COMPUTER SCIENCE (CS)

CS 502 - Advanced Programming (3.0 hours)
Introduces the fundamental concepts of programming from an object-oriented perspective with emphasis on advanced programming skills and good software development principles in a closed laboratory setting. Covers topics including object-oriented paradigm, design and programming, fundamental data structures and computing algorithms, and software development principles. If needed, course should be taken during first regular semester at Bradley. Credit for this course does not count towards graduation requirements in any graduate program within the Department of Computer Science and Information Systems.
Prerequisite: Graduate standing in CS or CIS. Consent of graduate program coordinator; at least two semesters of programming experience.

CS 503 - Programming Methodology (3.0 hours)
Predicate calculus, Dijkstra's methodology of algorithm development. Algorithm development. Algorithmic language characteristics; syntax, semantics. Postconditions and preconditions. Verification of postcondition states satisfied by algorithmic programs executed from preconditions.
Prerequisite: Graduate standing in CS or CIS, or senior standing in CS or CIS, or a grade of C or better in both MTH 120 and CS 102.

CS 510 - Numerical Methods (3.0 hours)
Introduction to numerical and computational aspects of various mathematical topics: finite precision, solutions to nonlinear equations, and interpolation, approximation, linear systems of equations, and integration. Cross listed as MTH 510.
Prerequisite: Graduate standing in CS or CIS, or senior standing in CS or CIS, or CS 101 and MTH 207 and MTH 223.

CS 511 - Numerical Methods II (3.0 hours)
Continuation of CS/MTH 510: further techniques of integration, ordinary differential equations, numerical linear algebra, nonlinear systems of equations, boundary value problems, and optimization. Cross listed as MTH 511.
Prerequisite: Graduate standing in CS or CIS, or senior standing in CS or CIS; or MTH 224 or MTH 345, and CS 510 or MTH 510.

CS 514 - Algorithms (3.0 hours)
Design and analysis of algorithms. Dynamic structures maintenance and hashing. Searching, sorting, and traversal. Time and space requirements; simplification; computational complexity; proof theory and testing; NP-hard and NP-complete problems.
Prerequisite: Graduate standing in CS or CIS, or senior standing in CS or CIS, or CS 210 or CIS 210 or equivalent and one semester of statistics.

CS 516 - Programming Languages (3.0 hours)
Design concepts of high-level languages. Description languages; grammars and syntax; expressions and data structures; selection and control structures; constructs for input and output; subprograms and parameter communications.
Prerequisite: Graduate standing in CS or CIS, or senior standing in CS or CIS, or CS 210 or CS 310 or equivalents.

CS 518 - Programming Language Translation (3.0 hours)
Overview of programming language translation with emphasis on modern compiler construction. Lexical analysis, parsing, syntax and semantic analysis, code generation, garbage collection, and optimization.
Prerequisite: Grade of C or better in CS 210 or CIS 210 or equivalent.

CS 520 - Advanced Computer Architecture (3.0 hours)
Fundamental computer sub-systems: central processing unit; memory systems; control and input/output units. General purpose computing systems design. Examples from existing typical computers.
Prerequisite: Graduate standing in CS or CIS, or senior standing in CS or CIS, or CS 220 or equivalent.

CS 531 - Web Development Technologies (3.0 hours)
ntroduction to PERL/CGI, XHTML, XML, JavaScript and scripting languages. Web page design and layout. Client and server side development of web applications. Database connectivity, Java Database Connectivity (JDBC).
Prerequisite: Graduate standing in CS or CIS, or senior standing in CS or CIS, or CS 102 or equivalent.

CS 532 - Advanced Java Computing (3.0 hours)
Developing Web-based systems using J2EE Java technologies. Topics include Java Security, Java GUI development using IDE, Java Servlets and JavaServer Pages, Java Enterprise JavaBeans, XML and Java Web Services, and Java Transaction Service and Java Message Service.
Prerequisite: Graduate standing in CS or CIS, or senior standing in CS or CIS, or CS 531 or equivalent.

CS 541 - Python Programming for Data Science (3.0 hours)
This course will cover programming constructs and features, data structures for data storage, such as sets, tuples, lists, dictionaries, trees and graphs, and algorithms for sorting, information retrieval from tree and graph data structures and search techniques such as binary tree search, depth and breadth depth first search of graphs. The programming language used is Python. Packages like pandas and numpy will also be presented. Assignments will focus on Python programming for natural language processing, machine learning, and data science applications. Students will design, write, test and run computer programs using Python and within an integrated development environment.
Prerequisite: Graduate standing in Data Science and Analytics. Not for CS or CIS students. This course does not count towards graduation requirements for the MS degree in Computer Science or Computer Information Systems.

CS 560 - Fundamentals of Data Science (3.0 hours)
This course will combine two types of problem-solving: inferential thinking, and computational thinking applied to real-world problems. The course teaches critical concepts and skills in computer programming, at an accelerated pace, and an analysis of real-world datasets using statistical inference and a number of machine learning algorithms. The emphasis is on the use of tools and languages for data analysis and modeling.
Prerequisite: Graduate students in Computer Science or Computer Information Systems or Data Science and Analytics, who have taken: one semester of calculus-based statistics (IME 511 or equivalent); two semesters of computer programming or CS 541 or CS 502.

CS 561 - Artificial Intelligence (3.0 hours)
Pattern recognition, search strategies, game playing, knowledge representation; logic programming, uncertainty, vision, natural language processing, robotics, programming in LISP and PROLOG. Advanced topics in artificial intelligence. Cross-listed with CS 461. For cross-listed undergraduate/graduate courses, the graduate-level course will have additional academic requirements beyond those of the undergraduate course.
Prerequisite: Graduate standing in CS or CIS. Consent of instructor for all other students with graduate standing.

CS 562 - Machine Learning (3.0 hours)
Machine learning and intelligent systems. Covers the major approaches to ML and IS building, including the logical (logic programming and fuzzy logic, covering ML algorithms), the biological (neural networks and deep learning, genetic algorithms), and the statistical (regression, Bayesian and belief networks, Markov models, decision trees and clustering) approaches. Students use ML to discover the knowledge base and then build complete, integrated, hybrid intelligent systems for solving problems in a variety of applications. Cross listed with CS 462. For cross-listed undergraduate/graduate courses, the graduate-level course will have additional academic requirements beyond those of the undergraduate course.
Prerequisite: Graduate students in Computer Science or Computer Information Systems or Data Science and Analytics who have taken: CS 560 and two semesters of calculus.

CS 563 - Knowledge Discovery and Data Mining (3.0 hours)
Brings together the latest research in statistics, databases, machine learning, and artificial intelligence that are part of knowledge discovery and data mining. Topics include algorithms for the data cleansing and preprocessing phase, selected supervised machine learning algorithms for modeling forecasting and classification, selected unsupervised machine learning algorithms, trend and deviation analysis, dependency modeling, integrated discovery and ensemble systems, meta-processing (boosting, stacking, etc.) and application case studies. Cross-listed with CS 463. For cross-listed undergraduate/graduate courses, the graduate-level course will have additional academic requirements beyond those of the undergraduate course.
Prerequisite: Graduate students in CS or CIS or Data Science and Analytics who have taken one semester of calculus-based statistics, for example: IME 511 or equivalent.

CS 571 - Database Management Systems (3.0 hours)
Relational database design, including entity relationship modeling and normalization. Structured query language (SQL) for creating and querying databases. Other topics include the theory of relational databases, including relational algebra, various loading and reporting utilities, and the implementation of database management systems, e.g., how query optimization works. Cross-listed with CIS 571.
Prerequisite: Graduate standing in CS or CIS or Data Science and Analytics who have taken CS 541 or two semesters of computer programming.

CS 572 - Distributed Databases and Big Data (3.0 hours)
Designing and building enterprise-wide data warehouses. Cover topics related to large, distributed databases, including designing distributed databases, replicating data, and concurrency. NoSQL, object-oriented, multimedia databases and their query languages. Next generation database systems, data warehousing, and OLAP. Applications using distributed databases like Hadoop and its associated machine learning libraries. Cross-listed with CS 472. For cross-listed undergraduate/graduate courses, the graduate-level course will have additional academic requirements beyond those of the undergraduate course.
Prerequisite: Graduate students in CS or CIS or Data Science and Analytics who have taken: CS 571 and a calculus-based statistics course (for example, IME 511 or equivalent).

CS 590 - Fundamentals of Software Engineering (3.0 hours)
Software engineering: software product; prescriptive process models; system engineering; analysis modeling; design engineering; architectural design; user interface design; testing strategies and techniques; software systems' implementation; software systems' maintenance.
Prerequisite: Graduate standing in CS or CIS, or senior standing in CS or CIS, or CS 390 or equivalent.

CS 591 - Software Project Management (3.0 hours)
Methods of PMBOK-based management of software systems design and development projects, including systems view, main project management process groups and knowledge areas, management plans, project metrics and estimates, tools for project management, project reports and documentation. Cross listed with CIS 491 and CIS 591 courses. For cross listed undergraduate/graduate courses, the graduate level course will have additional academic requirements beyond those of the undergraduate course.
Prerequisite: Graduate standing in CS or CIS, or senior standing in CS or CIS, or CS 390 or equivalent, or consent of instructor.

CS 592 - Requirements Development (3.0 hours)
Covers topics including basic concepts and principles of software requirements engineering, the requirements engineering process, requirements elicitation, requirements analysis, requirements specification, system modeling, requirements validation and requirements management, and techniques, methods, and tools for requirements engineering and software systems requirements modeling (including structured, object-oriented and formal approaches to requirements modeling and analysis).
Prerequisite: Graduate standing in CS or CIS, or senior standing in CS or CIS, or CS 210 or CIS 210 or equivalent, or consent of instructor.

CS 593 - Agile Software Development (3.0 hours)
Agile methodology, agile methods, and agile software engineering, including framework activities, SDLC models, requirements analysis, architectures, services, integrated development environments, testing, and quality issues. Cross listed with CS 493. For cross listed undergraduate/graduate courses, the graduate level course will have additional academic requirements beyond those of the undergraduate course.
Prerequisite: Graduate standing in CS or CIS, or senior standing in CS or CIS, or CS 390 or equivalent.

CS 594 - Capstone Project for Data Science (3.0 hours)
Applies the concepts and skills learned by Data Science and Analytics graduate students at Bradley University. Students are required to work on a team on a significant Data Science project. Cross listed with CS 494. For cross-listed undergraduate/graduate courses, the graduate-level course will have additional academic requirements beyond those of the undergraduate course.
Prerequisite: Graduate Standing in Data Science and Analytics-Computational Data Science concentration (DSA-CD). Taken in the last semester of enrollment.

CS 612 - Automata, Computation and Complexity (3.0 hours)
Theory of formal languages and computability, Automata, Turing machines, grammars. Context free and context sensitive languages; parsing. Recursion theory; limits of effective computability, P and NP class of problems, NP-complete problems. Non Turing computable problems, reducibility, complexity.
Prerequisite: Graduate standing in CS or CIS, or CS 502 or equivalent.

CS 614 - Parallel Algorithms (3.0 hours)
Parallel algorithms for multi-processor computer architectures: concurrent programming, SIMD and MIMD systems, and time complexity.
Prerequisite: Graduate standing in CS or CIS, or CS 514 or equivalent.

CS 625 - Operating Systems Design (3.0 hours)
Advanced concepts in operating system design. Topics include process and thread management, virtual memory, interprocess communication, distributed systems, parallel and distributed file system designs, resource management, and security and protection.
Prerequisite: Graduate standing in CS or CIS, or CS 321 or equivalent.

CS 635 - Data Communications and Networks (3.0 hours)
Fundamentals of data communication, computer network architectures and protocols, wireless networks, network programming, and network security. Emphasis on OSI, TCP/IP, ATM, and IEEE 802 LAN layered architectures, and TCP/IP network programming.
Prerequisite: Graduate standing in CS or CIS, or CS 330 or equivalent.

CS 681 - Professional Practicum in Computer Science (0.0 hours)
Special projects under Smith Career Center supervision on student's professional practicum in corporate/business environment in computer science, with near-term economic benefit. Satisfactory/Unsatisfactory. Minimum of 5-10 hours per week required.
Prerequisite: Graduate CS or CIS student in good standing; consent of department chair and graduate program director.

CS 690 - Advanced Topics in Software Engineering (3.0 hours)
Special software engineering research and development projects under staff supervision. Emphasis on a specific topic and emerging technologies in the software engineering area.
Prerequisite: Graduate standing in CS or CIS, or CS 590 or CS 591 or equivalents, or consent of instructor.

CS 697 - Advanced Topics in Computer Science (3.0 hours)
Special projects under staff supervision on advanced problems in numerical or non-numerical branches of computer science. May be taken more than once under different topics for a maximum of 6 semester hours.
Prerequisite: Consent of instructor.

CS 698 - Directed Individual Studies in Computer Science (1.0-3.0 hours)
Individual study in an area of computer science relevant to the student's professional goals and not covered in a formal course offered by the department. May be repeated twice for a maximum of 6 credit hours.
Prerequisite: Consent of instructor.

CS 699 - Thesis in Computer Science (0.0-6.0 hours)
For graduate students in Computer Science (CS) or Data Science and Analytics-Computational Data Science concentration (DSA-CD). Computer Science or Data Science research and thesis preparation. Required of candidates choosing the thesis option. Total of 6 semester hrs. to be taken in one or two semesters. Any semester after the six hours, the student must register for zero hours to maintain progress, after the thesis advisor's and department chair's approval.
Prerequisite: Consent of department chair