# Department of Computer Science

**Tony Givargis, Department Chair**
**Padhraic Smyth, Vice Chair Computing Division**
**Ardalan Amiri Sani, Vice Chair of Graduate Studies**
**Jennifer Wong Ma, Vice Chair of Undergraduate Studies**
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With almost 60 full-time faculty members, 250+ PhD students and 200+ Masters students in two programs (professional MCS & research-oriented MS), and more than 2,300+ undergraduates, we provide a world-class research environment spanning not only the core areas of computer science — including computer architecture, system software, networking and distributed computing, data and information systems, the theory of computation, artificial intelligence, and computer graphics — but also highly interdisciplinary programs, such as biomedical informatics, data mining, security and privacy, and ubiquitous computing.

The diverse research interests of our faculty are reflected directly in our educational programs. Computer Science faculty teach most of the undergraduate and graduate courses for the degree programs in both Computer Science and Information and Computer Science. We jointly offer with our colleagues in The Henry Samueli School of Engineering an undergraduate degree in Computer Science and Engineering, as well as the graduate program in Networked Systems.

Our department collaborates with many other institutions in the United States and abroad, and its doors are always open to a multitude of visitors and collaborators from all corners of the globe.

- Bioinformatics, Minor
- Computer Science and Engineering, B.S.
- Computer Science, B.S.
- Computer Science, M.S.
- Computer Science, Ph.D.
- Master of Computer Science
- Mathematical, Computational, and Systems Biology, M.S.
- Mathematical, Computational, and Systems Biology, Ph.D.
- Networked Systems, M.S.
- Networked Systems, Ph.D.

## Faculty

Sangeetha Abdu Jyothi, Ph.D. University of Illinois, Urbana-Champaign, *Assistant Professor of Computer Science* (computer networking and systems, artificial intelligence and machine learning, natural language processing)

Iftekhar Ahmed, Ph.D. Oregon State University, *Assistant Professor of Informatics; Computer Science* (data mining, software engineering, software testing and analysis, software maintenance, empirical studies)

Mohammad Al Faruque, Ph.D. University of Kaiserslautern, *Chair of Emulex Career Development and Professor of Electrical Engineering and Computer Science; Computer Science; Mechanical and Aerospace Engineering* (cyber-physical systems, internet of things, embedded systems, CPS security)

Shannon L. Alfaro, M.S. University of California, Irvine, *Senior Continuing Lecturer of Computer Science* (design/analysis of combinational and sequential systems using SSI/MSI/LSI modules, hardware/firmware implementation of algorithms, computer science education)

Ardalan Amiri Sani, Ph.D. Rice University, *Associate Professor of Computer Science; Electrical Engineering and Computer Science* (security, privacy, and cryptography)

Pierre F. Baldi, Ph.D. California Institute of Technology, *Director of the Institute for Genomics and Bioinformatics and Distinguished Professor of Computer Science; Biological Chemistry; Biomedical Engineering; Mathematics* (algorithms and theory, artificial intelligence and machine learning, biomedical informatics, databases and data mining, environmental informatics, statistics and statistical theory)

Alexander Berg, Ph.D. University of California, Berkeley, *Associate Professor of Computer Science* (computational visual recognition, machine learning for computer vision, artificial intelligence and machine learning, and natural language processing)

Lubomir Bic, Ph.D. University of California, Irvine, *Professor Emeritus of Computer Science* (parallel and distributed computing, mobile agents, networks, and distributed systems)

Elaheh Bozorgzadeh, Ph.D. University of California, Los Angeles, *Professor of Computer Science* (computer architecture and design, design automation and synthesis for embedded systems, VLSI CAD, reconfigurable computing)

Carter Butts, Ph.D. Carnegie Mellon University, *Chancellor's Professor of Sociology; Computer Science; Electrical Engineering and Computer Science; Statistics* (mathematical sociology, social networks, quantitative methodology, human judgment and decision making, economic sociology)

Hung Cao, Ph.D. University of Texas at Arlington, *Associate Professor of Electrical Engineering and Computer Science; Biomedical Engineering; Computer Science* (MEMS, sensors, implants, heart disease, neurological disease, wireless biomedical systems)

Michael Carey, Ph.D. University of California, Berkeley, *Distinguished Professor Emeritus of Computer Science* (databases and data mining, parallel and distributed systems)

Qi Alfred Chen, Ph.D. University of Michigan, *Assistant Professor of Computer Science; Electrical Engineering and Computer Science* (smart systems and IoT, security, privacy, and cryptography)

Rina Dechter, Ph.D. University of California, Los Angeles, *Associate Dean for Research and Distinguished Professor of Computer Science* (algorithms and theory, automated reasoning, knowledge-representation, planning and learning)

Brian Demsky, Ph.D. Massachusetts Institute of Technology, *Professor of Computer Science; Electrical Engineering and Computer Science* (software reliability, security, software engineering, compilation, parallel software, program analysis, and program understanding)

Michael B. Dillencourt, Ph.D. University of Maryland, College Park, *Professor of Computer Science* (algorithms and complexity, networks and distributed systems, data structures, computational geometry, graph algorithms)

Nikil D. Dutt, Ph.D. University of Illinois at Urbana–Champaign, *Distinguished Professor of Computer Science; Cognitive Sciences; Electrical Engineering and Computer Science* (embedded systems, computer architecture, electronic design automation, software systems, brain-inspired architectures and computing)

Magnus Egerstedt, Ph.D. KTH Royal Institute of Technology, *Stacey Nicholas Dean of Engineering and Professor of Electrical Engineering and Computer Science; Computer Science; Mechanical and Aerospace Engineering* (Control theory and robotics, control and coordination of complex networks, multirobot systems, mobile sensor networks and cyber-physical systems)

Magda S. El Zarki, Ph.D. Columbia University, *Professor of Computer Science; Informatics* (telecommunications, networks, wireless communication, video transmission)

David A. Eppstein, Ph.D. Columbia University, *Distinguished Professor of Computer Science* (algorithms and complexity; computer graphics and visualization; geometric optimization)

Daniel Epstein, Ph.D. University of Washington, *Associate Professor of Informatics; Computer Science* (human-computer interaction, personal informatics, ubiquitous computing, social computing, health informatics)

Habiba Farrukh, Ph.D. Purdue University, *Assistant Professor of Computer Science* (security, privacy, mobile computing, and cryptography)

Charless C. Fowlkes, Ph.D. University of California, Berkeley, *Professor of Computer Science; Cognitive Sciences* (artificial intelligence, computer vision, machine learning, computational biology)

Roy Fox, Ph.D. The Hebrew University of Jerusalem, *Assistant Professor of Computer Science* (theory and applications of reinforcement learning, dynamical systems, information theory, robotics, artificial intelligence and machine learning, and natural language processing)

Michael S. Franz, Ph.D. Swiss Federal Institute of Technology in Zurich, *Distinguished Professor of Computer Science; Electrical Engineering and Computer Science* (systems software, particularly compilers and virtual machines, trustworthy computing, software engineering, security, privacy, and cryptography)

Richard Futrell, Ph.D. Massachusetts Institute of Technology, *Assistant Professor of Computer Science; Language Science* (language processing, Bayesian modeling, NLP)

Sergio Gago-Masague, Ph.D., *Assistant Professor of Teaching of Computer Science* (health informatics, pervasive computing, user-centric software design, human computer interaction, serious games, computer science education)

Irene Gassko, Ph.D. Boston University, *Continuing Lecturer of Computer Science* (computer science education)

Tony D. Givargis, Ph.D. University of California, Riverside, *Department Chair and Professor of Computer Science* (computer architecture, embedded systems, platform-based system-on-a-chip design, low-power electronics)

Michael T. Goodrich, Ph.D. Purdue University, *Distinguished Professor of Computer Science* (computer security, algorithm design, data structures, Internet algorithmics, geometric computing, graphic drawing)

Ian G. Harris, Ph.D. University of California, San Diego, *Professor of Computer Science; Electrical Engineering and Computer Science* (hardware/software co-validation, manufacturing test, application of natural language understanding to security and design)

Wayne B. Hayes, Ph.D. University of Toronto, *Associate Professor of Computer Science* (algorithms and theory, biomedical informatics and computational biology, computer vision, scientific and numerical computing)

Dan S. Hirschberg, Ph.D. Princeton University, *Professor Emeritus of Computer Science* (analyses of algorithms, concrete complexity, data structures, models of computation)

Alexander T. Ihler, Ph.D. Massachusetts Institute of Technology, *Professor of Computer Science* (algorithms and theory, artificial intelligence and machine learning, probabilistic models, sensor networks, computer graphics and vision, and distributed systems)

Mohsen Imani, Ph.D. University of California, San Diego, *Assistant Professor of Computer Science* (computer networking and systems)

Sandra S. Irani, Ph.D. University of California, Berkeley, *Associate Dean for Student Affairs and Professor of Computer Science* (algorithms and complexity)

Ramesh Chandra Jain, Ph.D. Indian Institute of Technology Kharagpur, *Distinguished Professor Emeritus of Computer Science* (computer vision, multimedia computing, image databases, machine vision, intelligent systems)

Stanislaw M. Jarecki, Ph.D. Massachusetts Institute of Technology, *Professor of Computer Science* (algorithms and complexity, applies and distributed cryptograph)

Scott A. Jordan, Ph.D. University of California, Berkeley, *Professor of Computer Science; Electrical Engineering and Computer Science* (pricing and differentiated services in the Internet, resource allocation in wireless networks, telecommunications policy)

Sang-Woo Jun, Ph.D. Massachusetts Institute of Technology, *Assistant Professor of Computer Science* (computer systems architecture, hardware acceleration, non-volatile memory)

Kalev Kask, Ph.D. University of California, Irvine, *Continuing Lecturer of Computer Science* (artificial intelligence focusing on automated reasoning, graphical models, computer science education)

David G. Kay, J.D. Loyola Marymount University, *Senior Professor Emeritus of Teaching of Informatics; Computer Science* (computer law, computer science education)

Solmaz S. Kia, Ph.D. University of California, Irvine, *Professor of Mechanical and Aerospace Engineering; Computer Science* (systems and control, decentralized/distributed algorithm design for multi-agent systems, cooperative robotics)

Dennis F. Kibler, Ph.D. University of California, Irvine, *Professor Emeritus of Computer Science* (artificial intelligence and machine learning, gene regulation, biological genomes)

Raymond O. Klefstad, Ph.D. University of California, Irvine, *Associate Professor of Teaching of Computer Science* (embedded systems, networks and distributed systems, programming languages and systems, computer science education)

Sven Koenig, Ph.D. Carnegie Mellon University, *Chancellor's Professor and Bren Chair of Computer Science* (algorithms and theory, artificial intelligence machine learning, natural language processing, computer games and virtual worlds, computer science education)

Jeffrey L. Krichmar, Ph.D. George Mason University, *Professor of Cognitive Sciences; Computer Science* (computational neuroscience, robotics, artificial intelligence, neural networks)

Fadi J. Kurdahi, Ph.D. University of Southern California, *Director, Center for Embedded Computer Systems and Associate Dean for Graduate and Professional Studies and Professor of Electrical Engineering and Computer Science; Computer Science* (embedded and cyber-physical systems, VLSI system design, design automation of digital systems)

Richard H. Lathrop, Ph.D. Massachusetts Institute of Technology, *Professor of Computer Science* (modeling structure and function, machine learning, intelligent systems and molecular biology, protein structure/function prediction)

Marco Levorato, Ph.D. University of Padua, *Professor of Computer Science; Electrical Engineering and Computer Science* (artificial intelligence and machine learning, networks and distributed systems, statistics and statistical theory, stochastic modeling, signal processing)

Chen Li, Ph.D. Stanford University, *Professor of Computer Science* (databases and text processing, multimedia databases, data integration)

Kwei-Jay Lin, Ph.D. University of Maryland, College Park, *Professor Emeritus of Electrical Engineering and Computer Science; Computer Science* (real-time systems, distributed systems, service-oriented computing)

George S. Lueker, Ph.D. Princeton University, *Professor Emeritus of Computer Science* (algorithms and complexity)

Scott Mahlke, Ph.D. University of Illinois at Urbana-Champaign, *Professor of Computer Science* (custom-fit architectures for energy efficiency and reliability, compilers and run-time systems)

Aditi Majumder, Ph.D. University of North Carolina at Chapel Hill, *Professor of Computer Science* (novel displays and cameras for computer graphics and visualization, human-computer interaction, applied computer vision)

Stephan Mandt, Ph.D. University of Cologne, *Associate Professor of Computer Science; Statistics* (artificial intelligence and machine learning, probabilistic modeling, Bayesian deep learning, variational inference, deep generative models, uncertainty quantification, neural data compression)

Athina Markopoulou, Ph.D. Stanford University, *Professor of Electrical Engineering and Computer Science; Computer Science* (networking: including network protocols, network measurement and analysis, mobile systems and mobile data analysis, network security and privacy)

Gopi Meenakshisundaram, Ph.D. University of North Carolina at Chapel Hill, *Professor of Computer Science* (geometry and topology for computer graphics, image-based rendering, object representation, surface reconstruction, collision detection, virtual reality, telepresence, human computer interaction)

Sharad Mehrotra, Ph.D. University of Texas at Austin, *Distinguished Professor of Computer Science* (databases and data mining, multimedia computing, networks and distributed systems)

Milena Mihail, Ph.D. Harvard University, *Professor Emerita of Computer Science* (randomization, expander graphs, Markov chains, network design)

Eric D. Mjolsness, Ph.D. California Institute of Technology, *Professor of Computer Science; Mathematics* (artificial intelligence and machine learning, biomedical informatics and computational biology, applied mathematics, mathematical biology, modeling languages)

Faisal Nawab, Ph.D. University of California, Santa Barbara, *Assistant Professor of Computer Science* (databases and data mining, networks and distributed systems)

Alexandru Nicolau, Ph.D. Yale University, *Professor of Computer Science* (architecture, parallel computation, programming languages and compilers)

Ioannis Panageas, Ph.D. Georgia Institute of Technology, *Assistant Professor of Computer Science* (algorithms and complexity artificial intelligence and machine learning)

Marios Papaefthymiou, Ph.D. Massachusetts Institute of Technology, *Ted and Janice Smith Family Foundation Dean and Professor of Computer Science* (computer architecture and design, networks and distributed systems)

Amir M. Rahmani, Ph.D. University of Turku, Finland, *Professor of Nursing; Computer Science; Electrical Engineering and Computer Science*

Isaac D. Scherson, Ph.D. Weizmann Institute of Science, *Professor of Computer Science* (parallel computing architectures, massively parallel systems, parallel algorithms, interconnection networks, performance evaluation)

Yanning Shen, Ph.D. University of Minnesota, *Assistant Professor of Electrical Engineering and Computer Science; Computer Science* (machine learning, data science, network science, and statistical-signal processing)

Michael Shindler, Ph.D. University of California, Los Angeles, *Associate Professor of Teaching of Computer Science* (theory and machine learning, computer science education)

Sameer Singh, Ph.D. University of Massachusetts Amherst, *Professor of Computer Science; Electrical Engineering and Computer Science; Language Science* (artificial intelligence and machine learning, databases and data mining, scientific and numerical computing)

Padhraic J. Smyth, Ph.D. California Institute of Technology, *Chancellor's Professor of Computer Science; Education; Statistics* (artificial intelligence and machine learning, pattern recognition, applied statistics, data mining, information theory)

Mark Steyvers, Ph.D. Indiana University, *Department Chair and Professor of Cognitive Sciences; Computer Science; Psychological Science* (human-AI collaboration, higher-order cognition, learning, metacognition, hybrid human-AI systems, computational modeling)

Erik B. Sudderth, Ph.D. Massachusetts Institute of Technology, *Professor of Computer Science; Statistics* (artificial intelligence and machine learning, computer vision, statistics and statistical theory)

Alexander W. Thornton, B.S. University of California, Irvine, *Continuing Lecturer of Computer Science* (computer science education)

Gene Y. Tsudik, Ph.D. University of Southern California, *Distinguished Professor of Computer Science* (computer and network security and privacy; applied cryptography)

Vijay Vazirani, Ph.D. University of California, Berkeley, *Distinguished Professor of Computer Science* (algorithms and complexity, scientific and numerical computing)

Alexander Veidenbaum, Ph.D. University of Illinois at Urbana-Champaign, *Professor of Computer Science* (computer architecture, embedded systems, compilers, programming languages and systems, database and data mining)

Nalini Venkatasubramanian, Ph.D. University of Illinois at Urbana-Champaign, *Professor of Computer Science* (multimedia computing, networks and distributed systems, global information infrastructure, multiple resource management services)

Jennifer Wong-Ma, Ph.D. University of California, Los Angeles, *Associate Professor of Teaching of Computer Science* (computer architecture and design, embedded systems, hardware intellectual property protection, statistical optimization, computer science education)

Xiaohui Xie, Ph.D. Massachusetts Institute of Technology, *Professor of Computer Science; Developmental and Cell Biology* (computational biology, bioinformatics, genomics, neural computation, artificial intelligence, and machine learning)

Xiangmin Xu, Ph.D. Vanderbilt University, *Director of Center for Neural Central Mapping and Chancellor's Professor of Anatomy and Neurobiology; Biomedical Engineering; Computer Science; Microbiology and Molecular Genetics*

Thomas Yeh, Ph.D. University of California, Los Angeles, *Assistant Professor of Computer Science* (computer architecture, acceleration of machine learning, and computer science education)

Jing Zhang, Ph.D. University of Southern California, *Assistant Professor of Computer Science; Biological Chemistry* (artificial intelligence and machine learning, biomedical informatics and computational biology, genomics)

Shuang Zhao, Ph.D. Cornell University, *Assistant Professor of Computer Science* (computer graphics with a focus on material appearance modeling and physically-based rendering)

## Courses

**COMPSCI 103. Advanced Programming and Problem Solving with C++. 4 Units.**
Advanced programming language concepts for more complex, higher performance software design. Builds depth of programming skills in C++ as a foundation for upper-division courses and projects. Focuses on strengthening programming, debugging, and problem solving skills.
Prerequisite: I&C SCI 45C.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 111. Digital Image Processing. 4 Units.**
Introduction to the fundamental concepts of digital signal and image processing as applicable in areas such as multimedia, graphics, AI, data mining, databases, vision, or video games. Topics include image representation, space- and frequency-domain transformations, filters, segmentation, and compression.
Prerequisite: I&C SCI 46 with a minimum grade of C and I&C SCI 6D with a minimum grade of C and (MATH 3A with a minimum grade of C or I&C SCI 6N with a minimum grade of C).
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 112. Computer Graphics. 4 Units.**
Introduction to the fundamental principles of 3D computer graphics including polygonal modeling, geometric transformations, visibility algorithms, illumination models, texturing, and rasterization. Use of an independently-learned 3D graphics API to implement these techniques.
Prerequisite: I&C SCI 46 with a minimum grade of C and (MATH 3A with a minimum grade of C or I&C SCI 6N with a minimum grade of C).
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 113. Computer Game Development. 4 Units.**
Introduction to the principles of interactive 2D and 3D computer game development. Concepts in computer graphics, algorithms, software engineering, art and graphics, music and sound, story analysis, and artificial intelligence are presented and are the basis for student work.
Prerequisite: COMPSCI 112 or COMPSCI 171 or IN4MATX 121 or ART 106B or I&C SCI 163 or I&C SCI 166.
Same as IN4MATX 125
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 114. Projects in Advanced 3D Computer Graphics. 4 Units.**
Projects in advanced 3D graphics such as illumination, geometric modeling, visualization, and animation. Topics include physically based and global illumination, solid modeling, curved surfaces, multiresolution modeling, image-based rendering, basic concepts of animation, and scientific visualization.
Prerequisite: COMPSCI 112 and I&C SCI 45C with a minimum grade of C. Recommended: COMPSCI 161 or COMPSCI 164 or COMPSCI 165.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 115. Computer Simulation. 4 Units.**
Discrete event-driven simulation; continuous system simulation; basic probability as pertaining to input distributions and output analysis; stochastic and deterministic simulation; static and dynamic system simulation.
Prerequisite: I&C SCI 6B with a minimum grade of C and (I&C SCI 6N with a minimum grade of C or MATH 3A with a minimum grade of C) and (STATS 67 with a minimum grade of C or (STATS 7 with a minimum grade of C or AP Statistics with a minimum score of 3) and STATS 120A with a minimum grade of C) and I&C SCI 51 with a minimum grade of C and IN4MATX 43 with a minimum grade of C.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 116. Computational Photography and Vision. 4 Units.**
Introduces the problems of computer vision through the application of computational photography. Specific topics include photo-editing (image warping, compositing, hole filling), panoramic image stitching, and face detection for digital photographs.
Prerequisite: I&C SCI 6D with a minimum grade of C and (MATH 3A with a minimum grade of C or I&C SCI 6N with a minimum grade of C) and (MATH 2B with a minimum grade of C or AP Calculus BC with a minimum score of 4 or AP Calculus AB with a minimum score of 4) and I&C SCI 46 with a minimum grade of C.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 117. Project in Computer Vision. 4 Units.**
Students undertake construction of a computer vision system. Topics include automatically building 3D models from photographs, searching photo collections, robot navigation, and human motion tracking.
Prerequisite: I&C SCI 6D with a minimum grade of C and (MATH 3A with a minimum grade of C or I&C SCI 6N with a minimum grade of C) and (MATH 2B with a minimum grade of C or AP Calculus BC with a minimum score of 4) and I&C SCI 46 with a minimum grade of C and (COMPSCI 112 or COMPSCI 116 or COMPSCI 171 or COMPSCI 178).
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 118. Introduction to Virtual Reality. 4 Units.**
Introduces virtual reality systems and software. Topics include computer graphics pipeline, human visual system and perception, head mounted displays, image formation, sensors and tracking, and 3D sound. Students use a popular cross-platform game engine to create VR environments.
Prerequisite: (I&C SCI 6N or MATH 3A) and I&C SCI 33.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 121. Information Retrieval. 4 Units.**
An introduction to information retrieval including indexing, retrieval, classifying, and clustering text and multimedia documents.
Prerequisite: (I&C SCI 45C with a minimum grade of C or I&C SCI 45J with a minimum grade of C) and (STATS 7 or STATS 67 or AP Statistics with a minimum score of 3).
Same as IN4MATX 141
Restrictions: School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 122A. Introduction to Data Management. 4 Units.**
Introduction to the design of databases and the use of database management systems (DBMS) for applications. Topics include entity-relationship modeling for design, relational data model, relational algebra, relational design theory, and Structured Query Language (SQL) programming.
Prerequisite: I&C SCI 33 with a minimum grade of C or EECS 114.
Same as EECS 116
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 122B. Project in Databases and Web Applications. 4 Units.**
Introduces students to advanced database technologies and web applications. Topics include database connectivity (ODBC/JDBC), extending databases using stored procedures, database administration, web servers, web programming languages (Java servlets, XML, Ajax, and mobile platforms).
Prerequisite: (COMPSCI 122A or EECS 116) and (I&C SCI 45J or AP Computer Science A with a minimum score of 4).
Overlaps with COMPSCI 137, IN4MATX 124.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 122C. Principles of Data Management. 4 Units.**
Covers fundamental principles underlying data management systems. Content includes key techniques including storage management, buffer management, record-oriented file system, access methods, query optimization, and query processing.
Prerequisite: COMPSCI 122A and (I&C SCI 53 or COMPSCI 143A).
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.
Concurrent: COMPSCI 222

**COMPSCI 122D. Beyond SQL Data Management. 4 Units.**
Survey of modern data management and analysis technologies beyond relational (SQL) database management. Topics include semistructured data, NoSQL databases, big data analysis, and text search/query engines. Additional topics vary and may include data frames, streaming data, and/or time-series data.
Prerequisite: I&C SCI 46 and (I&C SCI 51 or EECS 31) and (COMPSCI 122A or EECS 116).
Restrictions: Computer Science majors have the first consideration for enrollment. Computer Science and Engineering and all School of ICS majors have second right of consideration.

**COMPSCI 125. Next Generation Search Systems. 4 Units.**
Discusses concepts and techniques related to all aspects of search systems. After considering basic search technology and the state-of-art systems, rapidly developing techniques for multimedia search, local search, event-search, and video-on-demand are explored.
Prerequisite: (I&C SCI 45C with a minimum grade of C or I&C SCI 45J with a minimum grade of C) and (STATS 7 or STATS 67 or AP Statistics with a minimum score of 3).
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 130. Introduction to Security and Privacy. 4 Units.**
Introductory course on security mindset and basic principles/practices of software and systems security. Covers the foundations of building, using, and managing secure systems. Topics include standard security principles, threats, and defenses for real-world systems, including web, mobile, and IoT security.
Prerequisite: I&C SCI 46 with a minimum grade of C.
Restrictions: Computer Science majors, Computer Science and Engineering majors, and School of Information and Computer Sciences students only.

**COMPSCI 131. Parallel and Distributed Computing. 4 Units.**
Parallel and distributed computer systems. Parallel programming models. Common parallel and distributed programming issues. Specific topics include parallel programming, performance models, coordination and synchronization, consistency and replication, transactions, fault tolerance.
Prerequisite: I&C SCI 53 or COMPSCI 143A.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 132. Computer Networks. 4 Units.**
Computer network architectures, protocols, and applications. Internet congestion control, addressing, and routing. Local area networks. Multimedia networking.
Prerequisite: EECS 55 or STATS 67.
Same as EECS 148
Restrictions: Computer Engineering majors and Computer Science and Engineering majors have the first consideration for enrollment.

**COMPSCI 133. Advanced Computer Networks. 4 Units.**
Fundamental principles in computer networks are applied to obtain practical experience and skills necessary for designing and implementing computer networks, protocols, and network applications. Various network design techniques, simulation techniques, and UNIX network programming are covered.
Prerequisite: COMPSCI 132 or EECS 148.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 134. Computer and Network Security. 4 Units.**
Overview of modern computer and networks security, attacks, and countermeasures. Authentication, identification, data secrecy, data integrity, authorization, access control, computer viruses, network security. Also covers secure e-commerce and applications of public key methods, digital certificates, and credentials.
Prerequisite: COMPSCI 161 and I&C SCI 53.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 137. Internet Applications Engineering. 4 Units.**
Concepts in Internet applications engineering with emphasis on the Web. Peer-to-Peer and Interoperability. Topics include HTTP and REST, Remote Procedure/Method Calls, Web Services, data representations, content distribution networks, identity management, relevant W3C/IETF standards, and relevant new large-scale computing styles.
Prerequisite: (COMPSCI 132 or EECS 148) and I&C SCI 45J.
Same as IN4MATX 124
Overlaps with COMPSCI 122B.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 141. Concepts in Programming Languages. 4 Units.**
In-depth study of several contemporary programming languages stressing variety in data structures, operations, notation, and control. Examination of different programming paradigms, such as logic programming, functional programming and object-oriented programming; implementation strategies, programming environments, and programming style.
Prerequisite: (I&C SCI 51 with a minimum grade of C or EECS 31 with a minimum grade of C) and I&C SCI 46 with a minimum grade of C.
Same as IN4MATX 101
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students only.

**COMPSCI 142A. Compilers and Interpreters. 4 Units.**
Introduction to the theory of programming language processors covering lexical analysis, syntax analysis, semantic analysis, intermediate representations, code generation, optimization, interpretation, and run-time support.
Prerequisite: (I&C SCI 46 or EECS 114) and (I&C SCI 51 or EECS 31). Recommended: COMPSCI 141 or IN4MATX 101 or I&C SCI 45J or EECS 40
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students only.

**COMPSCI 142B. Project in Compilers and Interpreters. 4 Units.**
Project course which provides working laboratory experience in construction and behavior of compilers and interpreters. Students build actual language processors and perform experiments which reveal their behaviors.
Prerequisite: COMPSCI 142A.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 143A. Principles of Operating Systems. 4 Units.**
Principles and concepts of process and resource management, especially as seen in operating systems. Processes, memory management, protection, scheduling, file systems, and I/O systems are covered. Concepts illustrated in the context of several well-known systems.
Prerequisite: (I&C SCI 46 or CSE 46) and (I&C SCI 51 or EECS 31 or CSE 31).
Overlaps with EECS 111.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 143B. Project in Operating System Organization. 4 Units.**
Detailed specification and design of critical components of an actual operating system including a memory manager, a process server, and a file/IO subsystem. Hardware/software tradeoffs. Emphasis on logical organization of system and communication.
Prerequisite: COMPSCI 143A.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 145. Embedded Software. 6 Units.**
Principles of embedded computing systems: embedded systems architecture, hardware/software components, system software and interfacing, real-time operating systems, hardware/software co-development, and communication issues. Examples of embedded computing in real-world application domains. Simple programming using an embedded systems development environment.
Prerequisite: I&C SCI 46 and (I&C SCI 51 or EECS 31).
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 146. Programming in Multitasking Operating Systems. 4 Units.**
User- and systems-level programming of modern Internet-connected, multi-user, multitasking operating systems. Shells, scripting, filters, pipelines, programmability, extensibility, concurrency, inter-process communication. Concrete examples of a modern operating system (such as, but not necessarily, Unix programmed in C) are used.
Prerequisite: I&C SCI 46 with a minimum grade of C and I&C SCI 51 with a minimum grade of C. Recommended: COMPSCI 143A.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 147. Internet of Things (IoT) Software and Systems. 4 Units.**
Introduction to the Internet of Things (IoT) from a systems and software perspective. IoT ecosystem including sensors, embedded CPUs, networking protocols, software, cloud services, and security and privacy requirements. IoT use cases, system design, and programming project.
Prerequisite: I&C SCI 33.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 151. Digital Logic Design. 4 Units.**
Boolean algebra. Design/analysis of combinational and sequential systems using SSI/MSI/LSI modules. Number systems. Error detecting and correction codes. Arithmetic algorithms. Hardware/firmware implementation of algorithms.
Prerequisite: I&C SCI 33 with a minimum grade of C and I&C SCI 51 with a minimum grade of C and I&C SCI 6B and I&C SCI 6D.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 152. Computer Architecture. 4 Units.**
Design of computer elements; ALU, control unit, and arithmetic circuits. Memory hierarchy and organization. Caches. Function unit sharing and pipelining. I/O and interrupt processing. RTL and behavioral modeling using hardware description languages. Microprocessor organization and implementation techniques.
Prerequisite: I&C SCI 51.
Overlaps with IC SCI 160, EECS 112.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 154. Computer Design Laboratory. 4 Units.**
Underlying primitives of computer instruction sets. Principles of microprogramming. Microprogramming. Microprograms written for one or more systems. Typical microprogramming applications discussed and implemented or simulated.
Prerequisite: COMPSCI 151 or COMPSCI 152.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 161. Design and Analysis of Algorithms. 4 Units.**
Techniques for efficient algorithm design, including divide-and-conquer and dynamic programming, and time/space analysis. Fast algorithms for problems applicable to networks, computer games, and scientific computing, such as sorting, shortest paths, minimum spanning trees, network flow, and pattern matching.
Prerequisite: I&C SCI 46 with a minimum grade of C and I&C SCI 6B and I&C SCI 6D and (MATH 2B or AP Calculus BC with a minimum score of 4).
Restrictions: Computer Science and Engineering majors, Computer Science majors, Data Science majors, Software Engineering majors, and School of Information and Computer Sciences students only. Business Information Management, Computer Game Science, and Informatics majors have second right of consideration.

**COMPSCI 162. Formal Languages and Automata. 4 Units.**
Formal aspects of describing and recognizing languages by grammars and automata. Parsing regular and context-free languages. Ambiguity, nondeterminism. Elements of computability; Turning machines, random access machines, undecidable problems, NP-completeness.
Prerequisite: I&C SCI 46 with a minimum grade of C and (MATH 2B or AP Calculus BC with a minimum score of 4) and I&C SCI 6B and I&C SCI 6D.
Same as LSCI 102
Restrictions: Cognitive Sciences majors, Computer Science and Engineering majors, Language Science majors, and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 163. Graph Algorithms. 4 Units.**
Algorithms for solving fundamental problems in graph theory. Graph representations, graph traversal, network flow, connectivity, graph layout, matching problems.
Prerequisite: COMPSCI 161.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.
Concurrent: COMPSCI 265

**COMPSCI 164. Computational Geometry. 4 Units.**
Algorithms and data structures for computational geometry and geometric modeling, with applications to computer vision and graphics. Topics: convex hulls, Voronoi diagrams, algorithms for triangulation, motion planning, and data structures for geometric searching and modeling of 2D and 3D
Prerequisite: COMPSCI 161.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.
Concurrent: COMPSCI 266

**COMPSCI 165. Project in Algorithms and Data Structures. 4 Units.**
Design, implementation, execution, and analysis of algorithms for problems such as sorting, searching, data compression, and data encryption. Time-space-structure trade-offs.
Prerequisite: COMPSCI 161. Recommended: I&C SCI 45C.
Restrictions: Computer Science majors and School of Information and Computer Sciences students have the first consideration for enrollment. Computer Science and Engineering majors and all School of ICS majors have second right of consideration.

**COMPSCI 166. Quantum Computation and Information. 4 Units.**
Basic models for quantum computation and their foundations in quantum mechanics. Quantum complexity classes and quantum algorithms, including algorithms for factoring and quantum simulation. Introduction to quantum information theory and quantum entanglement.
Prerequisite: (I&C SCI 6N with a minimum grade of C+ or MATH 3A with a minimum grade of C+) and (COMPSCI 161 or PHYSICS 113A).
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.
Concurrent: COMPSCI 264

**COMPSCI 167. Introduction to Applied Cryptography. 4 Units.**
An introduction to the essential aspects of applied cryptography, as it is used in practice. Topics include classical cryptography, block ciphers, stream ciphers, public-key cryptography, digital signatures, one-way hash functions, basic cryptographic protocols, and digital certificates and credentials.
Prerequisite: COMPSCI 161.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 169. Introduction to Optimization. 4 Units.**
A broad introduction to optimization. Unconstrained and constrained optimization. Equality and inequality constraints. Linear and integer programming. Stochastic dynamic programming.
Prerequisite: (I&C SCI 6N or MATH 3A)( and (STATS 67) or STATS 7 or AP Statistics with a minimum score of 3) and STATS 120A).
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.
Concurrent: COMPSCI 268

**COMPSCI 171. Introduction to Artificial Intelligence. 4 Units.**
Different means of representing knowledge and uses of representations in heuristic problem solving. Representations considered include predicate logic, semantic nets, procedural representations, natural language grammars, and search trees.
Prerequisite: (STATS 67 or STATS 7 or AP Statistics with a minimum score of 3) and STATS 120A and I&C SCI 46 and (MATH 2B or AP Calculus BC with a minimum score of 4).
Overlaps with EECS 118.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 172B. Neural Networks and Deep Learning . 4 Units.**
Neural network and deep learning from multiple perspectives. Theory of parallel distributed processing systems, algorithmic approaches for learning from data in various manners, applications to difficult problems in AI from computer vision, to natural language understanding, to bioinformatics and chemoinformatics.
Prerequisite: (STATS 120A and STATS 120B) or MATH 121A or COMPSCI 178 or COMPSCI 273A.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.
Concurrent: COMPSCI 274C

**COMPSCI 172C. Artificial Intelligence Frontiers: Technical, Ethical, and Societal. 4 Units.**
Explores the frontiers of artificial intelligence and related technologies with a focus on the underlying ethical, legal, and societal challenges and opportunities they create. Encourages critical thinking about these issues.
Prerequisite: COMPSCI 171 and COMPSCI 172B. Recommended: COMPSCI 178
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.
Concurrent: COMPSCI 274D

**COMPSCI 175. Project in Artificial Intelligence. 4 Units.**
Construction of a working artificial intelligence system. Evaluation of capabilities of the system including impact of knowledge representation.
Prerequisite: COMPSCI 171 and COMPSCI 178.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 177. Applications of Probability in Computer Science. 4 Units.**
Application of probability to real-world problems in computer science. Typical topics include analysis of algorithms and graphs, probabilistic language models, network traffic modeling, data compression, and reliability modeling.
Prerequisite: (MATH 2B or AP Calculus BC with a minimum score of 4) and I&C SCI 6B and I&C SCI 6D and (MATH 3A or I&C SCI 6N) and STATS 67.

Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 178. Machine Learning and Data-Mining. 4 Units.**
Introduction to principles of machine learning and data-mining applied to real-world datasets. Typical applications include spam filtering, object recognition, and credit scoring.
Prerequisite: I&C SCI 6B and I&C SCI 6D and (I&C SCI 6N or MATH 3A) and (MATH 2B or AP Calculus BC with a minimum score of 4) and STATS 67 or ((STATS 7 or AP Statistics with a minimum score of 3) and STATS 120A).
Overlaps with EECS 125.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 179. Algorithms for Probabilistic and Deterministic Graphical Models. 4 Units.**
Graphical model techniques dealing with probabilistic and deterministic knowledge representations. Focuses on graphical models such as constraint networks, Bayesian networks, and Markov networks that have become a central paradigm for knowledge representation and reasoning in AI and general computer science.
Prerequisite: COMPSCI 171.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 180A. Project in Computer Science. 4 Units.**
Students to solve a substantial real-world problem with knowledge gained from many areas in computer science. Project has a focus on computer science but can overlap with neighbor disciplines.
Prerequisite: I&C SCI 46.
Restrictions: School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 180B. Project in Computer Science. 4 Units.**
Students to solve a substantial real-world problem with knowledge gained from many areas in computer science. Project has a focus on computer science but can overlap with neighbor disciplines.
Prerequisite: COMPSCI 180A. In Progress (IP) grade for COMPSCI 180A is also accepted.
Restrictions: School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 183. Introduction to Computational Biology. 4 Units.**
The use of theories and methods based on computer science, mathematics, and physics in molecular biology and biochemistry. Basics in biomolecular modeling. Analysis of sequence and structural data of biomolecules. Analysis of biomolecular functions.
Prerequisite: MATH 2D or MATH 3A or STATS 7 or STATS 8.
Same as BIO SCI M123, BME 132
Concurrent: MOL BIO 223, BME 232

**COMPSCI 184A. Artificial Intelligence in Biology and Medicine. 4 Units.**
Introduction to computational methods in molecular biology, aimed at those interested in learning about this interdisciplinary area. Covers computational approaches to understanding and predicting the structure, function, interactions, and evolution of DNA, RNA, proteins, and related molecules and processes.
Prerequisite: I&C SCI 6N or MATH 3A.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.
Concurrent: COMPSCI 284A

**COMPSCI 184C. Computational Systems Biology. 4 Units.**
Computational inference and modeling of gene regulation networks, signal transduction pathways, and the effects of regulatory networks in cellular processes, development, and disease. Introduction of required mathematical, computational, and data handling tools.
Prerequisite: COMPSCI 184A.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.
Concurrent: COMPSCI 284C

**COMPSCI 189. Project in Bioinformatics. 4 Units.**
Teaches problem definition and analysis, data representation, algorithm design, component integration, solution validation, and testability with teams specifying, designing, building, and testing a solution to a bioinformatics problem. Lectures include engineering values, discussions, and ethical ramifications of biomedical computing issues.
Prerequisite: COMPSCI 184A with a minimum grade of C.
Restrictions: Computer Science and Engineering majors and School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 190. Special Topics in Information and Computer Science. 4 Units.**
Studies in selected areas of Information and Computer Science. Topics addressed vary each quarter.
Prerequisite: Prerequisites vary.
Repeatability: May be taken unlimited times as topics vary
Restrictions: School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI H198. Honors Research. 4 Units.**
Directed independent research in computer science for honors students.
Repeatability: May be taken unlimited times
Restrictions: Campuswide Honors Collegium only. School of Information and Computer Sciences Honors students only.

**COMPSCI 199. Individual Study. 2-5 Units.**
Individual research or investigation with Computer Science faculty.
Repeatability: May be taken unlimited times

**COMPSCI 200S. Seminar in Computer Science Research. 1 Unit.**
Graduate colloquium series. Includes weekly talks by notable computer scientists.
Grading Option: Satisfactory/Unsatisfactory only
Repeatability: May be taken unlimited times

**COMPSCI 201. Foundations of Cryptographic Protocols. 4 Units.**
Explores fundamental cryptographic tools, including encryption, signatures, and identification schemes. Students are introduced to the provable security paradigm of modern cryptography, focusing on understanding of security properties provided by cryptographic tools, and on proving security (or insecurity) of cryptographic constructions.
Prerequisite: COMPSCI 260 with a minimum grade of B- or COMPSCI 263 with a minimum grade of B-.

**COMPSCI 201P. Computer Security. 4 Units.**
Introduction to computer security, including systems, technology, and management. Topics include authorization, authentication, data integrity, malware, operating systems security, network security, web security, and basic cryptography.
Prerequisite: Knowledge of Python or C++ programming is required.
Restrictions: Master of Computer Science and Master of Data Science only.

**COMPSCI 202. Applied Cryptography. 4 Units.**
Design and analysis of algorithms for applied cryptography. Topics include symmetric and asymmetric key encryption, digital signatures, one-way hash functions, digital certificates and credentials, and techniques for authorization, non-repudiation, authentication, identification, data integrity, proofs of knowledge, and access control.
Prerequisite: COMPSCI 260 with a minimum grade of B- and COMPSCI 263 with a minimum grade of B-.

**COMPSCI 203. Network and Distributed Systems Security. 4 Units.**
Modern computer and networks security: attacks and countermeasures, authentication, identification, data secrecy, data integrity, authorization, access control, computer viruses, network security. Group communication and multicast security techniques. Covers secure e-commerce and applications of public key methods, digital certificates, and credentials.
Prerequisite: EECS 148 or COMPSCI 132.
Same as NET SYS 240

**COMPSCI 203P. Network Security. 4 Units.**
Introduction to network security, including network threats and attacks, as well as defenses against such attacks. Topics include network infrastructure security, mobile and Wi-Fi security, spam, phishing, firewalls, anonymity, secure email, secure and private cloud computing, and web security.
Prerequisite: COMPSCI 201P with a minimum grade of B- or COMPSCI 202P with a minimum grade of B-.
Restrictions: Master of Computer Science only.

**COMPSCI 204. Usable Security and Privacy. 4 Units.**
Examines how to design for security and privacy from a user-centered perspective by combining insights from computer systems and human-centered computing. Explores several challenges in integrating usability into core security and privacy systems design.
Overlaps with IN4MATX 231, COMPSCI 203.
Restrictions: Undergraduate degree in Computer Science is strongly recommended.

**COMPSCI 205. Computer and Systems Security . 4 Units.**
Lecture and discuss latest security research in software, OS, protocols, mobile devices, machine learning, sensors, and emerging IoT/CPS systems such as smart home and smart transportation. Students perform research projects and gain hands-on experience evaluating and designing secure systems.
Prerequisite: COMPSCI 134 and COMPSCI 142A and COMPSCI 143A.
Restrictions: School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 206. Principles of Scientific Computing. 4 Units.**
Overview of widely used principles and methods of numerical and scientific computing, including basic concepts and computational methods in linear algebra, optimization, and probability.
Prerequisite: Basic courses in multivariate calculus, linear algebra, and probability.
Overlaps with STATS 230.

**COMPSCI 211A. Visual Computing. 4 Units.**
Fundamentals of image processing (convolution, linear filters, spectral analysis), vision geometry (projective geometry, camera models and calibration, stereo reconstruction), radiometry (color, shading, illumination, BRDF), and visual content synthesis (graphics pipeline, texture- bump-, mip-mapping, hidden surface removal, anti-aliasing).

**COMPSCI 211B. Computer Graphics and Visualization. 4 Units.**
Interactive 3D graphics rendering pipeline, illumination and shading, ray tracing, texture-, bump-, mip-mapping, hidden surface removal, anti-aliasing, multiresolution representations, volume rendering techniques, iso-surface extraction.
Prerequisite: COMPSCI 211A with a minimum grade of B-.

**COMPSCI 211C. Realistic Image Synthesis. 4 Units.**
Provides an in-depth overview on a core sub-field of computer graphics. Graduate students who take this course are better prepared for conducting research on the related topics in computer graphics, vision, and scientific computing.
Restrictions: School of Information and Computer Sciences students only.

**COMPSCI 216. Image Understanding. 4 Units.**
The goal of image understanding is to extract useful semantic information from image data. Course covers low-level image and video processing techniques, feature descriptors, segmentation, objection recognition, and tracking.
Prerequisite: I&C SCI 6D and (I&C SCI 6N or MATH 6G or MATH 3A) and MATH 2B and I&C SCI 46.

**COMPSCI 217. Light and Geometry in Computer Vision. 4 Units.**
Examines the issues of light transport and multiview geometry in computer vision. Applications include camera calibration, 3D understanding, stereo reconstruction, and illumination estimation.
Prerequisite: I&C SCI 6D and (I&C SCI 6N or MATH 6G or MATH 3A) and MATH 2B and I&C SCI 46 and COMPSCI 211A with a minimum grade of B-.

**COMPSCI 219S. Seminar in Graphics and Visualization. 2 Units.**
Current research and research trends in computer graphics, visualization, virtual/augmented reality, and other visual computing topics.
Grading Option: Satisfactory/Unsatisfactory only
Repeatability: May be taken unlimited times
Restrictions: School of Information and Computer Sciences students only.

**COMPSCI 220P. Databases and Data Management. 4 Units.**
Introduction to the design of databases and the use of database management systems (DBMS) for managing and utilizing data. Topics include entity-relationship modeling for design, relational data model, relational algebra, relational schema design, and use of SQL (Structured Query Language).
Restrictions: Master of Computer Science only.

**COMPSCI 221. Information Retrieval, Filtering, and Classification. 4 Units.**
Algorithms for the storage, retrieval, filtering, and classification of textual and multimedia data. The vector space model, Boolean and probabilistic queries, and relevance feedback. Latent semantic indexing; collaborative filtering; and relationship to machine learning methods.
Prerequisite: COMPSCI 161 and COMPSCI 171 and (I&C SCI 6N or MATH 3A or MATH 6G).
Same as SWE 225

**COMPSCI 222. Principles of Data Management. 4 Units.**
Covers fundamental principles underlying data management systems. Content includes key techniques including storage management, buffer management, record-oriented file system, access methods, query optimization, and query processing.
Prerequisite: COMPSCI 122A and (I&C SCI 53 or COMPSCI 143A).
Concurrent: COMPSCI 122C

**COMPSCI 222P. Principles of Data Management. 4 Units.**
Covers fundamental principles underlying data management systems. Understanding and implementation of key techniques including storage management, buffer management, record-oriented file system, access methods, query optimization, and query processing.
Prerequisite: Required: C++ programming skills, understanding of data structures and algorithms.
Restrictions: Master of Computer Science and Master of Data Science only.

**COMPSCI 223. Transaction Processing and Distributed Data Management. 4 Units.**
Covers fundamental principles underlying transaction processing including database consistency, concurrency control, database recovery, and fault-tolerance. Includes transaction processing in centralized, distributed, parallel, and client-server environments.

**COMPSCI 223P. Transaction Processing and Distributed Data Management. 4 Units.**
Introduction to fundamental principles underlying transaction processing systems including database consistency, atomicity, concurrency control, database recovery, replication, commit protocols, and fault-tolerance. Includes transaction processing in centralized, distributed, parallel, and client-server environments.
Prerequisite: COMPSCI 222P with a minimum grade of B or COMPSCI 222 with a minimum grade of B.
Restrictions: Master of Computer Science and Master of Data Science only.

**COMPSCI 224P. Big Data Management. 4 Units.**
Focuses on Big Data management frameworks such as Hadoop and Spark. Also covers relational and non-relational database technologies, including document (“NoSQL”) databases as well as emerging cloud data management solutions.
Prerequisite: COMPSCI 220P with a minimum grade of B or COMPSCI 122A with a minimum grade of C.
Restrictions: Master of Computer Science and Master of Data Science only.

**COMPSCI 230. Distributed Computer Systems. 4 Units.**
Principles of distributed computing systems. Topics covered include message-passing, remote procedure calls, distributed shared memory synchronization, resource and process/thread management, distributed file systems, naming and security.

**COMPSCI 231P. Parallel and Distributed Computing for Professionals . 4 Units.**
Covers a wide variety of concepts related to the design and application of high-performance concurrent computing systems, including architectural features, communications networks and models, parallel program development for numerical and non-numerical applications, programming models, and more.
Restrictions: Master of Computer Science only.

**COMPSCI 232. Computer and Communication Networks. 4 Units.**
Network architecture of the Internet, telephone networks, cable networks, and cell phone networks. Network performance models. Network performance models. Advanced concepts and implementations of flow and congestion control, addressing, internetworking, forwarding, routing, multiple access, streaming, and quality-of-service.
Prerequisite: EECS 148 or COMPSCI 132.
Same as EECS 248A, NET SYS 201

**COMPSCI 232P. Computer and Communication Networks . 4 Units.**
Internet architecture, protocols, and services. Advanced concepts of IP and TCP, including addressing, internetworking, forwarding, routing, and implementations of flow and congestion control. Internet services such as Network Address Translation and Domain Name Servers. Overview of Local Area Networks.

**COMPSCI 233. Networking Laboratory. 4 Units.**
A laboratory-based introduction to basic networking concepts such as addressing, sub-netting, bridging, ARP, and routing. Network simulation and design. Structured around weekly readings and laboratory assignments.
Prerequisite: EECS 148 or COMPSCI 132.
Same as NET SYS 202

**COMPSCI 234. Advanced Networks. 4 Units.**
Design principles of networked systems, advanced routing and congestion control algorithms, network algorithms, network measurement, management, security, Internet economics, and emerging networks.
Prerequisite: NET SYS 201 with a minimum grade of B- or COMPSCI 232 with a minimum grade of B- or EECS 248A with a minimum grade of B-.
Same as NET SYS 210

**COMPSCI 236. Wireless and Mobile Networking. 4 Units.**
Introduction to wireless networking. The focus is on layers 2 and 3 of the OSI reference model, design, performance analysis, and protocols. Topics covered include: an introduction to wireless networking, digital cellular, next generation cellular, wireless LANs, and mobile IP.
Prerequisite: EECS 148 or COMPSCI 132.
Same as NET SYS 230

**COMPSCI 237. Middleware for Networked and Distributed Systems. 4 Units.**
Discusses concepts, techniques, and issues in developing distributed systems middleware that provides high performance and Quality of Service for emerging applications. Also covers existing standards (e.g., CORBA, DCOM, Jini, Espeak) and their relative advantages and shortcomings.
Prerequisite: An undergraduate-level course in operating systems and networks.
Same as NET SYS 260

**COMPSCI 238. Advanced Operating Systems. 4 Units.**
Focuses on advanced and graduate-level topics in operating systems. Presents important recent developments in operating systems, topics not covered in undergraduate operating systems courses. This includes novel operating system designs and techniques to improve existing ones.
Prerequisite: COMPSCI 143A.

**COMPSCI 238P. Operating Systems. 4 Units.**
In-depth organization of the core operating system abstraction and its implementation (virtual memory, kernel and user mode, system calls, threads, context switches, interrupts, inter-process communication, hardware interface, etc.) and a range of recent developments in de-facto industry standard operating systems.
Prerequisite: Working knowledge of C and the Linux environment.
Restrictions: Master of Computer Science only.

**COMPSCI 241. Advanced Compiler Construction. 4 Units.**
Advanced study of programming language implementation techniques: optimizations such as common sub-expression elimination, register allocation, and instruction scheduling. Implementation of language features such as type-directed dispatch, garbage collection, dynamic linking, and just-in-time code generation.
Prerequisite: COMPSCI 142A.

**COMPSCI 242. Parallel Computing. 4 Units.**
Definition of parallel processing systems. Theory and application of arrays, trees, and hypercubes. Computational models, applications: sorting, integer arithmetic, matrix operations, Fast Fourier Transform, and others. Interconnection networks: a framework for the description, analysis, and construction of hypercube-derived networks.

**COMPSCI 244. Introduction to Embedded and Ubiquitous Systems. 4 Units.**
Embedded and ubiquitous system technologies including processors, DSP, memory, and software. System interfacing basics; communication strategies; sensors and actuators, mobile and wireless technology. Using pre-designed hardware and software components. Design case studies in wireless, multimedia, and/or networking domains.
Prerequisite: I&C SCI 51 and COMPSCI 152 and COMPSCI 161 and (I&C SCI 6N or MATH 3A or MATH 6G or I&C SCI 6D). B.S. degree in Computer Science is also accepted.
Same as IN4MATX 244

**COMPSCI 244P. Internet of Things. 4 Units.**
Develops a comprehensive understanding of the hardware and software technology, the communication protocols, and the security and privacy requirements underlying the Internet of Things ecosystem, particularly those using computing elements (processors, DSPs/ ASIPs), sensors, and accessing cloud services.
Prerequisite: Undergraduate-level familiarity with fundamentals of integrated circuit blocks, processors, optimization/algorithm design, and some programming experience.
Restrictions: Master of Computer Science only.

**COMPSCI 247. Complex Software Systems: Project Course. 4 Units.**
Building complex systems software systems, such as Database Management Systems, Operating Systems, and Optimizing Compilers. Such systems often involve low-level programming and intricate performance optimizations. Students learn how to build such a system.
Prerequisite: COMPSCI 222 (may be taken concurrently) with a minimum grade of B- or COMPSCI 238 (may be taken concurrently) with a minimum grade of B- or COMPSCI 241 (may be taken concurrently) with a minimum grade of B-.
Repeatability: May be taken unlimited times

**COMPSCI 248A. Introduction to Ubiquitous Computing. 4 Units.**
The "disappearing computer" paradigm. Differences to the desktop computing model: applications, interaction in augmented environments, security, alternate media, small operating systems, sensors, and embedded systems design. Evaluation by project work and class participation.
Same as IN4MATX 241

**COMPSCI 250A. Computer Systems Architecture. 4 Units.**
Study of architectural issues and their relation to technology and software: design of processor, interconnections, and memory hierarchies.
Prerequisite: COMPSCI 152.

**COMPSCI 250B. Modern Computer Systems. 4 Units.**
Fundamental concepts and recent advances in computer systems architecture necessary to achieve high performance and efficiency on systems available today. Topics span modern processor features, accelerators, storage and network architectures, as well as architecture-optimized software.
Prerequisite: Required: Undergraduate-level understanding of computer architecture concepts.
Overlaps with COMPSCI 243.

**COMPSCI 250P. Computer Systems Architecture . 4 Units.**
Study of architectural issues and their relation to technology and software: design of processor, interconnections, and memory hierarchies.
Prerequisite: Undergraduate-level familiarity with fundamentals of integrated circuit blocks, processors, and optimization/algorithm design, and some programming experience.
Restrictions: Master of Computer Science only.

**COMPSCI 253. Analysis of Programming Languages. 4 Units.**
Concepts in modern programming languages, their interaction, and the relationship between programming languages and methods for large-scale, extensible software development. Empirical analysis of programming language usage.
Same as SWE 212

**COMPSCI 253P. Advanced Programming and Problem Solving. 4 Units.**
Provides in-depth preparation for industry interviews requiring demonstration of problem solving and programming skills. Emphasis is on understanding problem statements, considering edge cases, developing effective test cases, designing correct solutions, explaining these clearly, and implementing a solution correctly.
Corequisite: COMPSCI 260P.
Restrictions: Master of Computer Science only.

**COMPSCI 256. Systems and Machine Learning. 4 Units.**
Course is divided into two parts. The first half covers recent research in systems for machine learning (ML) that enabled rapid progress in ML/AI. The second half revolves around application of machine learning in systems.
Prerequisite: Recommended: An undergraduate machine-learning course and an undergraduate course in one of the following areas: networking, distributed systems, or operating systems.
Restrictions: School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 257. Brain-Inspired Learning Systems. 4 Units.**
Introduces the latest developments in machine learning and cognitive computing algorithms inspired by the human brain. Includes examining various neural coding approaches for data representation and developing classification and reasoning algorithms that model human cognitive behavior.

**COMPSCI 259S. Seminar in Design Science. 2 Units.**
Current research and research trends in design science. Forum for presentation and criticism by students of research work in progress.
Repeatability: May be taken for credit 18 times

**COMPSCI 260. Fundamentals of the Design and Analysis of Algorithms. 4 Units.**
Covers fundamental concepts in the design and analysis of algorithms and is geared toward non-specialists in theoretical computer science. Topics include: deterministic and randomized graph algorithms, fundamental algorithmic techniques like divide-and-conquer strategies and dynamic programming, and NP-completeness.
Prerequisite: COMPSCI 161.

**COMPSCI 260P. Algorithms with Applications. 4 Units.**
Covers fundamental concepts in the design and analysis of algorithms and is geared toward practical application and implementation. Topics include greedy algorithms, deterministic and randomized graph algorithms, models of network flow, fundamental algorithmic techniques, and NP-completeness.
Restrictions: Master of Computer Science only.

**COMPSCI 261. Data Structures. 4 Units.**
An in-depth treatment of data structures and their associated management algorithms including resource complexity analysis.
Prerequisite: I&C SCI 46 and COMPSCI 161.

**COMPSCI 261P. Data Structures with Applications . 4 Units.**
Data structures and their associated management algorithms, including their applications and analysis.
Restrictions: Master of Computer Science and Master of Data Science only.

**COMPSCI 262P. Text Processing and Information Retrieval. 4 Units.**
Techniques for text pattern matching and algorithms for the storage, retrieval, and classification of textual and multimedia data. Topics include string searching, string data structures, document and website retrieval, and search engines.
Restrictions: Master of Computer Science only.

**COMPSCI 263. Analysis of Algorithms. 4 Units.**
Analysis of correctness and complexity of various efficient algorithms; discussion of problems for which no efficient solutions are known.
Prerequisite: COMPSCI 161 and COMPSCI 261 with a minimum grade of B-.

**COMPSCI 265. Graph Algorithms. 4 Units.**
Graph definitions, representation methods, graph problems, algorithms, approximation methods, and applications.
Prerequisite: Recommended: COMPSCI 161, COMPSCI 260, or equivalent.
Concurrent: COMPSCI 163

**COMPSCI 266. Computational Geometry. 4 Units.**
The design and analysis of algorithms and data structures for computational geometry, with applications to machine learning, computer vision, and graphics. Topics: convex hulls, Voronoi diagrams, Delaunay triangulations, geometric arrangements, polygon triangulation, and data structures for geometric searching and modeling.
Prerequisite: COMPSCI 161 or COMPSCI 260 with a minimum grade of B-.
Concurrent: COMPSCI 164

**COMPSCI 268. Introduction to Optimization. 4 Units.**
A broad introduction to optimization. Unconstrained and constrained optimization. Equality and inequality constraints. Linear and integer programming. Stochastic dynamic programming.
Prerequisite: STATS 67 or (STATS 7 and STATS 120A) and (I&C SCI 6N or MATH 3A).
Restrictions: School of Information and Computer Sciences students have the first consideration for enrollment.
Concurrent: COMPSCI 169

**COMPSCI 269S. Seminar in the Theory of Algorithms and Data Structures. 2 Units.**
Current research and research trends in the Theory of algorithms and data structures.
Repeatability: May be taken for credit 18 times

**COMPSCI 271. Introduction to Artificial Intelligence. 4 Units.**
The study of theories and computational models for systems which behave and act in an intelligent manner. Fundamental subdisciplines of artificial intelligence including knowledge representation, search, deduction, planning, probabilistic reasoning, natural language parsing and comprehension, knowledge-based systems, and learning.

**COMPSCI 271P. Artificial Intelligence. 4 Units.**
The study of theories and computational models for systems which behave and act in an intelligent manner. Fundamental sub-disciplines of artificial intelligence, including knowledge representation, search, deduction, planning, probabilistic reasoning, natural language parsing and comprehension, knowledge-based systems, and learning.
Restrictions: Master of Computer Science and Master of Data Science only.

**COMPSCI 272. Statistical Natural Language Processing. 4 Units.**
Statistical models, machine learning algorithms, and computational tasks involved in natural language processing. Focuses on approaches that learn these models from data, and covers applications such as information extraction, dialog systems, machine translation, and question answering.
Prerequisite: COMPSCI 171 and COMPSCI 178.
Restrictions: School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 273A. Machine Learning. 4 Units.**
Computational approaches to learning algorithms for classifications, regression, and clustering. Emphasis is on discriminative classification methods such as decision trees, rules, nearest neighbor, linear models, and naive Bayes.
Prerequisite: COMPSCI 271 with a minimum grade of B- and COMPSCI 206 with a minimum grade of B-.

**COMPSCI 273P. Machine Learning and Data Mining . 4 Units.**
Introduction to principles of machine learning and data-mining. Learning algorithms for classifications, regression, and clustering. Emphasis is on discriminative classification methods such as decision trees, rules, nearest neighbor, linear models, and naive Bayes.
Prerequisite: Required: Python programming knowledge.
Restrictions: Master of Computer Science and Master of Data Science only.

**COMPSCI 274A. Probabilistic Learning: Theory and Algorithms. 4 Units.**
An introduction to probabilistic and statistical techniques for learning from data, including parameter estimation, density estimation, regression, classification, and mixture modeling.
Prerequisite: COMPSCI 206 with a minimum grade of B-.

**COMPSCI 274B. Learning in Graphical Models. 4 Units.**
Models for data analysis are presented in the unifying framework of graphical models. The emphasis is on learning from data but inference is also covered. Real world examples are used to illustrate the material.
Prerequisite: COMPSCI 274A with a minimum grade of B-.

**COMPSCI 274C. Neural Networks and Deep Learning. 4 Units.**
Neural network and deep learning from multiple perspectives. Theory of parallel distributed processing systems, algorithmic approaches for learning from data in various manners, applications to difficult problems in AI from computer vision, to natural language understanding, to bioinformatics and chemoinformatics.
Prerequisite: (STATS 120A and STATS 120B) or MATH 121A or COMPSCI 178 or COMPSCI 273A with a minimum grade of B-.
Overlaps with COMPSCI 274A, COMPSCI 277, COMPSCI 276, COMPSCI 278, COMPSCI 274B, COMPSCI 273A, COMPSCI 275, COMPSCI 271.
Concurrent: COMPSCI 172B

**COMPSCI 274D. Artificial Intelligence Frontiers: Technical, Ethical, and Societal. 4 Units.**
Explores the frontiers of artificial intelligence and related technologies with a focus on the underlying ethical, legal, and societal challenges and opportunities they create. Encourages critical thinking about these issues.
Prerequisite: Recommended: COMPSCI 172B and COMPSCI 178.
Concurrent: COMPSCI 172C

**COMPSCI 274E. Deep Generative Models. 4 Units.**
Discusses probabilistic approaches to deep learning such as generative models and their applications in computer vision, NLP, the natural sciences, and other fields. Coursework may include both homework and project components.
Prerequisite: COMPSCI 178 or COMPSCI 273A with a minimum grade of B- or STATS 120B. Recommended: Advanced machine learning or graphical models courses such as COMPSCI 274A or COMPSCI 274B or COMPSCI 273C or COMPSCI 276.
Restrictions: School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 274P. Neural Networks and Deep Learning. 4 Units.**
Introduction to principles of machine learning and neural networks. Architecture design. Feedforward and recurrent networks. Learning models and algorithms. Applications to data analysis and prediction problems in areas such as machine vision, natural language processing, biomed, and finance.
Prerequisite: COMPSCI 271P with a minimum grade of B. Required: Knowledge of Python programming.
Restrictions: Master of Computer Science and Master of Data Science only.

**COMPSCI 275. Network-Based Reasoning/Constraint Networks. 4 Units.**
Study of the theory and techniques of constraint network model. Covers techniques for solving constraint satisfaction problems: backtracking techniques, consistency algorithms, and structure-based techniques. Tractable subclasses. Extensions into applications such as temporal reasoning, diagnosis, and scheduling.
Prerequisite: Basic course in algorithm design and analysis.

**COMPSCI 275P. Graphical Models and Statistical Learning. 4 Units.**
Introduction to principles of statistical machine learning with probabilistic graphical models. Studies efficient inference algorithms based on optimization-based variational methods, and simulation-based Monte Carlo methods. Several approaches to learning from data are covered.
Prerequisite: COMPSCI 273P with a minimum grade of B. Required: Python programming experience.
Restrictions: Master of Conservation and Restoration Science and Master of Data Science only.

**COMPSCI 276. Causal and Probabilistic Reasoning with Graphical Models. 4 Units.**
Provides in-depth exposition of causal reasoning and probabilistic graphical models theory and algorithms within Structural Causal Models and Bayesian Networks. Covers algorithms for Bayesian networks and central concepts (e.g., identifiability, the do-calculous, counterfactuals)
Prerequisite: Recommended: A basic course in probability.

**COMPSCI 277. Control and Reinforcement Learning. 4 Units.**
Introduction to learning agents that make sequences of decisions to interact with a system and control it. The main focus is reinforcement learning from a reward signal, with emphasis on algorithms that can learn differentiable policy parametrizations (Deep Reinforcement Learning).
Prerequisite: COMPSCI 178 or COMPSCI 273A with a minimum grade of B-. Recommended: COMPSCI 274A and COMPSCI 275B and COMPSCI 275C and COMPSCI 276.

**COMPSCI 278. Probability Models. 4 Units.**
Advanced probability, discrete time Markov chains, Poisson processes, continuous time Markov chains. Queuing or simulation as time permits.
Prerequisite: STATS 120A.
Concurrent: STATS 121

**COMPSCI 279. Foundations of Multi-Agent Systems. 4 Units.**
Introduction to the fundamental principles of multi-agent systems. Techniques for centralized/decentralized planning for cooperative/competitive agents. Examples include robotic warehousing and homeland security.
Prerequisite: Recommended: (COMPSCI 161 or CSE 161) and COMPSCI 171. Knowledge of Python.

**COMPSCI 280. Algorithmic Game Theory . 4 Units.**
Cover topics at the interface of theoretical computer science and economics: zero sum games and LP duality, mechanism design, voting and impossibility theorems, "price of anarchy". Algorithms and complexity theory for learning and computing Nash equilibria.
Restrictions: School of Information and Computer Sciences students only.

**COMPSCI 284A. Artificial Intelligence in Biology and Medicine. 4 Units.**
Introduction to computational methods in molecular biology, aimed at those interested in learning about this interdisciplinary area. Covers computational approaches to understanding and predicting the structure, function, interactions, and evolution of DNA, RNA, proteins, and related molecules and processes.
Prerequisite: A Basic course in algorithms or a basic course in molecular biology.
Concurrent: COMPSCI 184A

**COMPSCI 284C. Computational Systems Biology. 4 Units.**
Computational inference and modeling of gene regulation networks, signal transduction pathways, and the effects of regulatory networks in cellular processes, development, and disease. Introduction of required mathematical, computational, and data handling tools.
Prerequisite: COMPSCI 284A with a minimum grade of B- or (BIO SCI 99 and MATH 2D).
Concurrent: COMPSCI 184C

**COMPSCI 287. Approximation Algorithms . 4 Units.**
Most optimization problems arising in practice turn out to be NP-hard and therefore intractable. A pragmatic recourse is the design of polynomial time algorithms which find near-optimal solutions. This idea has led to a deep theory to address such problems.
Prerequisite: COMPSCI 161 (may be taken concurrently) with a minimum grade of B-. Required: A course on Linear Programming or working knowledge of LP-duality theory and working knowledge of complexity theory and NP-completeness.
Concurrent: COMPSCI 263

**COMPSCI 288. Algorithms for Matching Markets. 4 Units.**
Discusses algorithms underlying matching markets, drawing ideas from CS theory, economics, and game-theory. Topics include Gale-Shapley stable-matching algorithm, its incentive compatibility and LP formulation; online bipartite matching and Adwords market; one-sided matching markets; and market equilibria.
Prerequisite: Recommended: COMPSCI 263 and COMPSCI 295 (when the topic title is Game Theory), or a course on linear programming, or working knowledge of LP-duality theory.
Restrictions: School of Information and Computer Sciences students have the first consideration for enrollment.

**COMPSCI 290. Research Seminar. 2 Units.**
Forum for presentation and criticism by students of research work in progress. Presentation of problem areas and related work. Specific goals and progress of research.
Grading Option: Satisfactory/Unsatisfactory only
Repeatability: May be taken unlimited times

**COMPSCI 295. Special Topics in Information and Computer Science . 4 Units.**
Studies in selected areas of Information and Computer Science. Topics addressed vary each quarter.
Repeatability: May be taken unlimited times as topics vary

**COMPSCI 295P. Keystone Project for Computer Science. 4 Units.**
Design and development of a software system or a hardware component of a system based on knowledge of advanced computer science principles. Students implement at least a working prototype and test this using relevant input data.
Restrictions: Master of Computer Science only.

**COMPSCI 296. Elements of Scientific Writing. 4 Units.**
Introduces the concepts and principles of good scientific writing, demonstrates them by examples drawn from the literature, and uses a hands-on approach to apply them to documents being written by the participants.
Grading Option: Satisfactory/Unsatisfactory only

**COMPSCI 296P. Capstone Professional Writing and Communication for Computer Science Careers . 4 Units.**
Written and oral communication for computer science and IT careers. Production of the detailed design and development document for the concurrent capstone design class and refinement of written documents and oral communications skills needed for a successful job search.
Restrictions: Master of Computer Science only.

**COMPSCI 297P. Capstone Design Project for Computer Science . 4 Units.**
Design and development of app, software system, or hardware component of system based on students' prior knowledge of advanced computer science principles. Implement at least a working prototype and test this using relevant use cases and/or input data.
Restrictions: Master of Computer Science only.

**COMPSCI 298. Thesis Supervision. 2-12 Units.**
Individual research or investigation conducted in preparation for the M.S. thesis option or the dissertation requirements for the Ph.D. program.
Repeatability: May be taken unlimited times
Restrictions: Graduate students only.

**COMPSCI 298P. Computer Science Practicum. 2 Units.**
Internship in which students work individually at an outside organization to gain experience with the challenges involved in technology-related work.
Grading Option: Satisfactory/Unsatisfactory only
Repeatability: May be taken unlimited times
Restrictions: Master of Computer Science only.

**COMPSCI 299. Individual Study. 1-12 Units.**
Individual research or investigation with Computer Science faculty.
Repeatability: May be taken unlimited times
Restrictions: Graduate students only.

**COMPSCI 299P. Individual Study. 2 Units.**
Supervised individual study in computer science.
Grading Option: Satisfactory/Unsatisfactory only
Repeatability: May be taken for credit 4 times
Restrictions: Master of Computer Science only.