

COMPUTER SCIENCE (CS)

Computer Science (CS) Courses

CS 5013. Fundamentals of Software. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing in Computer Science or consent of instructor. This course is a bridge course for graduate students who do not have a bachelor degree in Computer Science. It cannot be applied to the graduate degrees in computer science. Topics include discrete math, advanced data structure and basic algorithms, such as binary tree and stack, as well as system programming basics and concepts of compilation. This course has Differential Tuition. Course Fee: GS01 \$90.

CS 5023. Fundamentals of Systems. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing in Computer Science or consent of instructor. This course is a bridge course for graduate students who do not have a bachelor degree in Computer Science. It cannot be applied to the graduate degrees in computer science. Topics include basic concepts and knowledge in computer organization, architecture, operating systems and compilers. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 5103. Software Engineering. (3-0) 3 Credit Hours.

Prerequisite: CS 4773 or software development experience. Introduction to methods and tools for the requirements analysis and design stages of software life cycles. Discussion of software requirements including elicitation, modeling notations, analysis, and documentation. Brief overview of process models and project management. Examination of major architectural styles in existing software systems, design methods, design patterns, and reverse engineering. Course will include design experience using CASE tools. This course has Differential Tuition. Course Fee: GS01 \$90.

CS 5113. Computer Graphics. (3-0) 3 Credit Hours.

Prerequisite: CS 3343 and MAT 2233. Topics include display device coordinate system, 2D and 3D geometric transformations, scene interaction and animation, algorithms for drawing primitives such as lines, circles, curves and polygons, perspectives in 3D, hidden-line elimination, interactive lighting models, shadow generation, rendering and global illumination. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 5123. Software Testing and Quality Assurance. (3-0) 3 Credit Hours.

Prerequisite: CS 4773 or software development experience. Introduction of testing techniques for software systems: unit testing, integration testing, system testing, acceptance testing, and regression testing; test plan and test case design; quality assurance; verification and validation. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 5153. User Interfaces and Usability. (3-0) 3 Credit Hours.

Prerequisite: CS 4773 or software development experience. This course focuses on the development of high-quality user interfaces. The course reviews the basics of user interface development, tools, and use-case driven design techniques; examines the elements of good design and usability, metrics for usability, and procedures for user testing. This course has Differential Tuition. Course Fee: GS01 \$90.

CS 5163. Data Science. (3-0) 3 Credit Hours.

Prerequisite: CS 3343 or consent of instructor. This course covers the fundamentals of data science. Topics include data management, data pre-processing, data visualization, data dissemination, and the mathematical and statistical foundations for data modeling. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 5173. Steganography. (3-0) 3 Credit Hours.

Prerequisite: CS 3424 or consent of instructor. Steganography is the science of hiding secret data within innocuous data. This course covers a broad set of background topics including data compression, encryption, hashing, number theory, and human perception. It will also cover techniques for data hiding using image and audio files (e.g., bitmaps, jpegs, and wave files). The course will also explore steganalysis—the detection of hidden data—in various file types. It will also discuss the use of steganography in practice, particularly use by malware. The course includes a course project where a team of students develop and test their own steganography program. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 5183. Software and Malware Reverse Engineering. (3-0) 3 Credit Hours.

Prerequisite: CS 3843, and CS 3113 or CS 3433, or consent of instructor. Reverse engineering in the context of computing is a process through which one attempts to understand how an existing computing system (hardware or software) accomplishes a task or functionality with very little insight, if any, into exactly how it does so. This course provides an introduction to the basic processes and procedures used for reverse engineering of software, hardware and malware. This includes a review of the hexadecimal/decimal/binary numbering systems, two's complement representation, basic logic functions and how they apply to reverse engineering, 32 bit x86 assembly language, stack structure, memory layout and little endian representation. It introduces students to tools for static disassembly such as hex editors, IDA Pro and Ghidra, dynamic debugging using Visual Studio, WinDbg, and other dynamic debugging tools, and binary reversing by covering the PE file format and advanced obfuscation techniques. It discusses relevant advanced topics such as data compression, steganography, forensics, and network analysis. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 5233. Artificial Intelligence. (3-0) 3 Credit Hours.

Prerequisite: CS 3343. This course covers the construction of programs that exhibit intelligence in solving problems. Major topics include searching, game playing, constraint satisfaction, decisions and probabilistic reasoning, machine learning, neural networks, computer vision and natural language understanding. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 5243. Computer Vision. (3-0) 3 Credit Hours.

Prerequisite: CS 3343 and MAT 2233 or an equivalent or consent of instructor. Topics include image formation, geometry and transformations, multi-view geometry and 3D reconstruction, camera calibration, feature detection and matching, estimation and tracking, image classification, object detection, and scene understanding. This course has Differential Tuition. Course Fees: GS01 \$90; IUCS \$45.

CS 5263. Bioinformatics. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing in Computer Science or consent of instructor. Introduction to bioinformatics. Problem areas such as sequence analysis and gene component analysis, structure prediction, gene ontology, phylogenetic inference, gene regulation, and pathway construction and analysis will be approached from a computational viewpoint. (Same as BME 6323. Credit cannot be earned for both BME 6323 and CS 5263.) This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 5323. Principles of Cyber Security. (3-0) 3 Credit Hours.

Prerequisite: CS 3733 and CS 3873. An introduction to the protection of computer systems and networks. Topics include authentication, access controls, malicious logic, formal security methods, assurance and trust in computer systems and networks, firewalls, auditing and intrusion detection, cryptography and information hiding, risk management, computer forensics, and ethics. (Formerly titled Principles of Computer and Information Security.) This course has Differential Tuition. Course Fee: GS01 \$90.

CS 5343. Developing Secure Systems and Software. (3-0) 3 Credit Hours.

Prerequisite: CS 3733. An examination of methods for designing secure computer systems, networks, and software. Topics include the security development process, security policies and models, threat modeling, security code reviews and testing, the formal verification process, validation, and assessments. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 5353. Formal Languages, Automata, and Theory of Computation. (3-0) 3 Credit Hours.

Prerequisite: CS 2233 and CS 3343. Formal models of computation and syntax such as Turing machines, finite automata, non-determinism, formal languages, regular and context free grammars, complexity classes and NP-completeness. This course has Differential Tuition. Course Fee: GS01 \$90.

CS 5363. Programming Languages and Compilers. (3-0) 3 Credit Hours.

Prerequisite: CS 2233 and CS 3343. A study of programming languages with an emphasis on their implementation. Topics include lexical analysis, language syntax, control structures, the binding of names, procedures, and their implementation in compilers. This course has Differential Tuition. Course Fee: GS01 \$90.

CS 5443. Database Management Systems. (3-0) 3 Credit Hours.

Prerequisite: CS 3743. Design and implementation of database management systems. Topics include storage management, query optimization, concurrency control, crash recovery, integrity, and security in relational databases, object-oriented databases, object-relational databases, parallel databases, and distributed databases. This course has Differential Tuition. Course Fee: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

CS 5453. Penetration Testing. (3-0) 3 Credit Hours.

Prerequisite: CS 3873. Introduction to the principles and techniques associated with the cybersecurity practice known as penetration testing or ethical hacking. Topics include planning, reconnaissance, scanning, exploitation, post-exploitation, and result reporting. The student learns to use penetration testing tools, discover system vulnerabilities and avoid exploitation of vulnerabilities. This course has Differential Tuition. Course Fee: GS01 \$90.

CS 5463. Topics in Computer Science. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing in Computer Science or consent of instructor. Topics in an area of computer science. May be repeated for credit when topics vary. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 5473. Data Mining. (3-0) 3 Credit Hours.

Prerequisite: CS 3343 or consent of instructor. Concepts, principles, algorithms, performance, and applications of data mining and knowledge discovery. Topics may include data preprocessing, classification and prediction, clustering analysis, association and pattern analysis, outlier detection, and data mining software. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 5483. Topics in Data Science. (3-0) 3 Credit Hours.

Prerequisite: CS 5163. Specialized topics in an area of data science. May be repeated for credit when topics vary. (Credit cannot be earned for both CS 5483 and CS 4973 on the same topic). This course has Differential Tuition. Course Fee: GS01 \$90.

CS 5493. Large-Scale Data Management. (3-0) 3 Credit Hours.

Prerequisite: Graduate student standing in Computer Science or permission of instructor. Modern big data systems managing 3 Vs of big data (variety, volume, and velocity). Topics include, but not limited to overview of classic data management, web search, information retrieval, MapReduce, data integration, natural language processing at scale. This course has Differential Tuition. Course Fee: GS01 \$90.

CS 5513. Computer Architecture. (3-0) 3 Credit Hours.

Prerequisite: CS 3733 and CS 3853. Study of modern computer architecture, including parallel computers, multiprocessors, pipelines, and fault tolerance. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 5523. Operating Systems. (3-0) 3 Credit Hours.

Prerequisite: CS 3733 and CS 3853. Operating systems concepts with an emphasis on distributed systems. Topics include process management and threads, inter-process communication, distributed objects and remote invocation, distributed naming and directory services, distributed file systems, middleware such as CORBA, access control and security. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 5573. Cloud Computing. (3-0) 3 Credit Hours.

Prerequisite: CS 3733 and CS 3853. Introduction to Cloud Computing. A study of the system architecture, enabling technologies, software environment, and innovative applications of the Cloud Computing paradigm. Topics include data center virtualization, cloud platforms, cloud resource management, cloud programming and software environments, big data processing in the cloud, cloud performance and energy efficiency analysis. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 5593. Multi-Agent Systems. (3-0) 3 Credit Hours.

Prerequisite: CS 5233. This course covers the theory and the approaches where more than one autonomous agent interacts with each other either in a cooperative or competitive manner. Topics include agent theory, agent architecture, agent communication, agent interaction, team organization, distributed rational decision making, and learning in multi-agent environment. This course has Differential Tuition. Course Fee: GS01 \$90.

CS 5623. Simulation Techniques. (3-0) 3 Credit Hours.

Prerequisites: CS 2123 or equivalent, and any statistics course. This course introduces discrete-event simulation techniques, statistical models in simulation, random number generation, input modeling, output analysis and comparisons, and verification and validation of simulation models. Differential Tuition: \$150. Course Fees: GS01 \$90.

CS 5633. Analysis of Algorithms. (3-0) 3 Credit Hours.

Prerequisite: CS 3343. Models of computation and algorithm design and analysis techniques such as divide-and-conquer, greedy algorithms, dynamic programming, graph algorithms, amortized analysis. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 5713. Practical Attack and Defense Techniques. (3-0) 3 Credit Hours.

Prerequisite: CS 5323. This course will provide a comprehensive hands-on experience on various open-source software tools and techniques for conducting information gathering, vulnerability analysis, web application analysis, password cracking, wireless attacks, network sniffing and spoofing, software exploits and reverse engineering, social engineering, forensics and post-exploitation services. This course has Differential Tuition. Course Fee: GS01 \$90.

CS 5723. Crypto Currencies and Bitcoins. (3-0) 3 Credit Hours.

Prerequisite: CS 5323 or any introductory graduate level information/cybersecurity course. Study of public permission-less blockchains and its applications with an emphasis on Bitcoins. Topics include Blockchain fundamentals, Operation of the Bitcoin cryptocurrency, Bitcoin security, User privacy and anonymity in Bitcoin, Bitcoin as a distributed application platform, Bitcoin and cryptocurrency regulation, Future of Bitcoins and cryptocurrencies, Ethereum and Smart Contracts. This course has Differential Tuition. Course Fee: GS01 \$90.

CS 5733. Privacy Enhancing Techniques. (3-0) 3 Credit Hours.

Prerequisite: CS 5323 or permission of instructor. This course will introduce theoretical foundations and practical implementations of the various state-of-the-art privacy enhancing techniques (PETS) that provide web anonymity, location privacy, data privacy, social network privacy and other forms of contextual privacy in traditional web, mobile, internet of things (IoT) and cyber-physical system (CPS) applications. This course has Differential Tuition. Course Fee: GS01 \$90.

CS 5813. Cognitive Neuroscience Inspired Machine Learning. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing in Computer Science or consent of instructor. Study of applying mathematical and computational methodologies toward understanding the human mind, brain and behavior, along with fundamentals of machine learning. Topics include but not limited to (1) Fundamentals for underpinning perception, language, attention mechanisms 2) Cognitive processes of learning and memory 3) Psychology research methods 4) the future applications using cognitive-inspired intelligence ranging from public health to cybersecurity. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 5823. Trust, Confidence and Explainability in Artificial Intelligence. (3-0) 3 Credit Hours.

Prerequisite: CS 3343 or consent of instructor. Study of fundamental methods for understanding strengths and weaknesses of machine learning and AI algorithms, including convolutional networks, recurrent neural networks, transformers and perceivers. Topics for explainability include attribution methods for AI, such as those based on gradients, Hessians, path integrals and Shapley values. Topics in trust and confidence include Platt scaling, temperature scaling, Bayesian networks and more modern calibration approaches based on attributions. Notions such as adversarial attacks, out-of-distribution (OOD) detection, and GANs will be discussed in the context of AI robustness. All concepts will be illustrated using real-world examples from both archival and contemporary literature. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 5893. AI Practicum. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing or consent of instructor. This AI practicum course includes weekly AI seminar which provides insights on the current state of the AI and ML technologies and covers a wide variety of AI topics, such as computer vision, natural language processing (NLP), theoretical ML, AI fairness & ethics, cognitive science, AI hardware, etc. The seminars will include speakers from industry and academia, who discuss the state of the practice with real use cases and methodologies to make AI projects a tangible success. The practicum also offers an experiential training opportunity to apply AI to problems in the real world. Standard AI programming tool suites and design flow concepts will be learned through the mini-project. Students will also be introduced to how AI is impacting society, the ethics of AI solutions, concerns surrounding AI, and deploying AI in complex scenarios. Python programming experience is needed. This course has Differential Tuition. Course Fee: IUCS \$45; GS01 \$90.

CS 5931. Internship in Computer Science. (0-0) 1 Credit Hour.

Prerequisite: An overall 3.0 grade point average, and permission in writing from the instructor, the Department Chair, and the Dean of the College of Sciences. This internship is an opportunity for a semester-long work experience in a private business or public agency in a computer science-related position. Not more than 3 semester credit hours of CS 5931 or CS 5933, and not more than a total of 6 semester credit hours of CS 5931, CS 5933, and CS 6953 may count toward the Master of Science degree or Ph.D. degree in Computer Science. The grade report for this course is either "CR" (satisfactory participation in the internship) or "NC" (unsatisfactory participation in the internship). This course has Differential Tuition. Course Fee: GS01 \$30; IUCS \$15.

CS 5933. Internship in Computer Science. (0-0) 3 Credit Hours.

Prerequisite: An overall 3.0 grade point average, and permission in writing from the instructor, the Department Chair, and the Dean of the College of Sciences. This internship is an opportunity for a semester-long work experience in a private business or public agency in a computer science-related position. Not more than 3 semester credit hours of CS 5931 or CS 5933, and not more than a total of 6 semester credit hours of CS 5931, CS 5933, and CS 6953 may count toward the Master of Science degree or Ph.D. degree in Computer Science. The grade report for this course is either "CR" (satisfactory participation in the internship) or "NC" (unsatisfactory participation in the internship). This course has Differential Tuition. Course Fees: GS01 \$90; IUCS \$45.

CS 5971. Directed Research. (0-0) 1 Credit Hour.

Prerequisite: Graduate standing in Computer Science and permission in writing (form available) from the instructor and the Graduate Advisor of Record. The directed research course may involve either a laboratory or a theoretical problem. May be repeated for credit, but not more than 6 hours of CS 5971, CS 5972, CS 5973, and CS 6953, regardless of discipline, will apply to a degree. This course has Differential Tuition. Course Fee: GS01 \$30; IUCS \$15.

CS 5972. Directed Research. (0-0) 2 Credit Hours.

Prerequisite: Graduate standing in Computer Science and permission in writing (form available) from the instructor and the Graduate Advisor of Record. The directed research course may involve either a laboratory or a theoretical problem. May be repeated for credit, but not more than 6 semester credit hours of CS 5971, CS 5972, CS 5973, and CS 6953, regardless of discipline, will apply to a degree. This course has Differential Tuition. Course Fees: GS01 \$60; IUCS \$30.

CS 5973. Directed Research. (0-0) 3 Credit Hours.

Prerequisite: Graduate standing in Computer Science and permission in writing (form available) from the instructor and the Graduate Advisor of Record. The directed research course may involve either a laboratory or a theoretical problem. May be repeated for credit, but not more than 6 semester credit hours of CS 5971, CS 5972, CS 5973, and CS 6953, regardless of discipline, will apply to a degree. This course has Differential Tuition. Course Fees: GS01 \$90; IUCS \$45.

CS 6133. Software Specification and Verification. (3-0) 3 Credit Hours.

Prerequisite: CS 5103. This course introduces the theory and practice of formal methods for the specification and verification of computer-based systems. It emphasizes various techniques for modeling behavior of sequential and concurrent systems and reasoning about properties of models using automated analysis tools. This course has Differential Tuition. Course Fee: GS01 \$90; LRS1 \$46.20; STSI \$7.20.

CS 6243. Machine Learning. (3-0) 3 Credit Hours.

Prerequisite: CS 3343 or consent of instructor. This course is a study of fundamental concepts and methods of machine learning. The strengths, weaknesses, and challenges of several machine learning algorithms will be covered. Topics include regression analysis, support-vector machine, dimensionality reduction, clustering, decision tree, k-nearest neighbor, neural networks, and other advanced topics selected by the instructor. This course has Differential Tuition. Course Fees: GS01 \$90; IUCS \$45.

CS 6263. Natural Language Processing. (3-0) 3 Credit Hours.

Prerequisite: CS 6243 or consent of the instructor. This course will explore various algorithms, topics, and applications related to natural language processing. The topics such as N-gram language models, Sentiment Classification, Vector Semantics, Embedding, Sequence Labeling, Parsing, and Coreference Resolution will be explored. Moreover, this course will cover a range of NLP applications such as Automatic Speech recognition and Text-to-Speech, Chatbots and Dialogue Systems, Question Answering, Machine Translation, Recommender Systems, etc. This course will also cover how the blending of statistical techniques and neural networks continues to provide performance gain for NLP tasks. This course has Differential Tuition. Course Fees: GS01 \$90; IUCS \$45.

CS 6273. Parallel Algorithms. (3-0) 3 Credit Hours.

Prerequisite: CS 3343. Study of various design techniques and representative algorithms on shared memory and network models of parallel computation, and possibly, a few emerging topics in distributed and network computing arena. Topics may include algorithms for sorting, searching, selection, trees, graphs, data structures, etc., and new and emerging models and applications. This course has Differential Tuition. Course Fee: GS01 \$90.

CS 6283. Deep Learning. (3-0) 3 Credit Hours.

Prerequisite: MAT 2233 and CS 5163 or consent of instructor. This course studies machine learning techniques in the area of artificial intelligence. Topics include neural networks, convolution networks, recurrent neural networks (RNNs), LSTM, generative and adversarial models, model training and validation, model dropout, and learning algorithms. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 6313. Deep Reinforcement Learning. (3-0) 3 Credit Hours.

Prerequisite: CS 5233 and CS 6283, or consent of instructor. This course covers the theory and the approaches to building autonomous agents that learn to act and accomplish goals in dynamic environments. Topics include Markov decision processes (MDPs), learning behavioral policies, policy gradients, policy iteration, value iteration, agent explorations vs. exploitation, Q learning, and DNN for RL. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 6323. Cybersecurity Models and Systems. (3-0) 3 Credit Hours.

Prerequisite: CS 5323 or permission of instructor. Advanced coverage of core cybersecurity and privacy principles, models and technologies, and their applications in designing and building practical scalable systems. Emphasis on recently deployed and emerging cyber technologies and applications. This course has Differential Tuition. Course Fee: GS01 \$90.

CS 6333. Cybersecurity Data Analytics. (3-0) 3 Credit Hours.

Prerequisite: CS 4373. Study on analyzing cybersecurity data to extract useful cybersecurity intelligence and information. Topics may include intrusion detection methods, anomaly detection methods, adversarial machine learning, malware detection methods, adversarial malware detection methods, and time series methods. Emphasis is on explaining cybersecurity meanings of phenomena and properties exhibited by cybersecurity data. This course has Differential Tuition. Course Fee: GS01 \$90.

CS 6343. Cyber Risk Management. (3-0) 3 Credit Hours.

Prerequisite: CS 5323. Real-world cyber defenders and chief information/cybersecurity officers often need to make decisions in both operations and investments. This course aims to prepare next generation cyber defenders and chief information/cybersecurity officers with the-way-of-thinking in coping with cyber risks and the state-of-the-art in cyber risk management and decision-making. This course aims to prepare students with the body of knowledge that is needed for accomplishing such tasks and understanding and managing cyber risks. The course systematically describes the various kinds of cyber risks, strategies for mitigating these cyber risks, methodologies for qualitative and quantitative cyber risk management, and principles and approaches for making cost-effective (if not optimal) decisions. This course has Differential Tuition. Course Fee: GS01 \$90.

CS 6353. Network and System Security. (3-0) 3 Credit Hours.

Prerequisite: CS 5323 or permission of instructor. This course is a review of cryptographic primitives. Study of network security protocols at different network layers including but not limited to IPsec, SSL/TLS and Kerberos. Public-key infrastructure in theory and practice. Firewalls, virtual private networks, denial of service countermeasures, and intrusion detection. Identity, authentication and access management protocols, models and standards, and their practical applications. This course has Differential Tuition. Course Fees: GS01 \$90; IUCS \$45.

CS 6373. Applied Cryptography. (3-0) 3 Credit Hours.

Prerequisite: CS 5323. A course in applied cryptography with an emphasis on applying cryptographic techniques to solve real-world problems. Topics include a review of cryptographic primitives such as symmetric and asymmetric (public-key) cryptosystems, digital signatures, pseudo-random sequences, and hash functions. An emphasis will be placed on utilizing advanced protocols to solve problems such as key management in various environments and applications. This course has Differential Tuition. Course Fee: GS01 \$90.

CS 6383. Quantum Machine Learning. (3-0) 3 Credit Hours.

Prerequisite: CS 3343 or consent of instructor. This course covers quantum computing, qubits, and important illustrative examples of quantum algorithms such as Grover search and Variational Quantum algorithms. Data representations in quantum computers, such as amplitude encoding, time-evolution encoding, and Hamiltonian encoding. Variational Quantum Classifiers and quantum neural networks. Quantum kernels and kernel-based training. Ising models and quantum annealing. Fault-tolerance in quantum machine learning. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 6393. Advanced Topics in Computer Security. (3-0) 3 Credit Hours.

Prerequisite: CS 5323. Analysis of computer security. The topics may include but are not limited to database and distributed systems security, formal models for computer security, privacy and ethics, intrusion detection, critical infrastructure protection, network vulnerability assessments, wireless security, trusted computing, and highly dependable systems. May be repeated for credit when topics vary. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 6463. Advanced Topics in Computer Science. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing in Computer Science and consent of instructor. Advanced topics in an area of computer science. May be repeated for credit when topics vary. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 6513. Advanced Architecture. (3-0) 3 Credit Hours.

Prerequisite: CS 5513 and CS 5523. Areas of study include advanced architectures, including massively parallel and distributed systems. Issues of communication, fault tolerance, and performance are addressed. This course has Differential Tuition. Course Fee: GS01 \$90; LRS1 \$46.20; STSI \$7.20.

CS 6543. Networks. (3-0) 3 Credit Hours.

Prerequisite: CS 5523. This course introduces the underlying concepts and principles of modern computer networks, with emphasis on protocols, architectures and implementation issues in the internet. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 6553. Performance Evaluation. (3-0) 3 Credit Hours.

Prerequisite: CS 5513 and CS 5523. This course introduces analytical modeling, simulation analysis, and experimental evaluation of computer systems and networks. Particular emphasis will be placed on the analysis and design of medium- to large-scale distributed computer systems and networks. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 6643. Parallel Processing. (3-0) 3 Credit Hours.

Prerequisite: CS 5513. Parallel models of computation, performance measurement, and modeling of parallel algorithms and application studies on parallel computers. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 6663. Advanced Parallel Processing and Systems. (3-0) 3 Credit Hours.

Prerequisite: CS 5513 and CS 5523. An advanced parallel computing course focusing on large-scale data processing. Topics may include parallel processing with non-CPU processors (such as GPUs, FPGAs, Application-specific Circuits), large-scale Non-Uniform Memory Access architectures, parallel data-processing frameworks, non-volatile memory chips and large-scale public clouds. This course has Differential Tuition. Course Fee: GS01 \$90.

CS 6953. Independent Study. (0-0) 3 Credit Hours.

Prerequisite: Graduate standing in Computer Science and permission in writing (form available) from the instructor and the Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours of CS 5971, CS 5973, and CS 6953, regardless of discipline, will apply to a degree. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 6961. Comprehensive Examination. (0-0) 1 Credit Hour.

Prerequisite: Approval of the Graduate Program Committee to take the Comprehensive Examination. Independent study course for the purpose of taking the Comprehensive Examination. May be repeated as many times as approved by the Graduate Program Committee. Enrollment is required each term in which the Comprehensive Examination is taken if no other courses are being taken that term. The grade report for the course is either "CR" (satisfactory performance on the Comprehensive Examination) or "NC" (unsatisfactory performance on the Comprehensive Examination). This course has Differential Tuition. Course Fee: GS01 \$30; IUCS \$15.

CS 6981. Master's Thesis. (0-0) 1 Credit Hour.

Prerequisite: Consent of thesis advisor. Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress. This course has Differential Tuition. Course Fee: GS01 \$30; LRS1 \$5; STSI \$5.

CS 6983. Master's Thesis. (0-0) 3 Credit Hours.

Prerequisite: Consent of thesis advisor. Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 7123. Research Methods. (3-0) 3 Credit Hours.

Prerequisite: Doctoral Student standing. Examine and learn practical research skills and research writing techniques. Review, present, and critique recent research publications in the areas of Computer Science. May be repeated for credit. May not be counted towards the Master of Science degree in Computer Science. This course has Differential Tuition. Course Fee: GS01 \$90.

CS 7211. Doctoral Research. (0-0) 1 Credit Hour.

Prerequisite: Doctoral Student standing and consent of Doctoral Advisor. May be repeated, a minimum of 18 hours is required for the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 \$30; IUCS \$15.

CS 7212. Doctoral Research. (0-0) 2 Credit Hours.

Prerequisite: Doctoral Student standing and consent of Doctoral Advisor. May be repeated, a minimum of 18 hours is required for the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 \$60; IUCS \$30.

CS 7213. Doctoral Research. (0-0) 3 Credit Hours.

Prerequisite: Doctoral Student standing and consent of Doctoral Advisor. May be repeated, a minimum of 18 hours is required for the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 7216. Doctoral Research. (0-0) 6 Credit Hours.

Prerequisite: Successful completion of the Doctoral Qualifying Examination. May be repeated, a minimum of 18 hours is required for the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 \$180; IUCS \$90.

CS 7311. Doctoral Dissertation. (0-0) 1 Credit Hour.

Prerequisite: Admission to candidacy for the Doctoral degree. May be repeated, a minimum of 9 hours is required for the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 \$30; IUCS \$15.

CS 7312. Doctoral Dissertation. (0-0) 2 Credit Hours.

Prerequisite: Admission to candidacy for the Doctoral degree. May be repeated, a minimum of 9 hours is required for the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 \$60; IUCS \$30.

CS 7313. Doctoral Dissertation. (0-0) 3 Credit Hours.

Prerequisite: Admission to candidacy for the Doctoral degree. May be repeated, a minimum of 9 hours is required for the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 \$90; IUCS \$45.

CS 7316. Doctoral Dissertation. (0-0) 6 Credit Hours.

Prerequisite: Admission to candidacy for the Doctoral degree. May be repeated, a minimum of 9 hours is required for the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 \$180; IUCS \$90.