COMPUTER SCIENCE (CS)

CS 6010. Principles of Design. 3 Credit Hours.
This is an interactive hands-on course that will teach students the principles of design at the individual level.

CS 6035. Introduction to Information Security. 3 Credit Hours.
A broad spectrum of information security: threats, basic cryptography, software vulnerabilities, programming for malice, operating system protections, network security, privacy, data mining, computer crime.

CS 6150. Computing For Good. 3 Credit Hours.
Exploring challenges faced by underserved populations and developing countries from a computing perspective.

CS 6200. Graduate Introduction to Operating Systems. 3 Credit Hours.
This course teaches operating system abstractions, mechanisms, and their implementations, including for concurrency (threads) and synchronization, resource management (CPU, memory, I/O), and distributed services.

CS 6210. Advanced Operating Systems. 3 Credit Hours.
Introduction to graduate-level topics in operating systems using research papers, textbook excerpts, and projects. Provides students thorough comprehension of distributed and parallel computer systems. Credit is not awarded for both CS 4210 and CS 6210.

CS 6211. System Design for Cloud Computing. 3 Credit Hours.
Through in-depth presentations and hands-on projects for each layer of the full stack of cloud technologies, learners acquire the systems design skills for cloud computing.

CS 6220. Big Data Systems and Analytics. 3 Credit Hours.
This course will cover the concepts, techniques, algorithms, and systems of big data systems and data analytics, with strong emphasis on big data processing systems, fundamental models and optimizations for data analytics and machine learning, which are widely deployed in real world big data analytics and applications.

CS 6230. High-Performance Parallel Computing: Tools and Applications. 3 Credit Hours.
Introduction to MIMD parallel computation, using textbook excerpts, research papers, and projects on multiple parallel machines. Emphasizes practical issues in high-performance computing.

CS 6235. Real-Time System Concepts and Implementation. 3 Credit Hours.
Principles of real-time systems, as occurring in robotics and manufacturing, interactive, and multimedia applications. Reviews and uses real-time operating systems.Credit not awarded for both CS 6235 and CS 4220.

CS 6238. Secure Computer Systems. 3 Credit Hours.
Design principles of secure systems, authentication, access control and authorization, discretionary and mandatory security policies, secure kernel design, and secure databases.

CS 6239. Enterprise Cybersecurity Management. 3 Credit Hours.
The duties and concerns of an enterprise Chief Information Security Officer including strategy, cybersecurity operations, risk management, and governance.

CS 6241. Design and Implementation of Compilers. 3 Credit Hours.
Design and implementation of modern compilers, focusing upon optimization and code generation.

CS 6245. Compiling for Parallelism. 3 Credit Hours.
Design and implementation of compilers for parallel and distributed computers, focusing upon optimization and code generation.

CS 6246. Object-Oriented Systems and Languages. 3 Credit Hours.
Design and implementation of object-oriented systems. Aspect-oriented programming, type systems, OO language implementation (virtual dispatch, GC), OO language design (genericity, reflection, mixins).

CS 6250. Computer Networks. 3 Credit Hours.
Principles and practice of computer networks, including signaling and framing, error control, medium access, routing, congestion control, end-to-end transport, and network APIs.

CS 6255. Principles of Network Management. 3 Credit Hours.
Focus on network, system, and applications management. Principles and practice of various network management standards will be presented. Course includes project assignment.

CS 6260. Applied Cryptography. 3 Credit Hours.
Cryptographic algorithms, cryptanalysis, symmetric cryptography, public key cryptography, DES, AES, RSA, hash and MAC functions, digital signatures, pseudo-random generators, cryptographic protocols, SSL// TLS, SET. Credit not allowed for both CS 6260 and ECE 6280.

CS 6261. Security Operations and Incident Response. 3 Credit Hours.
The course covers the principles and technologies utilized in and the processes followed in responding to cybersecurity incidents and crises. The course utilizes real-life case studies to develop how these technologies and processes are applied within the cybersecurity industry.

CS 6262. Network Security. 3 Credit Hours.
Design principles of secure network protocols and systems, authentication, integrity, confidentiality, privacy, information hiding, digital watermarking, access control, firewall, intrusion detection, and case studies.

CS 6263. Intro to Cyber-Physical Systems Security. 3 Credit Hours.
This course provides an introduction to security issues relating to various cyber-physical systems including industrial control systems and those considered critical infrastructure systems.

CS 6264. Information Security Lab: System and Network Defenses. 3 Credit Hours.
This course will help students develop both in-depth knowledge and hands-on skills in a number of important cybersecurity areas, including software security, malware and threat analysis, end-point security, network security, web security, mobile security, and machine learning based security analytics.

CS 6265. Information Security Lab: Binary Exploitation. 3 Credit Hours.
This course covers advanced techniques for writing exploits, taught through an intense, hands-on security laboratory, following a cyberspace war game called Capture-The-Flag.

CS 6266. Information Security Practicum. 5 Credit Hours.
Capstone independent study placing each student in a commercial, industrial, academic, or government setting where they must solve real-world security problems.

CS 6267. Critical Infrastructures Security and Resilience. 3 Credit Hours.
Critical infrastructures are large cyber-physical networks essential to the well-being of the societies they serve. We study their resilience and security against a range of disruptions.

CS 6268. Psychology of Cybersecurity. 3 Credit Hours.
This course will explore psychological processes relevant to cybersecurity. Students will gain an appreciation for psychological influence factors inherent in the current cyberspace environment.

CS 6269. Formal Models and Methods for Information Assurance. 3 Credit Hours.
Logical foundations of high-assurance systems, formal models for access control, authentication, and trust; techniques for constructing high-assurance systems.

CS 6270. Technical Introduction to Blockchain and Cryptocurrencies. 3 Credit Hours.
Graduate Introduction to Blockchain and cryptocurrencies, building on formal crypto and distributed systems. Cover fundamental and practical aspects. Includes programming projects and research presentation.

CS 6271. Cybersecurity of Drones. 3 Credit Hours.
The course covers introductory topics in the security and privacy of cyber-physical systems especially unmanned aerial vehicles (UAVs) or drones. The goal is to expose students to fundamental security primitives specific to cyber-physical systems.

CS 6280. Performance Evaluation of Communication Networks. 3 Credit Hours.
Methods for evaluating the performance of communication networks with emphasis on modeling, mathematical analysis, computer simulation, and measurement.

CS 6290. High-Performance Computer Architecture. 3 Credit Hours.
Topics concerning very high-performance computers including techniques exploiting parallelism in single and multiple processor systems. Credit not allowed for both CS 6290 and any of the following courses: CS 4290, ECE 4100, ECE 6100.

CS 6291. Embedded Software Optimizations. 3 Credit Hours.
First, this course introduces the student to embedded domain-specific processor and instruction set design issues. Next, machine-specific optimizations for performance and for energy consumption are discussed.

CS 6300. Software Development Process. 3 Credit Hours.
The process of developing software systems. Includes development and assessment of processes, their instantiation in actual product development, and techniques ensuring quality of developed products.

CS 6301. Advanced Topics in Software Engineering. 3 Credit Hours.
This project-based course will cover fundamental principles, advanced techniques, and tools for the development of high-quality, industrial-strength software.

CS 6310. Software Architecture and Design. 3 Credit Hours.
Principles and concepts involved in the design and analysis of large software systems.

CS 6320. Software Requirements Analysis and Specification. 3 Credit Hours.
Methods and principles for determining, documenting, analyzing, and formally specifying requirements for software systems.

CS 6330. Software Generation, Testing, and Maintenance. 3 Credit Hours.
Introduction to methods and principles for programming, testing, and managing the evolution of software systems.

CS 6340. Advanced Topics in Software Analysis and Testing. 3 Credit Hours.
Fundamental prinicples and advanced techniques for static and dynamic program analysis and software testing. Software reliability, resilience, and trustworthiness.

CS 6365. Introduction to Enterprise Computing. 3 Credit Hours.
Survey of basic software concepts and techniques used in mission-critical systems and applications, combined with in-depth study of fundamental principles underlying enterprise computing. Credit not allowed for both CS 6365 and CS 4365.

CS 6390. Programming Language Design. 3 Credit Hours.
Design, structure, and goals of programming languages. Object-oriented, logic, functional, and traditional languages. Semantic models. Parallel programming languages.

CS 6400. Database Systems Concepts and Design. 3 Credit Hours.
Study of fundamental concepts with regard to relational databases. Topics covered include database design, query processing, concurrency control, and recovery. Credit not given for both CS 6400 and CS 6754.

CS 6402. Databases and Information Security. 3 Credit Hours.
Fundamentals of designing and using databases: conceptual data models to database-specific models, SQL, storage structures. Security-related topics include privacy, access control, backup, recovery, SQL injection. Credit not allowed for both CS 6402 and CS 4400.

CS 6411. Object-Oriented Database Models and Systems. 3 Credit Hours.
Study of advanced database concepts as they apply to object-oriented database systems. Topics include semantic data models, object-oriented query languages, tools, and applications.

CS 6421. Temporal, Spatial and Active Databases. 3 Credit Hours.
Study of advanced database concepts for temporal databases with emphasis on storage structure, processing and query languages, as well as active database concepts and implementation.

CS 6422. Database System Implementation. 3 Credit Hours.
Design and implementatuion of a databse system covering: storage manager, query optimizer, transaction manager, and recovery manager. Study of the advantages of different implementation algorithms. Credit not allowed for both CS 6422 and CS 4420.

CS 6423. Advanced Database System Implementation. 3 Credit Hours.
Study of advanced topics in implementing a database system, including the query optimizer, concurrency control and recovery protocols. Includes a project component.

CS 6430. Parallel and Distributed Database Systems and Applications. 3 Credit Hours.
Study of algorithms and performance in advanced databases. Systems include parallel, distributed, and client-server databases. Applications include data mining and on-line analytical processing.

CS 6435. Digital Health Equity. 3 Credit Hours.
This course introduces individual, interpersonal, and societal influences on health; how these create health disparities, and how digital health technologies can help achieve health equity.

CS 6440. Information to Health Informatics. 3 Credit Hours.
A broad review of the US health system and the application of informatics to the clinical practice of medicine, digital imaging, public health and bioinformatics.

CS 6441. Personal Health Informatics. 3 Credit Hours.
This course will cover the design of personal health technologies. Students will apply the taught design issues to a semester-long health application design project.

CS 6451. Introduction to Human-Centered Computing. 3 Credit Hours.
Introduction to the range of issues across the HCC disciplines, including design and research methodologies: cognitive, social, and cultural theories; assessment and evaluation: ethical issues.

CS 6452. Prototyping Interactive Systems. 3 Credit Hours.
Introduction to design, prototyping and implementation of systems for human-centered computing. Focuses on core concepts in computer science and implications for interactive systems.

CS 6454. Qualitative Methods for Design of Human Computer Interaction. 3 Credit Hours.
Qualitative methods for HCI including data collection through interviews, observations and design, analysis using research and industry standards, and methods for communicating findings to industry.

CS 6455. User Interface Design and Evaluation. 3 Credit Hours.
Examines usability in the software development process with an emphasis on usability, requirements, methodology, design, and evaluation.

CS 6456. Principles of User Interface Software. 3 Credit Hours.
Considers the architectural and algorithmic principles behind the implementation of interactive software systems and the tools that support them. Credit not awarded for CS 6456 and CS 4470.

CS 6457. Video Game Design and Programming. 3 Credit Hours.
Techniques for electronic game design and programming, including graphics, game engines, animation, behavioral control for autonomous characters, interaction, social and interface issues of multi-user play. Credit not allowed for both CS 6457 and CS 4455.

CS 6460. Educational Technology: Conceptual Foundations. 3 Credit Hours.
Introduction to educational technology, with an emphasis on theoretical foundations. Introduces basic philosophies, approaches, and technologies. Analyzes issues surrounding technology's impact on education. Credit not awarded for both CS 4660 and CS 6460.

CS 6461. CS Education Research. 3 Credit Hours.
Introduction to computing education research (CER). History and influential early work. Learning goals for different populations. Design of research studies in CER.

CS 6465. Computational Journalism. 3 Credit Hours.
Technology is rapidly affecting how news information is gathered, reported, visualized, aggregated, summarized, distributed, and consumed. This class studies the computational technologies that impact journalism. Credit not allowed for both CS 6455 and CS 4464.

CS 6470. Design of Online Communities. 3 Credit Hours.
Introduction to the design of online communities. Students study an existing community in depth, and then develop a new community design. Credit not allowed for both CS 6470 and CS 4472.

CS 6471. Computational Social Science. 3 Credit Hours.
This graduate seminar focuses on text and network analysis of data with applications to domains such as political science, sociolinguistics, and public health.

CS 6474. Social Computing. 3 Credit Hours.
Design and prototype new social computing systems, as well as analyze social media data.

CS 6475. Computational Photography. 3 Credit Hours.
This class explores the impact of computation on the entire workflow of photography, from how light is captured by a camera, to how the images are processed, enhanced, and improved to generate novel photographs.

CS 6476. Introduction to Computer Vision GR. 3 Credit Hours.
Introduction to computer vision including fundamentals of image formation, camera imaging geometry, feature detection and matching, stereo, motion estimation and tracking, image classification and scene understanding. Credit not awarded for both CS 6476 and CS 4495 or CS 4476.

CS 6480. Computer Visualization Techniques. 3 Credit Hours.
Principles, techniques, and practice in data, information, multivariate, and scientific visualization. Includes visualization methods, data structures, examples, and tools.

CS 6485. Visualization Methods for Science and Engineering. 3 Credit Hours.
Algorithms, software, and practical applications of visualization techniques in science, engineering, business, and medicine. Includes data structures, multivariate visualization, interactive visualization, and visual representations and examples. Computer science students cannot receive credit for this course.

CS 6491. Foundations of Computer Graphics. 3 Credit Hours.
Mathematical/physical/perceptual principles and modeling/rendering techniques used to create, represent, display, and animate models of 3D shapes and their properties.

CS 6492. Shape Grammars. 3 Credit Hours.
Shape grammars are production systems using shape rewriting rules to perform computations with shapes.

CS 6497. Computational Aesthetics. 3 Credit Hours.
Aesthetics play a key role in society and economy. Students will invent and test beautification algorithms for colors, music, and animations and more.

CS 6505. Computability, Algorithms, and Complexity. 3 Credit Hours.
Important concepts from computability theory; techniques for designing algorithms for combinatorial, algebraic, and number-theoretic problems; basic concepts such as NP-Completeness from computational complexity theory. Credit not awarded for both CS 6505 and CS 4540/6515.

CS 6515. Introduction to Graduate Algorithms. 3 Credit Hours.
Design and analysis of algorithms on a graduate level, including dynamic programming, divide and conquer, FFT, graph and flow algorithms, RSA, linear programming, and NP-completedness.

CS 6520. Computational Complexity Theory. 3 Credit Hours.
Introduction to resource-bounded computations, central complexity-theoretic concepts such as complexity classes, reducibility, completeness, and intractability.

CS 6550. Design and Analysis of Algorithms. 3 Credit Hours.
Advanced techniques for designing and analyzing efficient algorithms for combinatorial, algebraic, and number-theoretic problems.

CS 6601. Artificial Intelligence. 3 Credit Hours.
Basic concepts and methods of artificial intelligence including both symbolic/conceptual and numerical/probabilistic techniques.

CS 6603. AI, Ethics, and Society. 3 Credit Hours.
This course covers various Artificial Intelligence and bias mitigation techniques that can be used to counterbalance the potential misuse and abuse of learning from data.

CS 6641. Personal Health Informatics Personal Health Informatics. 3 Credit Hours.
This course will cover the design of personal health technologies. Students will apply the taught design issues to a semester-long health application design project.

CS 6670. Distributed Control Algorithms. 3 Credit Hours.
Algorithms for synchronous, asynchronous, and partially synchronous networks; analysis, control, and implementation of distributed systems such as robot fleets, animal groups.

CS 6675. Advanced Internet Computing Systems and Applications. 3 Credit Hours.
Survey of basic Internet computing concepts and techniques used in Internet systems and applications, combined with in-depth study of fundamental principles underlying Internet computing. Credit not allowed for both CS 6675 and CS 4675.

CS 6705. Applications of Artificial Intelligence. 3 Credit Hours.
A study of the principles and practice of artificial intelligence in areas other than computer science, with particular focus on engineering, science, and business applications. Computer science majors cannot receive credit for this course.

CS 6725. Information Security Strategies and Policies. 3 Credit Hours.
Information security vulnerabilities and risks; legal, cost, privacy, and technology constraints; derivation of strategies; technical and procedural means of achieving desired ends. Credit not awarded for both CS 6725 and CS 4725/MGT 4725/6725/PUBP 4725/6725.

CS 6726. Privacy, Technology, Policy, and Law. 3 Credit Hours.
This course takes a multi-disciplinary approach to privacy, a topic of great interest in the technology, policy, ethics, law, and business realms. Credit will not be awarded for both CS 6726 and CS 4726 or MGT 4726 or MGT 6726.

CS 6727. Cyber Security Practicum. 5 Credit Hours.
Capstone independent study project placing each student in a commercial, academic or government setting where he or she identifies a major cyber security problem, and explores and evaluates a solution that addresses it with realistic assumptions about the organizational context. The chose problem must be approved by course instructor. Cross-listed with ECE and PUBP 6727.

CS 6730. Data Visualization: Principles and Applications. 3 Credit Hours.
Introductory course on design principles and applications of data visualization. This course teaches best practices for visualizing datasets from diverse domains intended to help people make sense of data. Students cannot receive credit for both CS 6730 and CS 4460.

CS 6745. Information and Communication Technologies and Global Development. 3 Credit Hours.
Focus on technology design, adoption, and use as seen through the lens of global development.

CS 6747. Advanced Topics in Malware Analysis. 3 Credit Hours.
This course covers advanced approaches for the analysis of malicious software and explores recent research and unsolved problems in software protection and forensics.

CS 6750. Human-Computer Interaction. 3 Credit Hours.
Describes the characteristics of interaction between humans and computers and demonstrates techniques for the evaluation of user-centered systems. Crosslisted with PSYC 6750.

CS 6753. Human-Computer Interaction-Professional Preparation and Practice. 1 Credit Hour.
Preparation for a professional career in HCI. Hands-on workshops in resume and portfolio building, interviewing, public speaking, team work. HCI career choices and trajectories.

CS 6754. Engineering Database Management Systems. 3 Credit Hours.
Modeling and managing engineering information systems, integration of design and manufacturing functions in engineering product development, logical models of engineering product and processes. Credit not given for CS 6400 and CS 6754. Crosslisted with ME 6754.

CS 6755. Human-Computer Interaction Foundations. 3 Credit Hours.
Describes the theory and practice of designing effective and efficient interactions between people and technology. Students do not receive credit for both CS 6755 and PSYC 6755.

CS 6756. Human-Computer Interaction Applications. 3 Credit Hours.
This course supports MS-HCI students in a semester-long team project that is research-focused and results in portfolio-ready artifacts.

CS 6763. Design of Design Environments. 3 Credit Hours.
Analysis of design processes; analysis of current design tools at both the user interface and functional levels; procedures for developing better design tools. Credit not allowed for both CS 6763 and ID 6763 or COA 6763.

CS 6764. Geometric Modeling. 3 Credit Hours.
Software development course focusing on 3D geometric constructions and modeling; emphasizes solid modeling and its role in design. Crosslisted with COA 6764.

CS 6770. Mixed Reality Experience Design. 3 Credit Hours.
Introduction to the design of Mixed Reality experiences. Focuses on informal design, integration of media theory, HCI and technology issues. Significant group design projects.Credit not awarded for both CS 6770 and CS 4770/LMC 4733/6340.

CS 6780. Medical Image Processing. 3 Credit Hours.
A study of methods for enhancing, analyzing, interpreting, and visualizing information from two- and three-dimensional data obtained from a variety of medical image modalities. Crosslisted with ECE and BMED 6780.

CS 6795. Introduction to Cognitive Science. 3 Credit Hours.
Multidisciplinary perspectives on cognitive science. Interdisciplinary approaches to issues in cognition, including memory, language, problem solving, learning, perception, and action. Crosslisted with ISYE and PSYC 6795.

CS 6998. HCI Master's Project. 1-9 Credit Hours.

CS 6999. Master's Project. 1-9 Credit Hours.
Final project for students completing a master's degree in the College of Computing. Repeatable for multi-semester projects.

CS 6XXX. Computer Sci Elective. 1-21 Credit Hours.

CS 7000. Master's Thesis. 1-21 Credit Hours.

CS 7001. Overview of Graduate Studies in Computing. 5 Credit Hours.
Research tools including computer systems, as well as fundamental problem-solving skills, are introduced. Lectures on current computing research are presented and projects are required. Credit not allowed in a program of study for a graduate degree.

CS 7110. Parallel Computer Architectures. 3 Credit Hours.
Issues in the design, implementation, and programming of parallel machines. Credit not allowed for both CS 7110 and CS 4233.

CS 7210. Distributed Computing. 3 Credit Hours.
Fundamental concepts in distributed systems, including global states, logical clocks, and failure models. Distributed algorithms and their implementations using advanced distributed programming systems.

CS 7230. Systems Software Design, Implementation, and Evaluation. 3 Credit Hours.
Design, implementation, and evaluation of systems software. Distributed/parallel applications will be constructed and evaluated using the systems support that is developed.

CS 7250. Broadband Networking Systems. 3 Credit Hours.
Focus on the data link layer and its relationship to layers below and above. Gigabit Ethernet, SONTET, fibre channel; media including wireless, satellite, xDSL, cable.

CS 7260. Internetworking Architectures and Protocols. 3 Credit Hours.
Detailed discussion of the problems and solution techniques that arise in internetworking. Topics include routing, addressing, quality of service, and security.

CS 7270. Networked Applications and Services. 3 Credit Hours.
End-to-end functional building blocks and their use in adaptive and non-adaptive applications, including multimedia: coding, compression, security, directory services.

CS 7280. Network Science: Methods and Applications. 3 Credit Hours.
Characteristics of real networks in nature and technology, network measurement methods, network analysis, evolving networks, dynamic network processes, co-evolution of structure and function.

CS 7290. Advanced Topics in Microarchitecture and organization of high-performance processors.. 3 Credit Hours.
Low-level organization and hardware algorithms for the implementation of modern high-performance microprocessors including concept designs and real-world case studies.

CS 7292. Reliability and Security in Computer Architecture. 3 Credit Hours.
Hardware support for process isolation, virtualization, debugging, and protection from side-channel attacks. Faults and failures, error tolerance, error rate budgeting, lifetime realiability of devices.

CS 7400. Introduction to Quantum Computing. 3 Credit Hours.
Provide background on quantum computing and equip students with the skills to write code and optimize quantum programs on real quantum computers.

CS 7450. Information Visualization. 3 Credit Hours.
Study of computer visualization principles, techniques, and tools used for explaining and understanding symbolic, structured, and/or hierarchical information. Includes data and software visualization.

CS 7451. Human-Centered Data Analysis. 3 Credit Hours.
This course covers the role of people in data science and visual data analysis, including cognitive processes, bias, perception, and decision-making theories and frameworks.

CS 7455. Issues in Human-Centered Computing. 3 Credit Hours.
In-depth focus on theoretical, methodological, conceptual, and technical issues across the HCC disciplines associated with humans (cognitive, biological, socio-cultural); design; ethics; and analysis and evaluation.

CS 7460. Collaborative Computing. 3 Credit Hours.
Introduction to computer-supported collaborative work, workflow automation, and meeting augmentation. The course deals with models, enabling technology, systems, and applications.

CS 7462. Animal-Centered Computing. 3 Credit Hours.
Explores current research, techniques, and methods in computing as applied to animals, both domestic and wild. Covers technology for understanding animal cognition and behavior, animal communication, animal welfare and enrichment, and conservation, as well as ethics of computing for animals.

CS 7465. Educational Technology: Design and Evaluation. 3 Credit Hours.
Intensive project class in which students design, implement, and evaluate a piece of educational technology, applying the theory learned in Educational Technology: Conceptual Foundations.

CS 7467. Computer-Supported Collaborative Learning. 3 Credit Hours.
Computer-supported collaborative learning is the use of Internet-based technologies to support learning in social settings. Focus on issues of implementation and evaluation.

CS 7470. Mobile and Ubiquitous Computing. 3 Credit Hours.
Investigates the infrastructure required to develop mobile and ubiquitous computing applications and establishes major research themes and experimental practices. Credit not awarded for both CS 7470 and CS 4605.

CS 7476. Advanced Computer Vision. 3 Credit Hours.
Advanced topics in computer vision, which includes a deep dive into both the theoretical foundations of computer vision to the practical issues of building real systems that use computer vision. Credit will not be awarded for CS 7476 and CS 7495.

CS 7490. Advanced Image Synthesis. 3 Credit Hours.
Advanced techniques in realistic image synthesis based on the physics of light. Anti-aliasing, textures, surface reflectance, distribution ray tracing, volume rendering, radiosity, and image-based rendering.

CS 7491. 3D Complexity Techniques for Graphics, Modeling, and Animation. 3 Credit Hours.
Multiresolution, compression, collision, morphing, visibility, and computational geometry techniques for accessing, rendering, and animating complex 3D models in engineering, scientific, business, or entertainment applications.

CS 7492. Simulation of Biological Systems. 3 Credit Hours.
Study different computer simulation methods for use in investigating biological systems, including bio-molecules, cells and full organisms.

CS 7495. Computer Vision. 3 Credit Hours.
An introduction to computer vision and machine perception. An intensive study of the process of generating a symbolic description of the scene by interpretation of images(s). Credit will not be awarded for both CS 7495 and CS 7476.

CS 7496. Computer Animation. 3 Credit Hours.
Motion techniques for computer animation and interactive games (keyframing, procedural methods, motion capture, and simulation) and principles for storytelling, composition, lighting, and interactivity.

CS 7497. Virtual Environments. 3 Credit Hours.
An introduction to virtual reality and virtual environments. Issues covered will include VR technology, software design, 3D human-computer interaction, and applications for VR.

CS 7499. 3D Reconstruction and Mapping in Computer Vision, Robotics, and Augmented Reality. 3 Credit Hours.
In this course we study the principles and algorithms underlying 3D Reconstruction and Mapping in Computer Vision, Robotics, and Augmented Reality.

CS 7510. Graph Algorithms. 3 Credit Hours.
Algorithms for graph problems such as maximum flow, matching, network reliability, minimum cuts, covering, coloring, planarity, shortest paths, and connectivity. Crosslisted with MATH 7510 and ISYE 7510.

CS 7520. Approximation Algorithms. 3 Credit Hours.
Approximation algorithms for NP-hard optimization problems, design and analysis techniques for such algorithms. Credit not allowed for both CS 7520 and CS 4520.

CS 7525. Algorithmic Game Theory and Economics. 3 Credit Hours.
Algorithmic aspects of game theory covering topics at the intersection of computer science, economics, and game theory with applications to domains such as internet.

CS 7530. Randomized Algorithms. 3 Credit Hours.
Techniques for designing and analyzing randomized algorithms, derandomization techniques. Credit not allowed for both CS 7530 and CS 4530.

CS 7535. Markov Chain Monte Carlo Algorithms. 3 Credit Hours.
This course studies Markov Chain Monte Carlo algorithms, widely-used in a variety of scientific fields, focusing on mathematical techniques for analyzing their convergence rates.

CS 7540. Spectral Algorithms and Representations. 3 Credit Hours.
Spectral methods mathematics and algorithmic insights driving applications with large data sets in domains such as web-search, information-retrieval, and medical diagnosis and prediction.

CS 7545. Theoretical Foundations of Machine Learning. 3 Credit Hours.
This course provides a basic arsenal of powerful mathematical tools for the analysis of learning algorithms, focusing on both statistical and computational aspects.

CS 7560. Theoretical Foundations of Cryptography. 3 Credit Hours.
One-way functions, pseudorandomness, public-key and identity-based cryptography, commitment and zero knowledge.

CS 7610. Modeling and Design. 3 Credit Hours.
Information-processing theories of modeling and design; topics include design decision making, problem solving and learning, and knowledge-based modeling and design.

CS 7611. AI Problem Solving. 3 Credit Hours.
Basic concepts and methods of AI problem solving, knowledge representation, reasoning, and learning.

CS 7612. Artificial Intelligence Planning. 3 Credit Hours.
Symbolic numerical techniques that allow intelligent systems to decide how they should act in order to achieve their goals, including action and plan representation, plan synthesis and reasoning, analysis of planning algorithms, plan execution and monitoring, plan reuse and learning, and applications.

CS 7613. Knowledge Systems Engineering. 3 Credit Hours.
Techniques for constructing large knowledge-based systems. Advanced symbolic AI techniques. Constraint systems.

CS 7615. Knowledge Agents. 3 Credit Hours.
Knowledge-based interactive systems, knowledge-based autonomous agents, agent architectures, learning and adaptation, agent evolution.

CS 7616. Pattern Recognition. 3 Credit Hours.
This course provides an introduction to the theory and practice of pattern recognition. It emphasizes unifying concepts and the analysis of real-world datasets.

CS 7620. Case-Based Reasoning. 3 Credit Hours.
Topics include case representation, indexing and retrieval, adaptation, interpretive CBR, the cognitive model that CBR implies, and its implications for creativity, decision aiding, and education. Credit not allowed for both CS 7620 and CS 4622.

CS 7626. Introduction to Behavioral Imaging. 3 Credit Hours.
An introduction to the use of sensor data and machine learning methods to measure and model human behavior objectively and automatically for health applications.

CS 7630. Autonomous Robotics. 3 Credit Hours.
The principles and practice of autonomous robotics including behavior-based design and architectures, adaptive learning and team behavior, and the role of perception within robotic systems.

CS 7631. Autonomous Multi-Robot Systems. 3 Credit Hours.
In-depth examination of the current research on multi-robot systems. Students develop and critically analyze a multi-robot system.

CS 7632. Game Artificial Intelligence. 3 Credit Hours.
An exploration of how artificial intelligence is used in modern digital computer games. Credit will not be awarded for CS 7632 and CS 4731, CS 7632 and LCC 4731 or CS 7632 and LMC 4731.

CS 7633. Human-Robot Interaction. 3 Credit Hours.
Survey of the state of the art in HRI research, introduction to statistical methods for HRI research, research project studio.

CS 7634. AI Storytelling in Virtual Worlds. 3 Credit Hours.
An exploration of how artificial intelligence can enable us to use stories in virtual worlds for the purpose of entertaining, educatintg, and training human users.

CS 7636. Computational Perception. 3 Credit Hours.
Study of statistical and algorithmic methods for sensing people using video and audio. Topics include face detection and recognition, figure tracking, and audio-visual sensing.

CS 7637. Knowledge-Based AI. 3 Credit Hours.
Structured knowledge representation; knowledge-based methods of reasoning and learning; problem-solving, modeling and design.

CS 7638. Artificial Intelligence Techniques for Robotics. 3 Credit Hours.
AI techniques with applications to autonomous vehicles. Extensive programming exercises. Topics include probabilistic inference, Kalman/particle filters, planning/search algorithms, PID control, SLAM.

CS 7639. Cyber Physical Design and Analysis. 3 Credit Hours.
Cyber Physical Systems (CPS), including examples. Design methods. Formalisms: Different equations, finite-state machines. Analysis. Formal methods. Design processes, Model-Based Systems Engineering, Reference documents and regulations.

CS 7640. Learning in Autonomous Agents. 3 Credit Hours.
An in-depth look at agents that learn, including intelligent systems, robots, and humans. Design and implementation of computer models of learning and adaptation in autonomous intelligent agents.

CS 7641. Machine Learning. 3 Credit Hours.
Machine learning techniques and applications. Topics include foundational issues; inductive, analytical, numerical, and theoretical approaches; and real-world applications. Credit not awarded for both CS 7641 and CS 4641/CSE 6740/ISYE 6740.

CS 7642. Reinforcement Learning and Decision Making. 3 Credit Hours.
Efficient algorithms for multiagent planning, and approaches to learning near-optimal decisions using possibly partially observable Markov decision processes; stochastic and repeated games; and reinforcement learning.

CS 7643. Deep Learning. 3 Credit Hours.
This course will cover theory and practice of deep learning, including neural network and structured models, optimization algorithms, and applications to perception and Artificial Intelligence.

CS 7644. Machine Learning for Robotics. 3 Credit Hours.
Overview of a portfolio of machine learning techniques useful for robotic application: from regression to deep learning, applied on simulated real-time mobile robotic applications.

CS 7645. Numerical Machine Learning. 3 Credit Hours.
This course explores problems in classification/pattern recognition (OCR, speech, vision, fault detection, medical diagnosis), regression/function approximation, robot control, and reinforcement learning.

CS 7646. Machine Learning for Trading. 3 Credit Hours.
Introduces machine learning based trading strategies. Topics: Information processing, probabilistic analysis, portfolio construction, generation of market orders, KNN, random forests. Credit not awarded for both CS 4646 and CS 7646.

CS 7647. Machine Learning with Limited Supervision. 3 Credit Hours.
Explore advanced techniques in learning from visual data with limited human supervision through study of recently published research papers and completing a semester-long research project.

CS 7648. Interactive Robot Learning. 3 Credit Hours.
This course combines lectures in CS (Machine and Reinforcement Learning) and CogSci with a research seminar to enable students to develop learning from demonstration systems.

CS 7649. Robot Intelligence: Planning. 3 Credit Hours.
We investigate algorithms for robots and complex systems that make intelligent decisions. Emphasis on the theoretical and empirical properties of classical, geometric, stochastic/dynamic planning.

CS 7650. Natural Language. 3 Credit Hours.
Topics include lexical analysis, parsing, interpretation of sentences, semantic representation, organization of knowledge, inference mechanisms. Newer approaches combining statistical language processing and information retrieval techniques. Credit not allowed for both CS 7650 and CS 4650.

CS 7651. Human and Machine Learning. 3 Credit Hours.
Explores the gap between empirical research on human learning and models from machine learning. Covers symbolic, statistical, semantic space, neural network, unsupervised, and other approaches.

CS 7695. Philosophy of Cognition. 3 Credit Hours.
Examines problems in the foundations of cognition in relation to current issues in cognitive sciences. Topics include meaning, mental imagery, consciousness, and mind/body problem.

CS 7697. Cognitive Models of Science and Technology. 3 Credit Hours.
Examines how models of reasoning and representation developed in the cognitive sciences can provide a basis for an enriched understanding of scientific theories and research practices in science and technology.

CS 7741. Robotics Professional Preparation. 1 Credit Hour.
Preparation for a professional career in Robotics. Local & visiting speakers. Program introduction. Technical resume preparation. GT Robotics labs & resources.

CS 7742. Robotics Professional Preparation 2. 1 Credit Hour.
Preparation for a professional career in Robotics. Local & visiting speakers. Selecting and applying for Internship. Developing capstone project proposal. Public speaking practice and preparation.

CS 7743. Robotics Professional Preparation 3. 1 Credit Hour.
Preparation for a professional career in Robotics. Local & visiting speakers. Interview preparation & career search. Technical report writing and presentation.

CS 7750. Mathematical Foundations of Machine Learning. 3 Credit Hours.
Provides the mathematical background for two of the pillars of modern data science: linear algebra and applied probability.

CS 7751. Probabilistic Graphical Models in Machine Learning. 3 Credit Hours.
The course provides an introduction to theory and practice of graphical models in machine learning. It covers three main aspects; representation, probabilistic inference, and learning.

CS 7785. Introduction to Robotics Research. 3 Credit Hours.
Familiarizes students with the core areas of robotics; mechanics, control, perception, AI, and autonomy. Provides an introduction to the mathematical tools required in robotics research.

CS 7790. Cognitive Modeling. 4 Credit Hours.
A hands-on course covering a range of cognitive modeling methodologies. It explores the analysis, development, construction, and evaluation of models of cognitive processing. Crosslisted with ISYE and PSYC 7790.

CS 7999. Preparation for Doctoral Qualifying Exams. 1-21 Credit Hours.
Consent of the College required.

CS 8001. Seminar. 1 Credit Hour.
Group discussion of advanced topics in information and computer science. May not be used by computer science majors for degree credit.

CS 8002. Seminar. 2 Credit Hours.
Group discussion of advanced topics in information and computer science. May not be used by computer science majors for degree credit.

CS 8003. Seminar. 3 Credit Hours.
Group discussion of advanced topics in information and computer science. May not be used by computer science majors for degree credit.

CS 8004. Seminar. 4 Credit Hours.
Group discussion of advanced topics in information and computer science. May not be use by computer science majors for degree credit.

CS 8005. Seminar. 5 Credit Hours.
Group discussion of advanced topics in information and computer science. May not be used by computer science majors for degree credit.

CS 8006. Seminar. 6 Credit Hours.
Group discussion of advanced topics in information and computer science. May not be used by computer science majors for degree credit.

CS 8030. Software Engineering Seminar. 1 Credit Hour.
This seminar provides students with an opportunity to explore contemporary topics in software engineering.

CS 8740. Robotics Internship. 1-21 Credit Hours.
Graduate Internship at a partner company, GTRI or a GT Robotics lab.

CS 8741. Robotics Capstone Project. 3 Credit Hours.
Teams or individuals apply the knowledge and skills acquired throughout the MS program to a faculty supervised robotics project.

CS 8750. Robotics Research Foundation I. 3 Credit Hours.
Multidisciplinary research course supervised by two robotics faculty from different schools participating in the robotics Ph.D. program.

CS 8751. Robotics Research Foundation II. 3 Credit Hours.
Continuation of AE 8751 (Robotics Research Foundation I).

CS 8795. Colloquium in Cognitive Sciences. 1 Credit Hour.
Reading of research papers by leading cognitive scientists, attendance at their colloquia and meeting with them to discuss research. Crosslisted with ISYE and PSYC 8795.

CS 8801. Special Topics. 1 Credit Hour.
Special topics of current interest. Treatment of new developments in various areas of computing.

CS 8802. Special Topics. 2 Credit Hours.
Special topics of current interest. Treatment of new developments in various areas of computing.

CS 8803. Special Topics. 3 Credit Hours.
Special topics of current interest. Treatment of new developments in various areas of computing.

CS 8804. Special Topics. 4 Credit Hours.
Special topics of current interest. Treatment of new developments in various areas of computing.

CS 8805. Special Topics. 5 Credit Hours.
Special topics of current interest. Treatment of new developments in various areas of computing.

CS 8806. Special Topics. 6 Credit Hours.
Special topics of current interest. Treatment of new developments in various areas of computing.

CS 8811. Special Topics. 1 Credit Hour.
Special Topics in CS - Lab.

CS 8813. Special Topics. 3 Credit Hours.

CS 8816. Special Topics. 6 Credit Hours.

CS 8873. Special Topics. 3 Credit Hours.

CS 8893. Special Topics in Cognitive Science. 3 Credit Hours.
Topics of current interest in cognitive science.

CS 8901. Special Problems. 1-21 Credit Hours.
Small-group or individual investigation of advanced topics in computing. Guided study and research.

CS 8902. Special Problems. 1-21 Credit Hours.
Small-group or individual investigation of advanced topics in computing. Guided study and research.

CS 8903. Special Problems. 1-21 Credit Hours.
Small-group or individual investigation of advanced topics in computing. Guided study and research.

CS 8997. Teaching Assistantship. 1-9 Credit Hours.
For graduate students holding graduate teaching assistantships.

CS 8998. Research Assistantship. 1-6 Credit Hours.
For graduate students holding graduate research assistantships.

CS 8999. Doctoral Thesis Preparation. 1-21 Credit Hours.

CS 9000. Doctoral Thesis. 1-21 Credit Hours.