COMPUTER SCIENCE (COMS)

Courses primarily for undergraduates:

COMS 1010: Orientation
Credits: Required. Contact Hours: Discussion 1, Lecture 1.
Required orientation class for all incoming students in the Computer Science major. Topics include academic planning and policies, campus resources, and supports. Opportunity to connect with other computer science peers, faculty, alumni, and employers. Offered on a satisfactory-fail basis only. (Typically Offered: Fall, Spring)

COMS 1030: Computer Literacy and Applications
Credits: 4. Contact Hours: Lecture 3, Laboratory 2.
Introduction to computer literacy and applications. Literacy: Impact of computer technology in today's societies, hardware, software, software programming, database and information systems, communication and networks, digital media technology, computer security and safety, ethics and privacy. Applications: In-depth hands-on experience with the operating systems, Microsoft word processing, spreadsheets, database management and presentation software. No prior computer experience necessary. Offered online only. (Typically Offered: Fall, Spring, Summer)

COMS 1040: Brief Introduction to Computer Programming for Non-Majors
Credits: 2. Contact Hours: Lecture 1.5, Discussion 0.5.
Offered first 8 weeks and last 8 weeks. Use of personal computer and workstation and beginning programming. Project-oriented approach to computer operation and programming, including use of tools to aid in programming. Topics from computer history, using basic Windows and MacOS tools, program structure, expression, variables, decision and logic, and iteration. No prior computer experience necessary. (Typically Offered: Fall, Spring)

COMS 1050A: Short Course in Computer Programming: Perl
Credits: 2. Contact Hours: Lecture 1, Laboratory 2.
Prereq: COMS 1040
8-week course in programming using Perl.

COMS 1050B: Short Course in Computer Programming: MATLAB
Credits: 2. Contact Hours: Lecture 2.
Prereq: COMS 1040
8-week course in programming using MATLAB.

COMS 1060: Introduction to Web Programming
Credits: 3. Contact Hours: Lecture 3.
Introduction to web programming basics. Fundamentals of developing web pages using a comprehensive web development life cycle. Learn to design and code practical real-world homepage programs and earn adequate experience with current web design techniques such as HTML5 and cascading style sheets. Students also learn additional programming languages including JavaScript, jQuery, PHP, SQL, and MySQL. Strategies for accessibility, usability and search engine optimization. No prior computer programming experience necessary. (Typically Offered: Fall, Spring)

COMS 1070: Windows Application Programming
Credits: 3. Contact Hours: Lecture 3.
Introduction to computer programming for non-majors using a language such as the Visual Basic language. Basics of good programming and algorithm development. Graphical user interfaces. (Typically Offered: Fall, Spring)

COMS 1130: Introduction to Spreadsheets and Databases
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Using Microsoft Excel spreadsheets and Microsoft Access databases to input, store, process, manipulate, query, and analyze data for business and industrial applications. Graduation Restriction: Credit in COMS 1130 may not be applied toward graduation in the SE and CPRE majors. (Typically Offered: Fall, Spring, Summer)

COMS 1270: Introduction to Computer Programming
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Prereq: Credit or concurrent enrollment in MATH 1400 *or higher*
Introduction to computer programming with an emphasis on problem-solving. Topics include: program structures, expressions, variables, decision and logic, iteration, collections, input, and output. Program construction and testing. Programming assignments including games and applications. No prior programming experience necessary. (Typically Offered: Fall, Spring)

COMS 1920: Explorations in Computing Research I
Credits: 1. Contact Hours: Discussion 0.5.
Repeatable, maximum of 2 credits.
Explore research opportunities for undergraduate students in Computer Science; understanding the nature of research and development process; reviewing the literature; development of writing, presentation, and data reporting skills; rotation under different research labs; group work. (Typically Offered: Fall, Spring)

COMS 2030: Careers in Computer Science
Credits: Required. Contact Hours: Lecture 1.5.
Computer science as a profession. Introduction to career fields open to computer science majors. Relationship of coursework to careers. Presentations by computer science professionals. Offered on a satisfactory-fail basis only. (Typically Offered: Fall, Spring)

COMS 2070: Fundamentals of Computer Programming
Credits: 3. Contact Hours: Lecture 3, Discussion 1.
Prereq: MATH 1500 *or credit or enrollment in* MATH 1400 *or higher*
An introduction to computer programming using an object-oriented programming language. Emphasis on the basics of good programming techniques and style. Extensive practice in designing, implementing, and debugging small programs. Use of variable, if-statement, looping, method, and class. Interactive and file I/O. This course is not designed for computer science, software engineering, and computer engineering majors. Graduation Restriction: Credit may not be applied toward graduation for both COMS 2070 and COMS 2270. (Typically Offered: Fall, Spring, Summer)

COMS 2270: Object-oriented Programming
Credits: 4. Contact Hours: Lecture 3, Laboratory 2.
Prereq: Credit or concurrent enrollment in MATH 1430 *or higher; (*COMS 1270 *or* CPRE 1850 *or SE 1850 or EE 2850)*
Computer programming using objects as the mechanism for modularity, abstraction, and code reuse. Instance variables, methods, and encapsulation. Review of control structures for conditionals and iteration. Developing algorithms on strings, arrays, and lists. Recursion, searching, and sorting. Text parsing and file I/O. Interfaces, inheritance, polymorphism, and abstract classes. Exception handling. Tools for unit testing and debugging. Emphasis on a disciplined approach to specification, code development, and testing. Course intended for majors in computer science and related fields. Graduation Restriction: Credit may not be applied toward graduation for both COMS 2070 and 2270. (Typically Offered: Fall, Spring, Summer)

COMS 2280: Introduction to Data Structures
Credits: 3. Contact Hours: Lecture 3, Discussion 1.
Prereq: Minimum of C- in COMS 2270*; credit or concurrent enrollment in* MATH 1650
An object-oriented approach to data structures and algorithms. Object-oriented analysis, design, and programming, with emphasis on data abstraction, inheritance and subtype polymorphism, and generics. Abstract data type specification and correctness. Collections including lists, stacks, queues, trees, heaps, maps, hash tables, and graphs. Big-O notation and algorithm analysis. Searching and sorting. Graph search and shortest path algorithms. Emphasis on object-oriented design, writing and documenting medium-sized programs. This course is designed for majors. (Typically Offered: Fall, Spring, Summer)

COMS 2300: Discrete Computational Structures
(Cross-listed with MATH 2300).
Credits: 3. Contact Hours: Lecture 3, Discussion 1.
Prereq: Minimum of C- in COMS 2270 *and* MATH 1650*;* ENGL 1500
Concepts in discrete mathematics as applied to computer science. Logic, set theory, functions, relations, cardinality of sets, combinatorics, graph theory and number theory. Proof techniques, induction and recursion. (Typically Offered: Fall, Spring, Summer)

COMS 2520: Linux Operating System Essentials
Credits: 3. Contact Hours: Lecture 3.
Prereq: CPRE 1850 *or SE 1850 or* COMS 1270 *or* COMS 2070 *or* COMS 2270

Introduction to installation, utilization, and administration of Linux systems. Topics include open-source software, package installation and management, shell programming and command-line utilities, process and service management, account management, network configuration, file sharing, interoperation with other computers and operating systems, automation, and system security. (Typically Offered: Fall)

COMS 2900: Independent Study
Credits: 1-30. Repeatable, maximum of 6 credits.
Prereq: Instructor Permission for Course
Graduation Restriction: No more than 6 credits of COMS 2900 or COMS 2900H may be counted toward graduation. (Typically Offered: Fall, Spring, Summer)

COMS 2900H: Independent Study: Honors
Credits: 1-30. Repeatable, maximum of 6 credits.
Prereq: Instructor Permission for Course
Graduation Restriction: No more than 6 credits of COMS 2900 or COMS 2900H may be counted toward graduation. (Typically Offered: Fall, Spring)

COMS 2950: Programming-Based Problem Solving Practices
Credits: 1. Contact Hours: Lecture 1.
Repeatable, maximum of 3 times.
Prereq: COMS 2070 *or* COMS 2270
Basics of problem solving using programming techniques. Development and implementation of simple to advanced data structures and algorithms, evaluation of problem difficulty, design and implementation of solutions, debugging, and working under time pressure. (Typically Offered: Fall, Spring)

COMS 3090: Software Development Practices
(Cross-listed with SE 3090).
Credits: 3. Contact Hours: Lecture 3, Discussion 1.
*Prereq: Minimum of C- in (*COMS 2280*;* MATH 1650*)*
Practical introduction to methods for managing software development. Software engineering concepts, practices and tools. Requirements analysis, structured and object-oriented design, coding, testing, and maintenance. Software process models, software tools and environments. Programming projects that provide exposure to information management techniques, client/server model, networking and communication. (Typically Offered: Fall, Spring)

COMS 3110: Introduction to the Design and Analysis of Algorithms
Credits: 3. Contact Hours: Lecture 3, Discussion 1.
*Prereq: Minimum of C- in (*COMS 2280*;* MATH 1660*,* ENGL 1500*); (*COMS 2300 *or* CPRE 3100*)*
Basic techniques for design and analysis of algorithms. Sorting, searching, graph algorithms, string matching, algorithms for secure computing such as RSA, and NP-completeness. Design techniques such as dynamic programming, divide and conquer, greedy method, and approximation. Asymptotic, worst-case, average-case and amortized analyses. Topics from advanced data structures such as balanced trees and hashing. Programming projects. (Typically Offered: Fall, Spring, Summer)

COMS 3190: Construction of User Interfaces
(Cross-listed with SE 3190).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 2280
Overview of user interface design. Evaluation and testing of user interfaces. Review of principles of object orientation, object oriented design and analysis using UML in the context of user interface design. Design of windows, menus and commands. Developing Web and Windows-based user-interfaces. Event-driven programming. Introduction to Frameworks and APIs for the construction of user interfaces. (Typically Offered: Fall, Spring)

COMS 3210: Introduction to Computer Architecture and Machine-Level Programming
Credits: 3. Contact Hours: Lecture 4.
*Prereq: Minimum of C- in (*COMS 2280 *and* MATH 1650*); (*COMS 2300 *or* CPRE 2810*);* ENGL 2500
Introduction to computer architecture and organization. Emphasis on evaluation of performance, instruction set architecture, datapath and control, memory-hierarchy design, and pipelining. Assembly language programming. (Typically Offered: Fall, Spring)

COMS 3260: C for Programmers
Credits: 1. Contact Hours: Lecture 1.
*Prereq: Minimum of C- in (*COMS 2280*; [*COMS 2300 *or* CPRE 3100*])*
Half-semester course. Design and implementation of libraries and applications in C, for students with prior programming background. Emphasis on differences between C and other languages, including file I/O, string processing, memory management, and buffer overruns. Using build systems, debuggers, and other development tools. Programming projects. (Typically Offered: Fall, Spring)

COMS 3270: Advanced Programming Techniques
Credits: 3. Contact Hours: Lecture 3.
Prereq: Minimum of C- in COMS 2280 *and* MATH 1650
Object-oriented programming experience using a language suitable for exploring advanced topics in programming. Topics include memory management, parameter passing, inheritance, compiling, debugging, and maintaining programs. Significant programming projects. (Typically Offered: Fall, Spring)

COMS 3310: Theory of Computing
(Cross-listed with LING 3310).
Credits: 3. Contact Hours: Lecture 3, Discussion 1.
*Prereq: Minimum of C- in (*COMS 2280*;* MATH 1660*;* ENGL 2500*); (*COMS 2300 *or* CPRE 3100*)*
Models of computation: finite state automata, pushdown automata and Turing machines. Study of grammars and their relation to automata. Limits of digital computation, unsolvability and Church-Turing thesis. Relations between classes of languages. (Typically Offered: Fall, Spring)

COMS 3360: Introduction to Computer Graphics
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3270 *or* CPRE 2880*; concurrent enrollment in (*MATH 2070 *or* MATH 2650 *or* MATH 3170*)*
Programming interactive computer graphics systems using standard low-level libraries (such as OpenGL or DirectX) with an emphasis on 3D rendering. The graphics pipeline and programmable shaders. Coordinate systems and transformations in two and three dimensions. Homogeneous coordinates, viewing transformations and perspective. Euler angles and quaternions. Visible surface algorithms. Lighting models and shading. Texture mapping, bump mapping, reflection, elementary ray tracing. Offscreen buffers, render-to-texture and related techniques. (Typically Offered: Fall)

COMS 3420: Principles of Programming Languages
(Cross-listed with SE 3420).
Credits: 3. Contact Hours: Lecture 3, Discussion 1.
Prereq: Minimum of C- in COMS 2280 *and* MATH 1650*;* COMS 2300 *or* CPRE 3100
Study of concepts in programming languages, especially functional programming concepts. Overview of major programming paradigms, their relationship, and tradeoffs among paradigms enabling sound choices of programming language for application-specific development. Programming projects. (Typically Offered: Fall, Spring)

COMS 3500: Number Theory
(Cross-listed with MATH 3500).
Credits: 3. Contact Hours: Lecture 3, Discussion 1.
Prereq: COMS 2300 *or* CPRE 3100 *or* MATH 2010
Divisibility, integer representations, primes and divisors, linear diophantine equations, congruences, and multiplicative functions. Applications to cryptography. Additional topics, chosen at the discretion of the instructor. (Typically Offered: Spring)

COMS 3520: Introduction to Operating Systems
Credits: 3. Contact Hours: Lecture 3, Discussion 1.
*Prereq: (*COMS 3210 *or* CPRE 3810*); (*COMS 3270 *or* CPRE 2880*);* ENGL 2500
Survey of operating systems; process management including scheduling and multithreading; memory management including virtual memory and paging; concurrency including mutual exclusion, synchronization, and deadlocks; persistent storage and file systems; principles and practices of secure computing including threats and access control; networking and distributed systems; virtualization. Programming projects. (Typically Offered: Fall, Spring)

COMS 3620: Object-Oriented Analysis and Design
(Cross-listed with SE 3620).
Credits: 3. Contact Hours: Lecture 3.
Prereq: ENGL 2500 *and Minimum of C- in* COMS 2280 *and* MATH 1650
Object-oriented requirements analysis and systems design. Analysis and design methodologies including use case and Unified Modeling Language (UML). Design principles, heuristics, and patterns. Architectural patterns and alternative programming paradigms. Group design and programming project. (Typically Offered: Fall, Spring)

COMS 3630: Introduction to Database Management Systems
Credits: 3. Contact Hours: Lecture 3.
Prereq: ENGL 2500 *and Minimum of C- in* COMS 2280 *and* MATH 1650
Data models and database design using entity relationship model. Database implementation with relational and graph database management systems (DBMS) and query languages. DBMS internals including basic concepts of database storage, indexing, query optimization, and concurrent control. Database application development. Programming Projects. (Typically Offered: Fall, Spring)

COMS 3980: Cooperative Education
Credits: Required. Repeatable.
Prereq: Department Permission for Course
Required of all cooperative education students. Students must register for this course prior to commencing each work period. (Typically Offered: Fall, Spring, Summer)

COMS 3990X: Special Topics
Credits: 3. Contact Hours: Lecture 3.
Special Topics in Computer Science.

COMS 4010: Bioinformatics of Sequences
(Cross-listed with BIOL 4010/ BCBIO 4010/ GEN 4010).
Credits: 3. Contact Hours: Lecture 3.
Prereq: BCBIO 3220*; (*COMS 1270 *OR* COMS 2270*); (*MATH 1600 *or* MATH 1650*); (*MATH 1660 *or* STAT 3010*); (*STAT 1010 *or* STAT 1040 *or* STAT 3300*) or Permission of Instructor*
Application of computer science and statistics to molecular biology with a significant problem-solving component, including hands-on programming using Python to solve a variety of biological problems. String algorithms, sequence alignments, homology search, pattern discovery, genotyping, genome assembly, genome annotation, comparative genomics, protein structure. Offered odd-numbered years. (Typically Offered: Fall)

COMS 4020A: Computer Science Senior Project: Multimedia and Computer Gaming I
Credits: 2-3. Contact Hours: Studio 3.
Repeatable, maximum of 6 credits.
Prereq: COMS 3090*,* COMS 3110*,* COMS 3210*,* COMS 3310*,* COMS 4370 *and Senior classification*
Students conceive, plan, architect and design a computer game. Student registered in this course will work with students in ARTIS 4090. Oral and written reports. Graduation Restriction: No more than 6 credits of 4020A, 4020B, and 4020C may be used toward graduation. (Typically Offered: Fall)

COMS 4020B: Computer Science Senior Project: Multimedia and Computer Gaming II
Credits: 2-3. Contact Hours: Studio 3.
Repeatable, maximum of 6 credits.
Prereq: COMS 4020A *and Senior classification*
Students implement, test, and present a completed production computer game. Students in this class will work with students in ARTIS 4090. Oral and written reports. Graduation Restriction: No more than 6 credits of 4020A, 4020B, and 4020C may be used toward graduation. (Typically Offered: Spring)

COMS 4020C: Computer Science Senior Project: Project in Computer Science
Credits: 3. Contact Hours: Studio 3.
Prereq: COMS 3090*,* COMS 3110*,* COMS 3210*,* COMS 3310 *and Senior classification*
Students work as individuals and teams to complete the planning, design, and implementation of a significant project in the topic area. Oral and written reports. Recommended final semester Senior year.Graduation Restriction: No more than 6 credits of 4020A, 4020B, and 4020C may be used toward graduation. (Typically Offered: Fall, Spring)

COMS 4060: Bioinformatics of OMICS
(Cross-listed with BIOL 4060/ BCBIO 4060/ GEN 4060).
Credits: 3. Contact Hours: Lecture 3.
Prereq: BIOL 2120
Introduction to cutting edge OMICS analyses including transcriptome, proteome, metabolome, DNA-protein interactome, protein-protein interactome and methylome. Genomic analysis including transcriptome analysis, cancer genomics, comparative genomics, and regulatory network analysis. (Typically Offered: Spring)

COMS 4070: Applied Formal Methods
(Dual-listed with AERE 5070/ COMS 5070). (Cross-listed with AERE 4070).

Credits: 3. Contact Hours: Lecture 3.
Prereq: AERE 3610 *for AERE majors.* COMS 3110 *for COMS majors.* AERE 3610 *or* COMS 3110*, or an equivalent course, plus instructor permission for other majors.*
Introduction to the fundamentals of formal methods, a set of mathematically rigorous techniques for the formal specification, validation, and verification of safety- and security-critical systems. Tools, techniques, and applications of formal methods with an emphasis on real-world use-cases such as enabling autonomous operation. Build experience in writing mathematically analyzable specifications from English operational concepts for real cyberphysical systems, such as aircraft and spacecraft. Review capabilities and limitations of formal methods in the design, verification, and system health management of today's complex systems. (Typically Offered: Spring)

COMS 4090: Software Requirements Engineering
(Dual-listed with COMS 5090). (Cross-listed with SE 4090).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3090
The requirements engineering process including elicitation, requirements analysis fundamentals, requirements specification and communication, and requirements evaluation. Modeling of functional requirements and nonfunctional requirements, traceability, and requirements change management. Case studies and software projects.

COMS 4100: Distributed Development of Software
(Dual-listed with COMS 5100).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3090*; (*COMS 3270 *or* CPRE 2880*)*
Teams of students develop software applications in a modern software engineering environment. Importance, effective processes pertaining to team organization, management and communication, and cultural issues of distributed development. Graduate credit requires in-depth study of concepts and oral presentations.

COMS 4120: Formal Methods in Software Engineering
(Dual-listed with COMS 5120). (Cross-listed with CPRE 4120/ SE 4120).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3110*; (*STAT 3050 *or* STAT 3300 *or* STAT 3410*)*
A study of formal techniques for model-based specification and verification of software systems. Topics include logics, formalisms, graph theory, numerical computations, algorithmsand tools for automatic analysis of systems. Graduate credit requires in--depth study of concepts.

COMS 4130: Program Analysis
(Dual-listed with COMS 5130/ CPRE 5130). (Cross-listed with SE 4130).
Credits: 3. Contact Hours: Lecture 3.
*Prereq: (*COMS 3270 *or* CPRE 2880*);* COMS 3420
Algorithms, AI techniques and tools for automatically reasoning about code and program executions. Theory and foundations related to control flow analysis, dataflow analysis, abstract interpretation, and symbolic execution. Applications of program analysis to bug detection, test input generation, debugging, program repair, specification inference and trustworthy AI engineering. Concepts, algorithms, tools, benchmarks, methodologies for solving problems using program analysis and for preparing research in program analysis.

COMS 4140: Gerontechnology in Smart Home Environments
(Dual-listed with COMS 5140).
Credits: 3. Contact Hours: Lecture 3.
Interdisciplinary course designed for students interested in assistive technology, pervasive computing, mobile computing and principles of universal and inclusive design for end users, in particular, the elderly population. Students work in semester-long projects as interdisciplinary teams to apply knowledge obtained from lectures and mutual presentations. Research report and oral presentation required for graduate credit.

COMS 4150: Software System Safety
(Dual-listed with COMS 5150).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3090 *or* COMS 3110
An introduction to the hazard analysis, safety requirements, design, and verification of software for safety-critical and high-dependability systems. Safety analysis techniques, fault identification and recovery, and certification issues. Emphasizes a case-based and systematic approach to software's role in safe systems.

COMS 4170: Software Testing
(Cross-listed with SE 4170).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3090*; (*COMS 2300 *or* CPRE 3100*);* ENGL 2500
An introduction to software testing principles and techniques. Test models, test design, test adequacy criteria; regression, integration, and system testing; and software testing tools.

COMS 4180: Introduction to Computational Geometry
(Dual-listed with COMS 5180).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3110
Introduction to data structures, algorithms, and analysis techniques for computational problems that involve geometry. Convex hulls, line segment intersection, polygon triangulation, 2D linear programming, range queries, point location, arrangements and duality, Voronoi diagrams, Delaunay triangulations, geometric data structures, robot motion planning, visibility graphs. Other selected topics. Programming assignments. Scholarly report required for graduate credit.

COMS 4190X: Trustworthy Healthcare Software
(Dual-listed with COMS 5190X).
Credits: 3. Contact Hours: Lecture 3.
Introduction to healthcare software used for health diagnosis or treatment. Focus on software as part of a medical device, the emerging use of software as a medical device, and on mobile healthcare applications. Topics include: discovering and verifying usability, reliability, and safety requirements; design and verification of trustworthy healthcare software; assurance cases for healthcare software in a regulatory environment. (Typically Offered: Spring)

COMS 4210: Logic for Mathematics and Computer Science
(Cross-listed with MATH 4210).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 2300 *or* CPRE 3100 *or* MATH 2070 *or* MATH 3010 *or* MATH 3170
Propositional and predicate logic. Topics selected from Horn logic, equational logic, resolution and unification, foundations of logic programming, reasoning about programs, program specification and verification, model checking and binary decision diagrams, temporal logic and modal logic.

COMS 4240: Introduction to High Performance Computing
(Cross-listed with MATH 4240/ CPRE 4240).
Credits: 3.
*Prereq: (*MATH 2650*; [*MATH 2070 *OR* MATH 3170*]) or permission of instructor*
Unix, serial programming of scientific applications, OpenMP for shared-memory parallelization. No Unix, Fortran or C experience required. (Typically Offered: Fall)

COMS 4250: High Performance Computing for Scientific and Engineering Applications
(Cross-listed with CPRE 4250).
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Prereq: COMS 3110 *and* ENGL 2500 *and* SPCM 2120
Introduction to high performance computing platforms including parallel computers and workstation clusters. Discussion of parallel architectures, performance, programming models, and software development issues. Sample applications from science and engineering. Practical issues in high performance computing will be emphasized via a number of programming projects using a variety of programming models and case studies. Oral and written reports.

COMS 4260: Introduction to Parallel Algorithms and Programming
(Dual-listed with CPRE 5260/ COMS 5260). (Cross-listed with CPRE 4260).

Credits: 4. Contact Hours: Lecture 3, Laboratory 2.
Prereq: CPRE 3080 *or* COMS 3210 *and CPRE 3150 or* COMS 3110
Models of parallel computation, performance measures, basic parallel constructs and communication primitives, parallel programming using MPI, parallel algorithms for selected problems including sorting, matrix, tree and graph problems, fast Fourier transforms. (Typically Offered: Fall)

COMS 4300: Concurrent Programming in Practice
Credits: 3. Contact Hours: Lecture 3, Discussion 1.
Prereq: COMS 3110 *and* COMS 3620 *or* COMS 3630 *and* ENGL 2500 *and* SPCM 2120
A practical course in concepts, techniques, languages, and frameworks for concurrent and asynchronous systems. Concurrency fundamentals: threads, synchronization locks, waiting and notification, memory visibility. Immutability and thread confinement. Concurrent data structures and utilities, thread pools. Asynchronous programming with callbacks, futures, and message passing. Issues of aliasing, ownership and borrowing. Transactional memory, immutable and versioned data structures. Alternatives to threads and locks: event-driven systems, the actor model, CSP, coroutines. Students will investigate several non-mainstream languages supporting different concurrency models. Oral and written reports.

COMS 4330: Molecular Programming of Nanoscale Devices and Processes
(Dual-listed with COMS 5330).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Minimum of C- in COMS 3310 *or Permission of Instructor*
Programming, modeling, and analysis of natural and engineered systems at the nanoscale. Topics include chemical reaction networks, strand displacement systems, models of self-assembly, biomolecular origami, and molecular robotics. Emphasis on mathematical methods of describing, simulating, programming, and assessing the computational power of such systems. Graduate credit requires a written or oral report on current research.

COMS 4340: Quantum Information and Complexity
(Dual-listed with COMS 5340).
Credits: 3. Contact Hours: Lecture 3.
*Prereq: (*COMS 3310 *or* PHYS 4220 *or* PHYS 5220*); (*MATH 2070 *or* MATH 3170*)*
An exploration of quantum information and computation from a theoretical computer science perspective. Topics include quantum circuits, axioms of quantum mechanics, quantum entanglement, quantum teleportation, nonlocal games, quantum entropies, quantum information theory, quantum computational complexity, interactive proof systems, and quantum supremacy. (Typically Offered: Fall)

COMS 4350: Algorithms for Large Data Sets: Theory and Practice
(Dual-listed with COMS 5350).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3110 *or Permission of Instructor*
Algorithmic challenges involved in solving computational problems on massive data sets. Probabilistic data structures, Curse of Dimensionality and dimensionality reduction, locality sensitive hashing, similarity measures, matrix decompositions. Optimization problems in massive data analysis. Computational problems that arise in the context of web search, social network analysis, online advertising etc. Practical aspects include implementation and performance evaluation of the algorithms on real world data sets. Graduate credit requires a written report on current research.

COMS 4370: Computer Game and Media Programming
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3360
Video game programming using current game engine interfaces with real hardware. Particular attention is paid to the development environment, tool chains, 2D graphics, 3D graphics, controllers, memory management, and audio systems.

COMS 4400: Principles and Practice of Compiling
(Dual-listed with COMS 5400). (Cross-listed with SE 4400).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3310 *or* COMS 3420 *and* COMS 3090 *and* ENGL 2500
Theory of compiling and implementation issues of programming languages. Programming projects leading to the construction of a compiler. Projects with different difficulty levels will be given for 4400 and 5400. Topics include: lexical, syntactic and semantic analyses, syntax-directed translation, code generation, runtime environment and library support.

COMS 4410: Programming Languages
(Dual-listed with COMS 5410).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3420 *or* COMS 4400
Survey of the goals and problems of language design. Formal and informal studies of a wide variety of programming language features including type systems. Creative use of functional and declarative programming paradigms.

COMS 4530: Privacy Preserving Algorithms and Data Security
(Dual-listed with COMS 5530X).
Credits: 3. Contact Hours: Lecture 3.
*Prereq: COM S 3110; (*STAT 3050 *or* STAT 3300 *or* STAT 3410 *or* STAT 3470*)*
Latest online threats on identity theft, fundamentals of privacy preserving algorithms, techniques, and mechanisms to minimize disclosure of sensitive information while maintaining availability. Theory and fundamentals underpinning measures to evaluate the privacy and availability of data; implementation and deployment of privacy-preserving data operations including pre- and post-randomization techniques, homomorphisms, and secure function evaluation protocols. (Typically Offered: Spring)

COMS 4540: Distributed Systems
(Dual-listed with COMS 5540/ CPRE 5540). (Cross-listed with CPRE 4540).

Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3110 *and* COMS 3520 *or* CPRE 3080
Theoretical and practical issues of design and implementation of distributed systems. The client server paradigm, inter-process communications, synchronization and concurrency control, naming, consistency and replication, fault tolerance, and distributed file systems. Graduate credit requires additional in-depth study of concepts. Programming projects and written reports.

COMS 4550: Simulation: Algorithms and Implementation
(Dual-listed with COMS 5550).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3110 *and (*STAT 3050*,* STAT 3300 *or* STAT 3410*) and* ENGL 2500
Introduction to discrete-event simulation with a focus on computer science applications, including performance evaluation of networks and distributed systems. Overview of algorithms and data structures necessary to implement simulation software. Discrete and continuous stochastic models, random number generation, elementary statistics, simulation of queuing and inventory systems, Monte Carlo simulation, point and interval parameter estimation. Graduate credit requires additional in-depth study of concepts.

COMS 4590X: Security and Privacy in Cloud Computing
(Dual-listed with COMS 5590/ CPRE 5590). (Cross-listed with CPRE 4590X).
Credits: 3. Contact Hours: Lecture 3.
Introduction to cloud computing concepts and systems. Security and privacy threats in cloud computing. Practical techniques for cloud computing security. Theoretical and practical solutions for secure outsourcing of data and computation. Oral presentations and research projects. (Typically Offered: Fall)

COMS 4610: Principles and Internals of Database Systems
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3110 *and* ENGL 2500 *and* SPCM 2120
Database design including entity-relationship model, relational data model, and non-relational data models, data dependency, and normalization. Database management including physical storage, access methods, query processing, and transaction management. Database systems of special purposes such as spatial databases, mobile object databases, and multimedia databases. Introduction to current database research such as cloud data management and Internet information retrieval.

COMS 4630X: Healthcare Data Privacy, Security and Confidentiality: Principles and Algorithms
(Dual-listed with COMS 5630X).
Credits: 3. Contact Hours: Lecture 3.
Introduction to types of healthcare data, complexities of privacy, confidentiality and security within healthcare. Key laws and regulations specific to healthcare such as HIPAA and the European Data Protection Directive 95/46/EC. Types of data sources and data elements utilized in healthcare. Algorithms for privacy, security and confidentiality of electronic health records. Role-based access control in healthcare. (Typically Offered: Spring)

COMS 4640X: AI for Healthcare
(Dual-listed with COMS 5640X).
Credits: 3. Contact Hours: Lecture 3.
Introduction to use of AI techniques in healthcare. Topics may include: AI techniques for medical diagnosis, prognosis and treatment, AI techniques for diagnosis of lung and brain disorders from 2D medical imaging data, classification models of 2D medical images, AI techniques for 3D medical imaging data, use of multi-modal imaging data in disease detection and diagnosis. Programming projects.

COMS 4720: Principles of Artificial Intelligence
(Dual-listed with COMS 5720).
Credits: 3. Contact Hours: Lecture 3, Discussion 1.
Prereq: COMS 3110 *and (*STAT 3050*,* STAT 3300 *or* STAT 3410*) and* ENGL 2500
Basic principles, techniques, and applications of artificial intelligence. Specification, design, implementation, and applications of intelligent agents. Computational models of intelligent behavior, including problem solving, knowledge representation and reasoning, planning, decision making, learning, perception, and communication. Artificial intelligence programming. Term project and written report for graduate credit.

COMS 4740: Introduction to Machine Learning
(Dual-listed with COMS 5740).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3110*;* STAT 3300 *or* STAT 3050 *or* STAT 3410 *or* STAT 3470*;* MATH 1650*;* ENGL 2500
Introduction to concepts, tools and techniques of machine learning for applications. Selected machine learning algorithms in practical data mining tasks such as classification, regression, and clustering, e.g., association rules, decision trees, linear models, Bayesian learning, support vector machines, artificial neural networks, instance-based learning, probabilistic graphical models, ensemble learning, and c lustering algorithms. Selected applications in data mining and pattern recognition.

COMS 4760: Motion Planning for Robotics and Autonomous Systems
(Dual-listed with COMS 5760).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3110*;* ENGL 2500
Recent techniques for developing algorithms that automatically generate continuous motions while satisfying geometric constraints. Applications in areas such as robotics and autonomous systems. Discrete planning, kinematics, configuration space, collision detection, sampling-based motion planning, nonholonomic systems and differential constraints. Implementation of software that computes motion plans in Python. Written reports. (Typically Offered: Fall, Spring, Summer)

COMS 4770: Foundations of Robotics and Computer Vision
(Dual-listed with COMS 5770).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 2280*;* COMS 2300 *or* CPRE 3100*;* MATH 2070 *or* MATH 3170*, or consent of the instructor*
Selected topics from applied mathematics, algorithms, geometry, and mechanics that are fundamental to robotics and computer vision, and are also applied in computer graphics, geometric modeling and visualization, to me a few. Homogeneous coordinates and transformations, perspective projection, camera calibration, rotations and quaternions, roots of polynomials and polynomial systems, solution of linear and nonlinear equations, parametric and algebraic curves, curvature, torsion, Frenet formulas, surfaces, fundamental forms, principal curvatures, Gaussian and mean curvatures, geodesics, approximation, Fourier series and fast Fourier transform, nonlinear optimization, Lagrange multipliers, least squares, surface fitting and calculus of variations. Programming components. Scholarly report required for graduate credit.

COMS 4810: Numerical Methods for Differential Equations
(Dual-listed with MATH 5810). (Cross-listed with MATH 4810).
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATH 2650 *and one of* MATH 2660*,* MATH 2670
First order Euler method, high order Runge-Kutta methods, and multistep methods for solving ordinary differential equations. Finite difference and finite element methods for solving partial differential equations. Local truncation error, stability, and convergence for finite difference method. Numerical solution space, polynomial approximation, and error estimate for finite element method. Computer programming required. (Typically Offered: Spring)

COMS 4870: Introduction to Network Programming and Cloud Computing
(Dual-listed with COMS 5870).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3520 *or* CPRE 3080
Introduction to network programming: protocols, programming suites, and applications. Introduction to cloud computing: concepts and case study with AWS. Introduction to selected research issues in networking and cloud computing. Graduate credit requires written report and oral presentation.

COMS 4880: Computer Networks
(Dual-listed with COMS 5880).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3520 *or* CPRE 3080
Fundamental concepts in the design and implementation of computer communication in both wired and wireless networks, their protocols, and applications. Topics include the layered network architecture in the Internet, applications, transport, network, and data link layers and their protocols, Socket API, software-defined networking, and network security. Lectures organized in a top-down approach to cover the layers of network design. (Typically Offered: Fall, Spring)

COMS 4900: Independent Study
Credits: 1-30. Repeatable, maximum of 9 credits.
Prereq: 6 credits in COMS; Permission of Instructor
Graduation Restriction: No more than 9 credits of COMS 4900 or COMS 4900H may be counted toward graduation. (Typically Offered: Fall, Spring, Summer)

COMS 4900H: Independent Study: Honors
Credits: 1-30. Repeatable, maximum of 9 credits.
Prereq: 6 credits in COMS; Permission of Instructor
Graduation Restriction: No more than 9 credits of COMS 4900 or COMS 4900H may be counted toward graduation. (Typically Offered: Fall, Spring)

COMS 4990X: Special Topics
Credits: 3. Contact Hours: Lecture 3.
Special Topics in Computer Science.

Courses primarily for graduate students, open to qualified undergraduates:

COMS 5010X: Computational Methods I
Credits: 3. Contact Hours: Lecture 3.
Design of data structures and algorithms with an object-oriented programming methodology. Abstract data type specification and correctness. Collections including lists, stacks, queues, trees and hash tables. Searching and Sorting. Discrete mathematics concepts as applied to computer science. Basics of logic, set theory, functions, relations, combinatorics. Proof techniques such as induction and recursion. Background in Math and Computer Science equivalent to MATH 1650 and COMS 2270 required.

COMS 5040X: Computational Methods II
Credits: 3. Contact Hours: Lecture 3.
Basics of graph theory, number theory and discrete probability. Big O Notation and algorithm analysis. Analysis of sorting and searching algorithms. Algorithm design techniques such as divide and conquer, greedy method and dynamic programming. Graph algorithms.

COMS 5070: Applied Formal Methods
(Dual-listed with AERE 4070/ COMS 4070). (Cross-listed with AERE 5070).

Credits: 3. Contact Hours: Lecture 3.
Introduction to the fundamentals of formal methods, a set of mathematically rigorous techniques for the formal specification, validation, and verification of safety- and security-critical systems. Tools, techniques, and applications of formal methods with an emphasis on real-world use-cases such as enabling autonomous operation. Build experience in writing mathematically analyzable specifications from English operational concepts for real cyberphysical systems, such as aircraft and spacecraft. Review capabilities and limitations of formal methods in the design, verification, and system health management of today's complex systems. (Typically Offered: Spring)

COMS 5090: Software Requirements Engineering
(Dual-listed with COMS 4090/ SE 4090).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3090 *or Graduate Classification*
The requirements engineering process including elicitation, requirements analysis fundamentals, requirements specification and communication, and requirements evaluation. Modeling of functional requirements and nonfunctional requirements, traceability, and requirements change management. Case studies and software projects.

COMS 5100: Distributed Development of Software
(Dual-listed with COMS 4100).
Credits: 3. Contact Hours: Lecture 3.
Teams of students develop software applications in a modern software engineering environment. Importance, effective processes pertaining to team organization, management and communication, and cultural issues of distributed development. Graduate credit requires in-depth study of concepts and oral presentations.

COMS 5110: Design and Analysis of Algorithms
(Cross-listed with CPRE 5110).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3110 *or Graduate Classification*
A study of algorithm design and analysis techniques. Network flows and linear programming. Randomized algorithms. NP-completeness. Approximation algorithms. Fixed-parameter algorithms.

COMS 5120: Formal Methods in Software Engineering
(Dual-listed with COMS 4120/ CPRE 4120/ SE 4120).
Credits: 3. Contact Hours: Lecture 3.
A study of formal techniques for model-based specification and verification of software systems. Topics include logics, formalisms, graph theory, numerical computations, algorithms and tools for automatic analysis of systems. Graduate credit requires in-depth study of concepts.

COMS 5130: Program Analysis
(Dual-listed with COMS 4130/ SE 4130). (Cross-listed with CPRE 5130).
Credits: 3. Contact Hours: Lecture 3.
*Prereq: (*COMS 3270 *or* CPRE 2880*);* COMS 3420 *or Graduate Classification*
Algorithms, AI techniques and tools for automatically reasoning about code and program executions. Theory and foundations related to control flow analysis, dataflow analysis, abstract interpretation, and symbolic execution. Applications of program analysis to bug detection, test input generation, debugging, program repair, specification inference and trustworthy AI engineering. Concepts, algorithms, tools, benchmarks, methodologies for solving problems using program analysis and for preparing research in program analysis.

COMS 5140: Gerontechnology in Smart Home Environments
(Dual-listed with COMS 4140).
Credits: 3. Contact Hours: Lecture 3.
Prereq: ARTGR 2710 *or* COMS 2070 *or* COMS 2270 *or* GERON 3770 *or Graduate Classification*
Interdisciplinary course designed for students interested in assistive technology, pervasive computing, mobile computing and principles of universal and inclusive design for end users, in particular, the elderly population. Students work in semester-long projects as interdisciplinary teams to apply knowledge obtained from lectures and mutual presentations. Research report and oral presentation required for graduate credit.

COMS 5150: Software System Safety
(Dual-listed with COMS 4150).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3090 *or* COMS 3110 *or Graduate Classification*
An introduction to the hazard analysis, safety requirements, design, and verification of software for safety-critical and high-dependability systems. Safety analysis techniques, fault identification and recovery, and certification issues. Emphasizes a case-based and systematic approach to software's role in safe systems.

COMS 5160: Artificial Intelligence in Software Engineering
Credits: 3. Contact Hours: Lecture 3.
Application of artificial intelligence (AI) techniques used to solve problems in software engineering and the use of software engineering techniques to improve AI. AI techniques such as optimization/search, classification, natural language processing, and deep learning to address software engineering problems will be included. Offered even-numbered years. (Typically Offered: Spring)

COMS 5180: Introduction to Computational Geometry
(Dual-listed with COMS 4180).
Credits: 3. Contact Hours: Lecture 3.
Introduction to data structures, algorithms, and analysis techniques for computational problems that involve geometry. Convex hulls, line segment intersection, polygon triangulation, 2D linear programming, range queries, point location, arrangements and duality, Voronoi diagrams, Delaunay triangulations, geometric data structures, robot motion planning, visibility graphs. Other selected topics. Programming assignments. Scholarly report required for graduate credit.

COMS 5190X: Trustworthy Healthcare Software
(Dual-listed with COMS 4190X).
Credits: 3. Contact Hours: Lecture 3.
Introduction to healthcare software used for health diagnosis or treatment. Focus on software as part of a medical device, the emerging use of software as a medical device, and on mobile healthcare applications. Topics include: discovering and verifying usability, reliability, and safety requirements; design and verification of trustworthy healthcare software; assurance cases for healthcare software in a regulatory environment.

COMS 5250: Numerical Analysis of High Performance Computing
(Cross-listed with MATH 5250/ CPRE 5250).
Credits: 3. Contact Hours: Lecture 3.
Introduction to parallelization techniques and numerical methods for distributed memory high performance computers. A semester project in an area related to each student's research interests is required. (Typically Offered: Spring)

COMS 5260: Introduction to Parallel Algorithms and Programming
(Dual-listed with CPRE 4260/ COMS 4260). (Cross-listed with CPRE 5260).

Credits: 4. Contact Hours: Lecture 3, Laboratory 2.
Models of parallel computation, performance measures, basic parallel constructs and communication primitives, parallel programming using MPI, parallel algorithms for selected problems including sorting, matrix, tree and graph problems, fast Fourier transforms. (Typically Offered: Fall)

COMS 5270: High-Performance Deep Learning
(Cross-listed with CPRE 5270).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3520 *or* CPRE 3080
Fundamentals and advances in HPC in the context of GPUs, TPUs, multicore and HPC systems with specific focus on parallel programming models. Discussing of high-performance computing, GPGPU, scaling deep neural network training and machine learning algorithms, high-performance deep learning, intersection of HPC and AI for HPC, distributed parallel training, engineering parallel software and parallel design patterns.

COMS 5310: Theory of Computation
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3310 *or Graduate Classification*
A systematic study of the fundamental models and analytical methods of theoretical computer science. Computability, the Church-Turing thesis, decidable and undecidable problems. Computational resources such as time, space, and nonuniformity. Complexity classes, computational intractability and completeness. Selected topics from randomness, algorithmic information theory, and logic.

COMS 5330: Molecular Programming of Nanoscale Devices and Processes
(Dual-listed with COMS 4330).
Credits: 3. Contact Hours: Lecture 3.
Programming, modeling, and analysis of natural and engineered systems at the nanoscale. Topics include chemical reaction networks, strand displacement systems, models of self-assembly, biomolecular origami, and molecular robotics. Emphasis on mathematical methods of describing, simulating, programming, and assessing the computational power of such systems. Graduate credit requires a written or oral report on current research.

COMS 5340: Quantum Information and Complexity
(Dual-listed with COMS 4340).
Credits: 3. Contact Hours: Lecture 3.
*Prereq: (*COMS 3310 *or* PHYS 4220 *or* PHYS 5220*); (*MATH 2070 *or* MATH 3170*)*
An exploration of quantum information and computation from a theoretical computer science perspective. Topics include quantum circuits, axioms of quantum mechanics, quantum entanglement, quantum teleportation, nonlocal games, quantum entropies, quantum information theory, quantum computational complexity, interactive proof systems, and quantum supremacy.

COMS 5350: Algorithms for Large Data Sets: Theory and Practice
(Dual-listed with COMS 4350).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3110 *or equivalent; graduate standing or permission of instructor*
Algorithmic challenges involved in solving computational problems on massive data sets. Probabilistic data structures, Curse of Dimensionality and dimensionality reduction, locality sensitive hashing, similarity measures, matrix decompositions. Optimization problems in massive data analysis. Computational problems that arise in the context of web search, social network analysis, online advertising etc. Practical aspects include implementation and performance evaluation of the algorithms on real world data sets. Graduate credit requires a written report on current research.

COMS 5400: Principles and Practice of Compiling
(Dual-listed with COMS 4400/ SE 4400).
Credits: 3. Contact Hours: Lecture 3, Laboratory 1.
Theory of compiling and implementation issues of programming languages. Programming projects leading to the construction of a compiler. Projects with different difficulty levels will be given for 4400 and 5400. Topics include: lexical, syntactic and semantic analyses, syntax-directed translation, code generation, runtime environment and library support.

COMS 5410: Programming Languages
(Dual-listed with COMS 4410).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3420 *or* COMS 4400 *or Graduate Classification*
Survey of the goals and problems of language design. Formal and informal studies of a wide variety of programming language features including type systems. Creative use of functional and declarative programming paradigms.

COMS 5440: Fundamentals of Bioinformatics
(Cross-listed with BCB 5440/ GDCB 5440/ CPRE 5440).
Credits: 4. Contact Hours: Lecture 3, Laboratory 2.
A practical, hands-on overview of how to apply bioinformatics to biological research. Recommended for biologists desiring to gain computational molecular biology skills. Topics include: sequence analysis, genomics, proteomics, phylogenetic analyses, ontology enrichment, systems biology, data visualization and emergent technologies. Offered odd-numbered years. (Typically Offered: Fall)

COMS 5510: Genomic Data Science
Credits: 3. Contact Hours: Lecture 3.
Introduction to a big data research area in bioinformatics. Focus on applying computational techniques to huge genomic sequence data. These techniques include finding optimal sequence alignments, generating genome assemblies, finding genes in genomic sequences, mapping short sequences onto a genome assembly, finding single-nucleotide and structural variations, building phylogenetic trees from genome sequences, and performing genome-wide association studies.

COMS 5520: Principles of Operating Systems
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate classification or Permission of Instructor
A comparative study of high-level language facilities for process synchronization and communication. Analysis of deadlock, concurrency control and recovery. Protection issues including capability-based systems, access and flow control, encryption, and authentication. Additional topics chosen from distributed operating systems, soft real-time operating systems, and advanced security issues. Programming and research projects.

COMS 5530X: Privacy Preserving Algorithms and Data Security
(Dual-listed with COMS 4530).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3110*; (*STAT 3050 *or* STAT 3300 *or* STAT 3410 *or* STAT 3470*)*
Latest online threats on identity theft, fundamentals of privacy preserving algorithms, techniques, and mechanisms to minimize disclosure of sensitive information while maintaining availability. Theory and fundamentals underpinning measures to evaluate the privacy and availability of data; implementation and deployment of privacy-preserving data operations including pre- and post-randomization techniques, homomorphisms, and secure function evaluation protocols. (Typically Offered: Spring)

COMS 5540: Distributed Systems
(Dual-listed with COMS 4540/ CPRE 4540). (Cross-listed with CPRE 5540).

Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3110 *and (*COMS 3520 *or* CPRE 3080*) or Graduate Classification*
Theoretical and practical issues of design and implementation of distributed systems. The client server paradigm, inter-process communications, synchronization and concurrency control, naming, consistency and replication, fault tolerance, and distributed file systems. Graduate credit requires additional in-depth study of concepts. Programming projects and written reports.

COMS 5550: Simulation: Algorithms and Implementation
(Dual-listed with COMS 4550).
Credits: 3. Contact Hours: Lecture 3.
Introduction to discrete-event simulation with a focus on computer science applications, including performance evaluation of networks and distributed systems. Overview of algorithms and data structures necessary to implement simulation software. Discrete and continuous stochastic models, random number generation, elementary statistics, simulation of queuing and inventory systems, Monte Carlo simulation, point and interval parameter estimation. Graduate credit requires additional in-depth study of concepts.

COMS 5570: Computer Graphics and Geometric Modeling
(Cross-listed with ME 5570/ CPRE 5570).
Credits: 3. Contact Hours: Lecture 3.
Fundamentals of computer graphics technology. Data structures. Parametric curve and surface modeling. Solid model representations. Applications in engineering design, analysis, and manufacturing. Offered odd-numbered years. (Typically Offered: Fall)

COMS 5590: Security and Privacy in Cloud Computing
(Dual-listed with COMS 4590X/ CPRE 4590X). (Cross-listed with CPRE 5590).
Credits: 3. Contact Hours: Lecture 3.
Introduction to cloud computing concepts and systems. Security and privacy threats in cloud computing. Practical techniques for cloud computing security. Theoretical and practical solutions for secure outsourcing of data and computation. Oral presentations and research projects.

COMS 5600: Data-Driven Security and Privacy
(Cross-listed with CPRE 5600/ CYBSC 5600).
Credits: 3. Contact Hours: Lecture 3.
Examination of applications of machine learning and big data techniques to various security and privacy problems, as well as secure and privacy-preserving machine learning algorithms. Offered irregularly. (Typically Offered: Spring)

COMS 5610: Database Design, Management, and Research
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate classification
Database design including entity-relationship model, relational data model, and non-relational data models, data dependency, and normalization. Database management including physical storage, access methods, query processing, and transaction management. Database systems of special purposes such as spatial databases, mobile object databases, and multimedia databases. Introduction to current database research such as cloud data management and Internet information retrieval. Significant work on reading and presentation of research publications.

COMS 5630X: Healthcare Data Privacy, Security and Confidentiality: Principles and Algorithms
(Dual-listed with COMS 4630X).
Credits: 3. Contact Hours: Lecture 3.
Introduction to types of healthcare data, complexities of privacy, confidentiality and security within healthcare. Key laws and regulations specific to healthcare such as HIPAA and the European Data Protection Directive 95/46/EC. Types of data sources and data elements utilized in healthcare. Algorithms for privacy, security and confidentiality of electronic health records. Role-based access control in healthcare.

COMS 5640X: AI for Healthcare
(Dual-listed with COMS 4640X).
Credits: 3. Contact Hours: Lecture 3.
Introduction to use of AI techniques in healthcare. Topics may include: AI techniques for medical diagnosis, prognosis and treatment, AI techniques for diagnosis of lung and brain disorders from 2D medical imaging data, classification models of 2D medical images, AI techniques for 3D medical imaging data, use of multi-modal imaging data in disease detection and diagnosis. Programming projects.

COMS 5670: Bioinformatics Algorithms
(Cross-listed with BCB 5670/ CPRE 5670).
Credits: 3. Contact Hours: Lecture 3.
Biology as an information science. A review of the algorithmic principles that are driving the advances in bioinformatics and computational biology.

COMS 5680: Statistical Bioinformatics
(Cross-listed with BCB 5680/ GDCB 5680/ STAT 5680).
Credits: 3. Contact Hours: Lecture 3.
Statistical models for sequence data, including applications in genome annotation, motif discovery, variant discovery, molecular phylogeny, gene expression analysis, and metagenomics. Statistical topics include model building, inference, hypothesis testing, and simple experimental design, including for big data/complex models. (Typically Offered: Spring)

COMS 5690: Structural Bioinformatics
(Cross-listed with BCB 5690/ BBMB 5690/ CPRE 5690/ GDCB 5690).
Credits: 3. Contact Hours: Lecture 3.
Molecular structures including genes and gene products: protein, DNA and RNA structure. Structure determination methods, structural refinement, structure representation, comparison of structures, visualization, and modeling. Molecular and cellular structure from imaging. Analysis and prediction of protein secondary, tertiary, and higher order structure, disorder, protein-protein and protein-nucleic acid interactions, protein localization and function, bridging between molecular and cellular structures. Molecular evolution. (Typically Offered: Fall)

COMS 5700: Systems Biology
(Cross-listed with BCB 5700/ CPRE 5700/ GDCB 5700/ STAT 5700).
Credits: 3. Contact Hours: Lecture 3.
Algorithmic and statistical approaches in computational functional genomics and systems biology. Analysis of high throughput biological data obtained using system-wide measurements. Topological analysis, module discovery, and comparative analysis of gene and protein networks. Modeling, analysis, and inference of transcriptional regulatory networks, protein-protein interaction networks, and metabolic networks. Dynamic systems and whole-cell models. Ontology-driven, network based, and probabilistic approaches to information integration. (Typically Offered: Spring)

COMS 5710X: Responsible AI: Risk Management in Data Driven Discovery
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate classification
Risk assessment and mitigation mechanisms of various stages of machine learning/data science lifecycles with the emphasis on the early stages: study design, data acquisition, exploratory data analysis, feature engineering, modeling and training, and model evaluation. Case studies of machine learning/data science lifecycles used in application domains along with methods for risk assessment and mitigation. DS 2020 recommended. (Typically Offered: Fall)

COMS 5720: Principles of Artificial Intelligence
(Dual-listed with COMS 4720).
Credits: 3. Contact Hours: Lecture 3, Discussion 1.
Prereq: COMS 3110*;* STAT 3300 *or* STAT 3050 *or* STAT 3410 *or* STAT 3470*;* ENGL 2500*; graduate standing or permission of instructor*
Basic principles, techniques, and applications of artificial intelligence. Specification, design, implementation, and applications of intelligent agents. Computational models of intelligent behavior, including problem solving, knowledge representation and reasoning, planning, decision making, learning, perception, and communication. Artificial intelligence programming. Term project and written report for graduate credit.

COMS 5730: Machine Learning
Credits: 3. Contact Hours: Lecture 4.
Prereq: Graduate classification or Permission of Instructor
Basic principles, techniques, and applications of machine learning. Design, analysis, theoretical foundation, implementation, and applications of learning algorithms. Selected machine learning techniques in supervised learning, unsupervised learning, and reinforcement learning, including Bayesian decision theory, computational learning theory, decision trees, linear models, support vector machines, artificial neural networks, instance-based learning, probabilistic graphical models, ensemble learning, clustering algorithms, dimensionality reduction and feature selection. Selected applications in data mining and pattern recognition.

COMS 5740: Introduction to Machine Learning
(Dual-listed with COMS 4740).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3110*;* STAT 3050 *or* STAT 3300 *or* STAT 3410 *or* STAT 3470*;* MATH 1650*;* ENGL 2500*; Graduate standing or permission of instructor*
Introduction to concepts, tools and techniques of machine learning for applications. Selected machine learning algorithms in practical data mining tasks such as classification, regression, and clustering, e.g., association rules, decision trees, linear models, Bayesian learning, support vector machines, artificial neural networks, instance-based learning, probabilistic graphical models, ensemble learning, and c lustering algorithms. Selected applications in data mining and pattern recognition.

COMS 5750: Computational Perception
(Cross-listed with HCI 5750/ CPRE 5750).
Credits: 3. Contact Hours: Lecture 3.
This class covers statistical and algorithmic methods for sensing, recognizing, and interpreting the activities of people by a computer. This semester we will focus on machine perception techniques that facilitate and augment human-computer interaction. The main goal of the class is to introduce computational perception on both theoretical and practical levels. Participation in small groups to design, implement, and evaluate a prototype of a human-computer interaction system that uses one or more of the techniques covered in the lectures. (Typically Offered: Spring)

COMS 5760: Motion Planning for Robotics and Autonomous Systems
(Dual-listed with COMS 4760).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3110 *and* ENGL 2500 *or Graduate Classification*
Recent techniques for developing algorithms that automatically generate continuous motions while satisfying geometric constraints. Applications in areas such as robotics and autonomous systems. Discrete planning, kinematics, configuration space, collision detection, sampling-based motion planning, nonholonomic systems and differential constraints. Implementation of software that computes motion plans in Python. Proficiency with programming in Python expected. Written reports.

COMS 5770: Foundations of Robotics and Computer Vision
(Dual-listed with COMS 4770).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 2280 *and* COMS 2300 *or* CPRE 3100*;* MATH 2070 *or* MATH 3170*, or Graduate Classification*
Selected topics from applied mathematics, algorithms, geometry, and mechanics that are fundamental to robotics and computer vision, and are also applied in computer graphics, geometric modeling and visualization, to name a few. Homogeneous coordinates and transformations, perspective projection, camera calibration, rotations and quaternions, roots of polynomials and polynomial systems, solution of linear and nonlinear equations, parametric and algebraic curves, curvature, torsion, Frenet formulas, surfaces, fundamental forms, principal curvatures, Gaussian and mean curvatures, geodesics, approximation, Fourier series and fast Fourier transform, nonlinear optimization, Lagrange multipliers, least squares, surface fitting and calculus of variations. Programming components. Scholarly report required for graduate credit.

COMS 5780: Optimization for Machine Learning
Credits: 3. Contact Hours: Lecture 3.
Advances in optimization theory and algorithms with evolving applications for machine learning. Theoretical foundations at the intersection of optimization and machine learning to conduct advanced research in machine learning and related fields. Emphasis on proof techniques for optimization algorithms in machine learning.

COMS 5790: Natural Language Processing
Credits: 3. Contact Hours: Lecture 3.
Introduction to NLP and its connection with other branches of Artificial Intelligence, such as machine learning and knowledge representation. Text analysis including n-gram language models, stemming and lemmatization, part-of-speech (POS) tagging. Topic modeling, summarization, text classification, knowledge extraction, and text reasoning. Applications of deep learning in NLP including question answering, machine reading comprehension, word and sentence embedding. Research project required.

COMS 5810: Computer Systems Architecture
(Cross-listed with CPRE 5810).
Credits: 3. Contact Hours: Lecture 3.
Quantitative principles of computer architecture design, instruction set design, processor architecture: pipelining and superscalar design, instruction level parallelism, memory organization: cache and virtual memory systems, multiprocessor architecture, cache coherency, interconnection networks and message routing, I/O devices and peripherals. (Typically Offered: Fall)

COMS 5830: Reconfigurable Computing Systems
(Cross-listed with CPRE 5830).
Credits: 3. Contact Hours: Lecture 3.
Introduction to reconfigurable computing, FPGA technology and architectures, spatial computing architectures such as systolic and bit serial adaptive network architectures, static and dynamic rearrangeable interconnection architectures, processor architectures incorporating reconfigurabiltiy.

COMS 5870: Introduction to Network Programming and Cloud Computing
(Dual-listed with COMS 4870).
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 3520 *or* CPRE 3080*; graduate standing or permission of instructor*
Introduction to network programming: protocols, programming suites, and applications. Introduction to cloud computing: concepts and case study with AWS. Introduction to selected research issues in networking and cloud computing. Graduate credit requires written report and oral presentation.

COMS 5880: Computer Networks
(Dual-listed with COMS 4880).
Credits: 3. Contact Hours: Lecture 3.
Fundamental concepts in the design and implementation of computer communication in both wired and wireless networks, their protocols, and applications. Topics include the layered network architecture in the Internet, applications, transport, network, and data link layers and their protocols, Socket API, software-defined networking, and network security. Lectures organized in a top-down approach to cover the layers of network design. (Typically Offered: Fall, Spring)

COMS 5900: Special Topics
Credits: 1-30. Repeatable.
Prereq: Instructor Permission for Course
Special Topics in Computer Science.

COMS 5920: Graduate Studies in Computer Science
Credits: 1. Contact Hours: Lecture 1.
Prereq: Graduate classification
Introduction to Graduate program, Graduate Program Policies, Computing Resources, Faculty Research Areas, Reading Computer Science Research Articles, LaTEX, Research Writing and Presentation, Attend Research Colloquia. Offered on a satisfactory-fail basis only.

COMS 5930X: Experiential Learning in Responsible AI
Credits: 1. Repeatable.
Experience interacting with industry, government, or nonprofit organizations to learn AI/data science techniques in real-world settings. Explore risks to the trustworthiness of data science lifecycles in practice. (Typically Offered: Fall, Spring)

COMS 5980: Graduate Internship
Credits: Required. Repeatable.
Prereq: Graduate classification
Supervised internship working in professional settings appropriate to the student's degree program. Academic work under faculty supervision.

COMS 5990: Creative Component
Credits: 1-3. Repeatable.
Prereq: Instructor Permission for Course
Creative component for nonthesis option of Master of Science degree. (Typically Offered: Fall, Spring)

Courses for graduate students:

COMS 6100: Seminar
Credits: 1-30. Contact Hours: Lecture 30.
Repeatable.
Prereq: Instructor Permission for Course
Seminar in Computer Science. Offered on a satisfactory-fail basis only.

COMS 6110: Advanced Topics in Algorithms
Credits: 3. Contact Hours: Lecture 3.
Repeatable.
Advanced algorithm analysis and design techniques. Topics include, but are not limited to, graph algorithms, geometric algorithms, approximation algorithms, fixed-parameter algorithms, randomized algorithms and advanced data structures. Content varies by semester.

COMS 6120: Distributed Algorithms
Credits: 3. Contact Hours: Lecture 3.
The theory of distributed computation. Algorithms, lower bounds and impossibility results. Fundamental problems including consensus, leader election, mutual exclusion and clock synchronization. Synchronous, asynchronous and partially synchronous distributed systems models. Shared memory and message passing systems. Fault-tolerance and randomization. Wait-free object simulations. Distributed shared memory. Special topics vary from year to year.

COMS 6250: Advanced Topics in High Performance Computing
Credits: 3. Contact Hours: Lecture 3.
Parallel solutions of numerical and non-numerical problems, implementation of parallel programs on parallel machines, performance and other computational issues in parallel programming.

COMS 6260: Parallel Algorithms for Scientific Applications
(Cross-listed with CPRE 6260).
Credits: 3. Contact Hours: Lecture 3.
Algorithm design for high-performance computing. Parallel algorithms for multidimensional tree data structures, space-filling curves, random number generation, graph partitioning and load balancing. Applications to grid and particle-based methods and computational biology.

COMS 6310: Advanced Topics in Computational Complexity
Credits: 3. Contact Hours: Lecture 3.
Repeatable.
Advanced study in the quantitative theory of computation. Time and space complexity of algorithmic problems. The structure of P, NP, PH, PSPACE, and other complexity classes, especially with respect to resource-bounded reducibilities and complete problems. Complexity relative to auxiliary information, including oracle computation and relativized classes, randomized algorithms, advice machines, Boolean circuits. Kolmogorov complexity and randomness. Novel models of computation emerging in a rapidly changing field.

COMS 6330: Advanced Topics in Computational Randomness
Credits: 3. Contact Hours: Lecture 3.
Repeatable.
Advanced study of the role of randomness in computation. Randomized algorithms, derandomization, and probabilistic complexity classes. Kolmogorov complexity, algorithmic information theory, and algorithmic randomness. Applications chosen from cryptography, interactive proof systems, computational learning, lower bound arguments, mathematical logic, and the organization of complex systems. Novel models of computation emerging in a rapidly changing field.

COMS 6340: Theory of Games, Knowledge and Uncertainty
Credits: 3. Contact Hours: Lecture 3.
Fundamentals of Game Theory: individual decision making, strategic and extensive games, mixed strategies, backward induction, Nash and other equilibrium concepts. Discussion of Auctions and Bargaining. Repeated, Bayesian and evolutionary games. Interactive Epistemology: reasoning about knowledge in multiagent environment, properties of knowledge, agreements, and common knowledge. Reasoning about and representing uncertainty, probabilities, and beliefs. Uncertainty in multiagent environments. Aspects and applications of game theory, knowledge, and uncertainty in other areas, especially Artificial Intelligence and Economics, will be discussed.

COMS 6410: Advanced Topics in Programming Language Semantics
Credits: 3. Contact Hours: Lecture 3.
Repeatable.
Operational and other mathematical models of programming language semantics. Type systems and their soundness. Applications of semantics on areas such as program correctness, language design or translation.

COMS 6490: Advanced Topics in Computational Biology
(Cross-listed with CPRE 6490).
Credits: 3. Contact Hours: Lecture 3.
Design and analysis of algorithms for applications in computational biology, pairwise and multiple sequence alignments, approximation algorithms, string algorithms including in-depth coverage of suffix trees, semi-numerical string algorithms, algorithms for selected problems in fragment assembly, phylogenetic trees and protein folding. No background in biology is assumed. Also useful as an advanced algorithms course in string processing.

COMS 6520: Advanced Topics in Distributed Systems
Credits: 3. Contact Hours: Lecture 3.
Repeatable.
Prereq: COMS 5520
Selected topics in the research of distributed systems, including but not limited to blockchain, cloud computing, cyber-physical systems, distributed learning, edge computing, Internet of things, mobile computing, as well as fairness, privacy, reliability and security in the systems.

COMS 6560: Advanced Topics in Verification
Credits: 3. Contact Hours: Lecture 3.
Advanced formal methods to specify and study correctness and timing properties of complex systems and software, with a particular focus on concurrent and distributed behavior. Topics include: Petri nets and related formalisms to describe discrete-state systems; decision diagram algorithms for state-space and reachability graph generation, symbolic model checking, and timing analysis; Markov models for exact and approximate probabilistic verification.

COMS 6570: Advanced Topics in Computer Graphics
Credits: 3. Contact Hours: Lecture 3.
Repeatable, maximum of 2 times.
Modern lighting models: Rendering Equation, Spherical Harmonics, Lafortune, Cook-Torrance. Non-polygonal primitives: volumes, points, particles. Textures: filtering, reflections creation. Graphics hardware: pipeline, performance issues, programmability in vertex and fragment path. Per-pixel lighting. Nonphotorealistic rendering. Radiosity; Ray tracing.

COMS 6610: Advanced Topics in Database Systems
Credits: 3. Contact Hours: Lecture 3.
Repeatable.
Advanced topics chosen from the following: database design, data models, query systems, query optimization, incomplete information, logic and databases, multimedia databases; temporal, spatial and belief databases, semistructured data, concurrency control, parallel and distributed databases, information retrieval, data warehouses, wrappers, mediators, and data mining.

COMS 6650A: Advanced Topics in Software Engineering: Foundations
Credits: 3. Contact Hours: Lecture 3.
Repeatable, maximum of 6 credits.
Prereq: COMS 5110
Advanced topics on theoretical and technical foundations in Software Engineering. Content varies by semester. Graduation Restriction: Maximum 6 credits of COMS 6650 may apply toward graduation. Offered irregularly. (Typically Offered: Fall, Spring)

COMS 6650B: Advanced Topics in Software Engineering: Empirical
Credits: 3. Contact Hours: Lecture 3.
Repeatable, maximum of 6 credits.
Advanced topics on empirical studies on human factors and other software engineering topics. Content varies by semester. (Typically Offered: Fall, Spring, Summer)

COMS 6710X: Responsible AI: Advanced Topics in Risk Management in Data Driven Discovery
Credits: 3. Contact Hours: Lecture 3.
Selected topics in risk assessment and mitigation mechanisms on machine learning/data science lifecycles. Case studies of machine learning/data science lifecycles in application domains, along with risk assessment and mitigation methods. Content varies by semester. (Typically Offered: Spring)

COMS 6720: Advanced Topics in Artificial Intelligence
Credits: 3. Contact Hours: Lecture 3.
Repeatable.
Selected topics in probabilistic graphical models, causal inference, semantic web, information retrieval, natural language processing, knowledge representation and reasoning, deep learning, embedding, distributed learning, incremental learning, multi-task learning, multi-strategy learning, multi-relational learning, modeling the internet and the web, automated scientific discovery, neural and cognitive modeling. Advanced applications of artificial intelligence in bioinformatics, distributed systems, natural language, multimedia data, decision making, robotics, and more.

COMS 6730: Advanced Topics in Machine Learning
Credits: 3. Contact Hours: Lecture 3.
Repeatable.
Prereq: COMS 4720 *or* COMS 5720 *or* COMS 5730 *or* COMS 4740 *or* COMS 5740
Advanced topics in machine learning. Selected topics in computational learning theory, Bayesian and information theoretic models (ML, MAP, MDL, MML), probabilistic graphical models, statistical relational learning, reinforcement learning, and deep learning.

COMS 6760X: Advanced Topics in Autonomous Systems and Robotics
Credits: 3. Contact Hours: Lecture 3.
Prereq: COMS 5720 *or Permission of Instructor*
Theoretical and practical issues in the design and analysis of autonomous and robotic systems, including self-driving cars. Topics include object detection, perception, mapping, localization, prediction, planning, decision-making, control, learning, kinematics and dynamics, specification, and model-based design and verification.

COMS 6810: Advanced Topics in Computer Architecture
(Cross-listed with CPRE 6810).
Credits: 3. Contact Hours: Lecture 3.
Current topics in computer architecture design and implementation. Advanced pipelining, cache and memory design techniques. Interaction of algorithms with architecture models and implementations. Tradeoffs in architecture models and implementations. Offered odd-numbered years. (Typically Offered: Spring)

COMS 6880AX: Advanced Topics in Computer Networks: Foundations
Credits: 3. Contact Hours: Lecture 3.
Theoretical aspects of computer networks. Topics include cross-layer congestion control, routing, and scheduling optimization for wireless networks, distributed network optimization algorithms, and networking for big data. (Typically Offered: Fall, Spring)

COMS 6880BX: Advanced Topics in Computer Networks: Systems
Credits: 3. Contact Hours: Lecture 3.
Topics can include Internet architecture, inter-domain routing, Internet topology, passive and active Internet measurements, and Internet data analysis. (Typically Offered: Fall, Spring)

COMS 6880CX: Advanced Topics in Computer Networks: Security/Privacy
Credits: 3. Contact Hours: Lecture 3.
Advanced topics in network security and privacy. Topics can include security and privacy issues in cloud data center networks, wireless networks, vehicular networks, sustainable sensor networks, and the Internet of Things (IoT) systems, dark web, The Onion Router (TOR), cybersecurity, criminal hackers, and virtual currency. (Typically Offered: Fall, Spring)

COMS 6990: Research
Credits: 1-30. Repeatable.
Prereq: Instructor Permission for Course
Research. Offered on a satisfactory-fail basis only.