/423)
Organization and structure of modern operating systems and concurrent programming concepts. Deadlock, virtual memory, processor scheduling, and disk systems. Performance, security, and protection. Same as CSE 423. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 241 or ECE 391.

CS 424 Real-Time Systems  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/424)
Supervisory control aspects of Cyber Physical Systems (CPS): fundamentals of reliability analysis, real-time scheduling, simple feedback control, software fault tolerance architecture, wireless networking and energy saving, principles of safety critical system engineering. Student groups design and demonstrate supervisory control architecture for a robot. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 241.

CS 425 Distributed Systems  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/425)
Protocols, specification techniques, global states and their determination, reliable broadcast, transactions and commitment, security, and real-time systems. Same as ECE 428. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 241 or ECE 391.

CS 426 Compiler Construction  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/426)
Compiler structure, syntax analysis, syntax-directed translation, automatically constructed recognizers, semantic analysis, code generation, intermediate language, optimization techniques. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 421.

CS 427 Software Engineering I  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/427)
Software process, analysis and design. Software development paradigms, system engineering, function-based analysis and design, and object-oriented analysis and design. Course will use team-projects for hands-on exercises. Same as CSE 426. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 225 and CS 373.

CS 428 Software Engineering II  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/428)
Continuation of CS 427. Software development, management, and maintenance. Project and configuration management, collaborative development models, software quality assurance, interoperability domain engineering and software reuse, and software re-engineering. Same as CSE 429. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 427.

CS 429 Software Engineering II, ACP  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/429)
Continuation of CS 427. Identical to CS 428 except for the additional writing component. See CS 428. 3 undergraduate hours. 3 graduate hours. Prerequisite: CS 427.
This course satisfies the General Education Criteria for: Advanced Composition

CS 430 Artificial Intelligence  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/430)
Major topics in and directions of research in artificial intelligence: AI languages (LISP and PROLOG), basic problem solving techniques, knowledge representation and computer inference, machine learning, natural language understanding, computer vision, robotics, and societal impacts. Same as ECE 448. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 225 or ECE 391.

CS 431 Embedded Systems  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/431)
A survey of sampled data systems and embedded architecture; key concepts in common embedded system applications; signal processing and control; embedded microprocessor and device interface; time-critical I/O handling; data communications; real-time operating systems and techniques for the development and analysis of embedded real-time software; hands-on laboratory projects. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 241 or ECE 391.

CS 432 Computer System Organization  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/432)
Computer hardware design and analysis and interface with software. Advanced processor design, including superscalar, out-of-order issue, branch prediction, and speculation. Memory hierarchy design, including advanced cache optimizations, main memory, and virtual memory. Principles of multiprocessor design, including shared-memory, cache coherence, synchronization, and consistency. Other advanced topics depending on time; e.g., GPUs and accelerators, warehouse computers and data centers, security. Same as CSE 422. 3 undergraduate hours. 4 graduate hours. Prerequisite: CS 233.

CS 433 Communication Networks  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/433)
Layered architectures and the OSI Reference Model; design issues and protocols in the transport, network, and data link layers; architectures and control algorithms of local-area, point-to-point, and satellite networks; standards in networks access protocols; models of network interconnection; overview of networking and communication software. Same as ECE 438. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 241 or ECE 391; one of ECE 313, MATH 461, MATH 463.

CS 434 Computer Networking Laboratory  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/434)
Same as ECE 435. See ECE 435.

CS 435 Computer Networking  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/435)
Computer hardware design and analysis and interface with software. Advanced processor design, including superscalar, out-of-order issue, branch prediction, and speculation. Memory hierarchy design, including advanced cache optimizations, main memory, and virtual memory. Principles of multiprocessor design, including shared-memory, cache coherence, synchronization, and consistency. Other advanced topics depending on time; e.g., GPUs and accelerators, warehouse computers and data centers, security. Same as CSE 422. 3 undergraduate hours. 4 graduate hours. Prerequisite: CS 233.

CS 436 Distributed Systems  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/436)
Protocols, specification techniques, global states and their determination, reliable broadcast, transactions and commitment, security, and real-time systems. Same as ECE 428. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 241 or ECE 391.

CS 437 Compiler Construction  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/437)
Compiler structure, syntax analysis, syntax-directed translation, automatically constructed recognizers, semantic analysis, code generation, intermediate language, optimization techniques. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 421.

CS 438 Computer System Organization  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/438)
Computer hardware design and analysis and interface with software. Advanced processor design, including superscalar, out-of-order issue, branch prediction, and speculation. Memory hierarchy design, including advanced cache optimizations, main memory, and virtual memory. Principles of multiprocessor design, including shared-memory, cache coherence, synchronization, and consistency. Other advanced topics depending on time; e.g., GPUs and accelerators, warehouse computers and data centers, security. Same as CSE 422. 3 undergraduate hours. 4 graduate hours. Prerequisite: CS 233.

CS 439 Wireless Networks  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/439)
Layered architectures and the OSI Reference Model; design issues and protocols in the transport, network, and data link layers; architectures and control algorithms of local-area, point-to-point, and satellite networks; standards in networks access protocols; models of network interconnection; overview of networking and communication software. Same as ECE 438. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 241 or ECE 391; one of ECE 313, MATH 461, MATH 463.

CS 440 Software Engineering II, ACP  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/440)
Continuation of CS 427. Identical to CS 428 except for the additional writing component. See CS 428. 3 undergraduate hours. 3 graduate hours. Prerequisite: CS 427.
This course satisfies the General Education Criteria for: Advanced Composition

CS 441 Computer Vision  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/441)
Computer vision techniques to enhance, manipulate, and create media from photo collections, such as panoramic stitching, face morphing, texture synthesis, blending, and 3D reconstruction. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 225, MATH 225, and MATH 231.

Information listed in this catalog is current as of 05/2019
CS 446 Machine Learning  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/446)
Theory and basic techniques in machine learning. Major theoretical paradigms and key concepts developed in machine learning in the context of applications such as natural language and text processing, computer vision, data mining, adaptive computer systems and others. Review of several supervised and unsupervised learning approaches: methods for learning linear representations; on-line learning, Bayesian methods; decision-trees; features and kernels; clustering and dimensionality reduction. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 447 and LING 406. Credit is not given for both CS 447 and LING 406. Recommended: CS 374.

CS 447 Natural Language Processing  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/447)
Part-of-speech tagging, parsing, semantic analysis and machine translation. Relevant linguistics concepts from morphology (word formation) and lexical semantics (the meaning of words) to syntax (sentence structure) and compositional semantics (the meaning of sentences). 3 undergraduate hours. 3 or 4 graduate hours. Credit is not given for both CS 447 and LING 406. Prerequisite: CS 374.

CS 450 Numerical Analysis  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/450)
Linear system solvers, optimization techniques, interpolation and approximation of functions, solving systems of nonlinear equations, eigenvalue problems, least squares, and quadrature; numerical handling of ordinary and partial differential equations. Same as CSE 401, ECE 491, and MATH 450. 3 undergraduate hours. 3 or 4 graduate hours. Credit is not given for both CS 450 and CS 457. Prerequisite: CS 101 or CS 125; CS 357 or MATH 415; MATH 285.

CS 457 Numerical Methods II  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/457)
Continuation of CS 357. Orthogonalization methods for least squares, Krylov subspace methods, non-linear equations and optimization in multiple dimensions, initial and boundary value problems for ordinary and partial differential equations. 3 undergraduate hours. No graduate credit. Credit is not given for both CS 457 and CS 450. Prerequisite: CS 357.

CS 460 Security Laboratory  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/460)
Operating systems security: access control, least privilege mechanism and malware techniques. Network security: firewalls, sniffing, tunnels, intrusion detection, AAA and worm structure. System security: forensics security architectures, and attack/defend exercises. Complements CS 461 via hands-on project. Same as ECE 419. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 461.

CS 461 Computer Security I  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/461)
Fundamental principles of computer and communications security and information assurance: ethics, privacy, notions of threat, vulnerabilities, and risk in systems, information warfare, malicious software, data secrecy and integrity issues, network security, trusted computing, mandatory and discretionary access controls, certification and accreditation of systems against security standards. Security mechanisms: authentication, auditing, intrusion detection, access control, cryptography, security protocols, key distribution. Same as ECE 422. 4 undergraduate hours. 4 graduate hours. Prerequisite: CS 241 or ECE 391.

CS 463 Computer Security II  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/463)
Program security, trusted base, privacy, anonymity, non-interference, information flow, confinement, advanced auditing, forensics, intrusion detection, key management and distribution, policy composition and analysis, formal approaches to specification and verification of secure systems and protocols, and topics in applied cryptography. Same as ECE 424. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 461. Recommended: CS 475.

CS 465 User Interface Design  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/465)
A project-focused course covering fundamental principles of user interface design, implementation, and evaluation. Small teams work on a term-long project that involves: analysis of the problem domain, user skills, and tasks; iterative prototyping of interfaces to address user needs; conducting several forms of evaluation such as cognitive walkthroughs and usability tests; implementation of the final prototype. Non-technical majors may enroll as non-programmers who participate in all aspects of the projects with the possible exception of implementation. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 225.

CS 466 Introduction to Bioinformatics  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/466)
Algorithmic approaches in bioinformatics: (i) biological problems that can be solved computationally (e.g., discovering genes, and interactions among different genes and proteins); (ii) algorithmic techniques with wide applicability in solving these problems (e.g., dynamic programming and probabilistic methods); (iii) practical issues in translating the basic algorithmic ideas into accurate and efficient tools that biologists may use. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 225.

CS 467 Social Visualization  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/467)
Visualizing social interaction in networked spaces: investigation of patterns in networked communications systems such as messaging (email, instant messaging), social networking sites and collaborative sites; social network theory and visualizations; exploration of how to move beyond existing visualization techniques; visualizing the network identity over compilations of online data. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 225.

CS 468 Tech and Advertising Campaigns  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/468)
Same as ADV 492. See ADV 492.

CS 473 Algorithms  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/473)
Design and analysis techniques, approximation algorithms, randomized algorithms and amortized analysis, and advanced topics such as network flow, linear programming, and dynamic data structures, among others. Same as CSE 414 and MATH 473. 4 undergraduate hours. 4 graduate hours. Prerequisite: CS 374, and one of CS 361, MATH 461, or STAT 400.

CS 475 Formal Models of Computation  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/475)
Finite automata and regular languages; pushdown automata and context-free languages; Turing machines and recursively enumerable sets; linear-bounded automata and context-sensitive languages; computability and the halting problem; undecidable problems; recursive functions; Chomsky hierarchy; computational complexity. Same as MATH 475. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 374.
CS 475 Program Verification credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/476)
Formal methods for demonstrating correctness and other properties of programs. Invariant assertions; Hoare axiomatics; well-founded orderings for proving termination; structural induction; computational induction; data structures; parallel programs; overview of predicate calculus. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 225; CS 374 or MATH 414.

CS 477 Formal Software Devel Methods credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/477)
Mathematical models, languages, and methods for software specification, development, and verification. Same as ECE 478. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 225; CS 373 or MATH 414.

CS 481 Advanced Topics in Stochastic Processes & Applications credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/481)
Same as IE 410. See IE 410.

CS 482 Simulation credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/482)
Same as IE 413. See IE 413.

CS 483 Applied Parallel Programming credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/483)
Same as CSE 408 and ECE 408. See ECE 408.

CS 484 Parallel Programming credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/484)
Techniques for the programming of all classes of parallel computers and devices including shared memory and distributed memory multiprocessors, SIMD processors and co-processors, and special purpose devices. Key concepts in parallel programming such as reactive and transformational programming, speculation, speedup, isoefficiency, and load balancing. Synchronization primitives, libraries and languages for parallel programming such as OpenMP and MPI, performance monitoring, program tuning, analysis and programming of numerical and symbolic parallel algorithms. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 241.

CS 491 Seminar credit: 0 to 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/491)
Seminar on topics of current interest as announced in the Class Schedule. 0 to 4 undergraduate hours. 0 to 4 graduate hours. Approved for S/U grading only. May be repeated in the same or separate terms if topics vary to a maximum of 4 hours. Prerequisite: As specified for each topic offering, see Class Schedule or departmental course description.

CS 492 Senior Project I credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/492)
First part of a project course in computer science. Students work in teams to solve typical commercial or industrial problems. Work involves planning, design, and implementation. Extensive oral and written work is required both on-campus and possibly off-campus at sponsors' locations. CS 492 must be taken as a sequence with either CS 493 or CS 494. 3 undergraduate hours. No graduate credit. Credit is not given for both CS 492 and a project course in another engineering department for the same project. Prerequisite: For Computer Science majors with senior standing.

CS 493 Senior Project II, ACP credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/493)
Continuation of CS 492. Identical to CS 494 except for an additional writing component. See CS 494. 3 undergraduate hours. No graduate credit. Credit is not given for both CS 493 and a project course in another engineering department for the same project. Prerequisite: CS 492. This course satisfies the General Education Criteria for: Advanced Composition

CS 494 Senior Project II credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/494)
Continuation of CS 492. 3 undergraduate hours. No graduate credit. Credit is not given for both CS 494 and a project course in another engineering department for the same project. Prerequisite: CS 492.

CS 497 CS Team Project credit: 1 to 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/497)
Student teams work with CS faculty to complete a significant project requiring advanced knowledge of CS principles. Project topics vary. 1 to 3 undergraduate hours. No graduate credit. May be repeated in the same term up to 6 hours, if topics vary; may be repeated in separate terms. Prerequisite: For majors only: junior or senior standing required.

CS 498 Special Topics credit: 1 to 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/498)
Subject offerings of new and developing areas of knowledge in computer science intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. 1 to 4 undergraduate hours. 1 to 4 graduate hours. May be repeated in the same or separate terms if topics vary.

CS 499 Senior Thesis credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/CS/499)
Research and thesis development experience in computer science under guidance of a faculty member. Literature search, oral presentation, analysis and implementation, paper preparation, and completion of a written thesis. 3 undergraduate hours. No graduate credit. May be repeated to a maximum of 6 hours. Prerequisite: Consent of instructor. This course satisfies the General Education Criteria for: Advanced Composition

CS 508 Manycore Parallel Algorithms credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/508)
Same as ECE 508. See ECE 508.

CS 510 Advanced Information Retrieval credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/510)
Advanced concepts, models, and algorithms in information retrieval and major recent developments in the field, including historical milestones in information retrieval research, evaluation methodology, vector space retrieval model, probabilistic retrieval models, learning to rank algorithms, probabilistic topic models, information retrieval systems, text analytics, and topics of research frontiers in information retrieval. 4 graduate hours. No professional credit. Prerequisite: One of CS 410, CS 412, CS 446 or LING 406.

CS 511 Advanced Data Management credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/511)
Advanced concepts in data management and information system design and implementation, and recent developments in the field. 1) Relational roots, objects and extensibility, query languages, data indexing, query processing, transaction processing, benchmarks, and 2) semi-structured data and unstructured data, information extraction, information integration, web search and mining, and other emerging directions in the field. Prerequisite: CS 411.
**CS 512** Data Mining Principles credit: 4 Hours. ([courses.illinois.edu/schedule/terms/CS/512](https://courses.illinois.edu/schedule/terms/CS/512))

An advanced course on principles and algorithms of data mining. Data cleaning and integration; descriptive and predictive mining; mining frequent, sequential, and structured patterns; clustering, outlier analysis and fraud detection; stream data, web, text, and biomedical data mining; security and privacy in data mining; research frontiers. Prerequisite: CS 412.

**CS 513** Theory & Practice of Data Cleaning credit: 4 Hours. ([courses.illinois.edu/schedule/terms/CS/513](https://courses.illinois.edu/schedule/terms/CS/513))

Same as IS 532. See IS 532.

**CS 519** Scientific Visualization credit: 4 Hours. ([courses.illinois.edu/schedule/terms/CS/519](https://courses.illinois.edu/schedule/terms/CS/519))

Visualization techniques useful in analysis of engineering and scientific data. Physical models; methods of computational science; two- and three-dimensional data types; visual representation schemes for scalar, vector, and tensor data; iso-surface and volume visualization methods; visual monitoring; interactive steering. Same as CSE 527. Prerequisite: CS 418.

**CS 522** Programming Language Semantics credit: 4 Hours. ([courses.illinois.edu/schedule/terms/CS/522](https://courses.illinois.edu/schedule/terms/CS/522))

Theory of programming languages including functional programming, meta-circular interpreters, typed, untyped and polymorphic lambda-calculi, and denotational semantics. Prerequisite: CS 422 and CS 426.

**CS 523** Advanced Operating Systems credit: 4 Hours. ([courses.illinois.edu/schedule/terms/CS/523](https://courses.illinois.edu/schedule/terms/CS/523))

Advanced concepts in operating system design and coverage of recent research directions. Resource management for parallel and distributed systems. Interaction between operating system design and computer architectures. Process management, virtual memory, interprocess communication, context switching, parallel and distributed file system designs, persistent objects, process and data migration, load balancing, security, protection. Term projects. Prerequisite: CS 423, CS 425, and CS 433.

**CS 524** Concurrent Progrm Languages credit: 4 Hours. ([courses.illinois.edu/schedule/terms/CS/524](https://courses.illinois.edu/schedule/terms/CS/524))

Theory of concurrency and concurrent programming languages. Formal models of concurrent computation such as process algebras, nets, and actors; high level concurrent programming languages and their operational semantics; methods for reasoning about correctness and complexity of concurrent programs. Prerequisite: CS 422; CS 475 or CS 476.

**CS 525** Advanced Distributed Systems credit: 4 Hours. ([courses.illinois.edu/schedule/terms/CS/525](https://courses.illinois.edu/schedule/terms/CS/525))

Peer-to-peer systems, sensor networks, and fundamental theoretical distributed computing. Review of classical work in each area, and application of design methodologies to explore overlaps across them. Emphasis on protocol design, systems issues, and theory. Reading selections are roughly two-thirds classical to one-third contemporary. Students write critiques, make presentations, and create a conference paper in a systematic manner. Prerequisite: One of CS 423, CS 425, CS 438.

**CS 526** Advanced Compiler Construction credit: 4 Hours. ([courses.illinois.edu/schedule/terms/CS/526](https://courses.illinois.edu/schedule/terms/CS/526))

Incremental and interactive compiling, error correction, code optimization, models of code generators. Prerequisite: CS 426.
CS 547  Deep Learning  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/547)
Same as IE 534. See IE 534.

CS 548  Models of Cognitive Processes  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/548)
Formal models and concepts in automated cognition; integrating
machine learning and prior knowledge; current approaches and detailed
analyses of the role of reasoning in the learning process; computational
complexity and fundamental tradeoffs between expressiveness and
tractability; implications for state-of-the-art artificial intelligence areas
such as automated planning, the semantic web, relational learning,
structured prediction, latent models, structure learning, theory formation,
etc.; philosophical and psychological aspects of integrating analytic
and empirical evidence. Same as ECE 548. Prerequisite: CS 440 or CS 446.

CS 549  Seminar in Cognitive Science  credit: 2 or 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/549)
Same as PSYC 514, ANTH 514, EPSY 551, LING 570, and PHIL 514. See
PSYC 514.

CS 554  Parallel Numerical Algorithms  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/554)
Numerical algorithms for parallel computers: parallel algorithms in
numerical linear algebra (dense and sparse solvers for linear systems
and the algebraic eigenvalue problem), numerical handling of ordinary
and partial differential equations, and numerical optimization techniques.
Same as CSE 512. Prerequisite: One of CS 450, CS 457, CS 555.

CS 555  Numerical Methods for PDEs  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/555)
Numerical techniques for initial and boundary value problems in partial
differential equations. Finite difference and finite element discretization
techniques, direct and iterative solution methods for discrete problems,
and programming techniques and usage of software packages. Same as
CSE 510. Prerequisite: CS 450 or CS 457.

CS 556  Iterative & Multigrid Methods  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/556)
Comprehensive treatment of algebraic and multigrid iterative methods
to solve systems of equations, primarily linear equations arising from
discretization of partial differential equations. Same as CSE 511.

CS 558  Topics in Numerical Analysis  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/558)
Advanced topics in numerical analysis selected from areas of current
research. Same as CSE 513. May be repeated. Prerequisite: As specified
for each topic offering, see Schedule or departmental course description.

CS 563  Advanced Computer Security  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/563)
Current research trends in computer and network security. Privacy,
tamper-resistance, unwanted traffic, monitoring and surveillance, and
critical infrastructure protection. Subtopics will vary depending upon
current research trends. Students work in teams in close coordination
with the course instructor to develop one of the topics in depth by
carrying out background research and an exploratory project. Same as
ECE 524. Prerequisite: CS 461 or CS 463.

CS 565  Human-Computer Interaction  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/565)
In-depth coverage of advanced topics in human-computer interaction
(HCI). Applied models of human performance and attention, design tools
for creative design tasks, interruptions and peripheral displays, gestures,
and bimanual input, and usability evaluation techniques. Students
complete a research-oriented term project of their choosing. Prerequisite:
CS 465.

CS 571  Combinatorial Mathematics  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/571)
Same as MATH 580. See MATH 580.

CS 572  Extremal Graph Theory  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/572)
Same as MATH 581. See MATH 581.

CS 573  Algorithms  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/573)
NP-completeness, design and analysis techniques, approximation
algorithms, randomized algorithms, combinatorial optimization, linear
programming. Intended for graduate students in Computer Science.
Same as CSE 515. 4 graduate hours. No professional credit.

CS 574  Randomized Algorithms  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/574)
Basic and advanced concepts in the design and analysis of randomized
algorithms. Sampling; concentration inequalities such as Chernoff-
Hoeffding bounds; probabilistic method; random walks, dimension
reduction; entropy; martingales and Azuma's inequality; derandomization.
Randomized algorithms for sorting and searching; graphs; geometric
problems. Basics of pseudorandomness and randomized complexity
classes. Prerequisite: CS 473; MATH 461 or STAT 400.

CS 575  Methods of Combinatorics  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/575)
Same as MATH 584. See MATH 584.

CS 576  Topics in Automated Deduction  credit: 2 to 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/576)
Advanced topics in computer-aided methods for formal deduction,
selected from areas of current research, such as: resolution theorem
proving strategies, special relations, equational reasoning, unification
theory, rewrite systems, mathematical induction, program derivation,
hybrid inference systems, and programming with logic. May be repeated
in separate terms. Prerequisite: As specified for each topic offering, see
Schedule or departmental course description.

CS 579  Computational Complexity  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/579)
Turing machines; determinism and non-determinism; time and space
hierarchy theorems; speed-up and tape compression; Blum axioms;
structure of complexity classes NP, P, NL, L, and PSPACE; complete
problems; randomness and complexity classes RP, RL, and BPP;
alternation, polynomial-time hierarchy; circuit complexity; parallel
complexity, NC, and RNC; relativized computational complexity; time-
space trade-offs. Same as ECE 579. Prerequisite: CS 473 or CS 475.

CS 581  Algorithmic Genomic Biology  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/581)
Same as BIOE 540. See BIOE 540.
**CS 583** Approximation Algorithms credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/583)
Approximation algorithms for NP-hard problems. Basic and advanced techniques in approximation algorithm design: combinatorial algorithms; mathematical programming methods including linear and semi-definite programming, local search methods, and others. Algorithms for graphs and networks, constraint satisfaction, packing and scheduling. Prerequisite: CS 573 or consent of instructor.

**CS 584** Embedded System Verification credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/584)
Same as ECE 584. See ECE 584.

**CS 585** Hardware Verification credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/585)
Same as ECE 519. See ECE 519.

**CS 586** Combinatorial Optimization credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/586)
Same as IE 519. See IE 519.

**CS 591** Advanced Seminar credit: 0 to 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/591)
Seminar on topics of current interest as announced in the Class Schedule. Approved for S/U grading only. May be repeated in the same or separate terms if topics vary. Prerequisite: As specified for each topic offering, see Class Schedule or departmental course description.

**CS 597** Individual Study credit: 2 to 16 Hours. (https://courses.illinois.edu/schedule/terms/CS/597)
Individual study or reading in a subject not covered in normal course offerings. May be repeated. Prerequisite: Consent of instructor.

**CS 598** Special Topics credit: 2 to 4 Hours. (https://courses.illinois.edu/schedule/terms/CS/598)
Subject offerings of new and developing areas of knowledge in computer science intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. May be repeated in the same or separate terms if topics vary.

**CS 599** Thesis Research credit: 0 to 16 Hours. (https://courses.illinois.edu/schedule/terms/CS/599)
Approved for S/U grading only. May be repeated.