COMPUTER SCIENCE

http://www.cs.barnard.edu (https://cs.barnard.edu/)

Departmental Office: 504 Milstein Center; 212-853-0305

Director: Dr. Rebecca Wright, chair-cs@barnard.edu

Barnard’s computer science community is growing. The number of Computer Science majors at Barnard has doubled over the last several years. Barnard’s Computer Science program offers meaningful computing education and experiences to all Barnard students and partners with Columbia’s Computer Science department to offer a major in Computer Science. The program aims to expand students’ use and understanding of computation and data analysis across disciplines; offer students opportunities to think critically about the social implications of technology; and include how to harness it for social good; promote curricular and pedagogical advances in computer science and its multidisciplinary applications; and provide new models for engaging students and enhancing diversity in computing.

Program Director: Rebecca Wright (Druckenmiller Professor of Computer Science)

Faculty Fellow: Sarah Morrison-Smith (Roman Family Teaching and Research Fellow)

This QuickGuide is for Barnard students who are majoring or minoring in Computer Science. It explains how the program is structured, what courses to take and when. Please access the link below and view "BA in Computer Science (CC, GS, Barnard)" under Degree Programs.

http://www.cs.columbia.edu/education/undergraduate/

Barnard College Computer Science Courses

**COMS BC3099 INDEPENDENT STUDY. 4 points.**

INDEPENDENT STUDY.

**COMS BC3162 Developing Accessible User Interfaces. 3 points.**

Introduction to access technology and the development of accessible systems. In this course, students build and evaluate various access technologies. Topics include: text-to-speech, speech recognition, screen readers, screen magnification, alternative input, tactile displays, and web transformation. This course teaches students the deep inner workings of today’s user interface technology and serve as a guide for building the user interfaces of the future.

**COMS BC3364 Introduction to Contextual Design for Technology. 3 points.**

Introduces methods and tools used in Contextual Inquiry (CI) specifically the early stages of software design focused on meeting user needs. Key concepts include user research, contextual design, design thinking, ideation, iterative design, prototyping, and design documentation. Projects utilize software tools used in the industry.

**COMS BC3420 Privacy in a Networked World. 4 points.**

The ubiquity of computers and networks in business, government, recreation, and almost all aspects of daily life has led to a proliferation of online sensitive data: data that, if used improperly, can harm the data subjects. As a result, concern about the use, ownership, control, privacy, and accuracy of these data has become a top priority. This seminar course focuses on both the technical challenges of handling sensitive data, the privacy implications of various technologies, and the policy and legal issues facing data subjects, data owners, and data users.

**COMS BC3430 Computational Sound. 3 points.**

In this course, we explore the variety of roles that computation can play in the analysis, creation, and performance of music. We start with the fundamentals of sound in the digital domain, covering issues of representation and audio synthesis. We then move through various synthesis techniques including the additive, subtractive, frequency modulation (FM), and amplitude modulation (AM) synthesis. After covering some core DSP techniques, we put these concepts into performative practice by exploring “live coding”. In the space of live coding, we examine various programming language designs to understand how various domain specific languages (DSLs) support live coding. For the third module, we turn our focus to automated composition and analysis, addressing challenges in music information retrieval, generative art, and autonomous improvisation systems. All the while, we continue to develop our fluency in live coding by putting new topics to practice.
COMS BC3997 New Directions in Computing. 1 point.
This is an undergraduate seminar for special topics in computing arranged as the need and availability arises. Topics are usually offered on a one-time basis. Participation requires permission of the instructor. Since the content of this course changes each time it is offered, it may be repeated for credit.

Spring 2020: COMS BC3997
Course Number Section/Call Number Times/Location Instructor Points Enrollment
COMS 3997 001/0806 Rebecca Wright 1 3/10

Columbia College Computer Science Courses

COMS W1001 Introduction to Information Science. 3 points.
Lect: 3.

Basic introduction to concepts and skills in Information Sciences: human-computer interfaces, representing information digitally, organizing and searching information on the internet, principles of algorithmic problem solving, introduction to database concepts, and introduction to programming in Python.

COMS W1002 Computing in Context. 4 points.
CC/GS: Partial Fulfillment of Science Requirement

Introduction to elementary computing concepts and Python programming with domain-specific applications. Shared CS concepts and Python programming lectures with track-specific sections. Track themes will vary but may include computing for the social sciences, computing for economics and finance, digital humanities, and more. Intended for nonmajors. Students may only receive credit for one of ENGI E1006 or COMS W1002.

COMS W1004 Introduction to Computer Science and Programming in Java. 3 points.
Lect: 3.

A general introduction to computer science for science and engineering students interested in majoring in computer science or engineering. Covers fundamental concepts of computer science, algorithmic problem-solving capabilities, and introductory Java programming skills. Assumes no prior programming background. Columbia University students may receive credit for only one of the following two courses: 1004 or 1005.

COMS W1005 Introduction to Computer Science and Programming in MATLAB. 3 points.
CC/GS: Partial Fulfillment of Science Requirement

A general introduction to computer science concepts, algorithmic problem-solving capabilities, and programming skills in MATLAB. Assumes no prior programming background. Columbia University students may receive credit for only one of the following two courses: W1004 or W1005.

COMS W1007 Honors Introduction to Computer Science. 3 points.
Lect: 3.

Prerequisites: AP Computer Science with a grade of 4 or 5 or similar experience.
An honors-level introduction to computer science, intended primarily for students considering a major in computer science. Computer science as a science of abstraction. Creating models for reasoning about and solving problems. The basic elements of computers and computer programs. Implementing abstractions using data structures and algorithms. Taught in Java.

COMS W1404 Emerging Scholars Program Seminar. 1 point.
Pass/Fail only.

Prerequisites: the instructor’s permission. Corequisites: COMS W1002 or COMS W1004 or COMS W1007
Corequisites: COMS W1004,COMS W1007,COMS W1002
Peer-led weekly seminar intended for first and second year undergraduates considering a major in Computer Science. Pass/fail only. May not be used towards satisfying the major or SEAS credit requirements.

COMS W3101 Programming Languages. 1 point.
Lect: 1.

Prerequisites: Fluency in at least one programming language. Introduction to a programming language. Each section is devoted to a specific language. Intended only for those who are already fluent in at least one programming language. Sections may meet for one hour per week for the whole term, for three hours per week for the first third of the term, or for two hours per week for the first six weeks. May be repeated for credit if different languages are involved.
COMS W3102 Development Technologies. 1-2 points.

Prerequisites: Fluency in at least one programming language.
Introduction to software development tools and environments. Each
section devoted to a specific tool or environment. One-point sections
meet for two hours each week for half a semester, and two point sections
include an additional two-hour lab.

Spring 2020: COMS W3102
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
COMS 3102  001/12613  F 2:10pm - 4:00pm  Gary Zamchick  1-2  19/30
            302 Fayerweather
COMS 3102  002/12614  M 4:10pm - 6:00pm  Bruno Scap  1-2  35/30
            337 Seeley W. Mudd Building
COMS 3102  003/19973  W 6:10pm - 8:00pm  Robert Coyne  1-2  34/40
            303 Hamilton Hall

COMS W3134 Data Structures in Java. 3 points.
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: (COMS W1004) or knowledge of Java.
Data types and structures: arrays, stacks, singly and doubly linked lists,
queues, trees, sets, and graphs. Programming techniques for processing
such structures: sorting and searching, hashing, garbage collection.
Storage management. Rudiments of the analysis of algorithms. Taught
in Java. Note: Due to significant overlap, students may receive credit for
only one of the following three courses: COMS W3134, COMS W3136, COMS W3137.

Spring 2020: COMS W3134
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
COMS 3134  001/12615  M W 5:40pm - 6:55pm  Paul Blaer  3  333/350
            417 International Affairs Bldg
COMS 3134  001/10066  M W 5:40pm - 6:55pm  Paul Blaer  3  266/350
            Room TBA

COMS W3136 Data Structures with C/C++. 4 points.
Prerequisites: (COMS W1004) or (COMS W1005) or (COMS W1007) or
(ENGI E1006)
A second programming course intended for nonmajors with at least
one semester of introductory programming experience. Basic elements
of programming in C and C++, arraybased data structures, heaps,
linked lists, C programming in UNIX environment, object-oriented
programming in C++, trees, graphs, generic programming, hash tables.
Due to significant overlap, students may only receive credit for either
COMS W3134, W3136, or W3137.

Fall 2020: COMS W3136
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
COMS 3136  001/15273  T Th 5:40pm - 6:55pm  Timothy Paine  4  5/85
            Room TBA

COMS W3137 Honors Data Structures and Algorithms. 4 points.
Prerequisites: (COMS W1004) or (COMS W1007)
Corequisites: COMS W3203
An honors introduction to data types and structures: arrays, stacks, singly
and doubly linked lists, queues, trees, sets, and graphs. Programming
techniques for processing such structures: sorting and searching,
hashing, garbage collection. Storage management. Design and analysis
of algorithms. Taught in Java. Note: Due to significant overlap, students
may receive credit for only one of the following three courses: COMS
W3134, W3136, or W3137.

Spring 2020: COMS W3137
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
COMS 3137  001/12617  T Th 2:40pm - 3:55pm  Paul Blaer  4  37/50
            503 Hamilton Hall

COMS W3157 Advanced Programming. 4 points.
Lect: 4.

Prerequisites: (COMS W3134) or (COMS W3137)
C programming language and Unix systems programming. Also covers
Git, Make, TCP/IP networking basics, C++ fundamentals.

Spring 2020: COMS W3157
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
COMS 3157  001/12618  T Th 4:10pm - 5:25pm  Jae Lee  4  248/272
            301 Pupin Laboratories

COMS W3203 Discrete Mathematics: Introduction to Combinatorics and
Graph Theory. 3 points.
Lect: 3.

Prerequisites: Any introductory course in computer programming.
Logic and formal proofs, sequences and summation, mathematical
induction, binomial coefficients, elements of finite probability, recurrence
relations, equivalence relations and partial orderings, and topics in graph
theory (including isomorphism, traversability, planarity, and colorings).

Spring 2020: COMS W3203
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
COMS 3203  001/12619  M W 10:10am - 11:25am  Ansa Salleb-Aouissi  3  147/152
            417 International Affairs Bldg
COMS 3203  001/11672  T Th 10:10am - 11:25am  Ansa Salleb-Aouissi  3  148/150
            Room TBA
COMS 3203  002/11673  T Th 11:40am - 12:55pm  Ansa Salleb-Aouissi  3  150/150
            Room TBA
COMS W3210 Scientific Computation. 3 points.
CC/GS: Partial Fulfillment of Science Requirement


COMS W3261 Computer Science Theory. 3 points.
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: (COMS W3203)
Corequisites: COMS W3134, COMS W3136, COMS W3137

COMS W3410 Computers and Society. 3 points.
Lect: 3.


COMS W3902 Undergraduate Thesis. 1-6 points.
Prerequisites: Agreement by a faculty member to serve as thesis adviser. An independent theoretical or experimental investigation by an undergraduate major of an appropriate problem in computer science carried out under the supervision of a faculty member. A formal written report is mandatory and an oral presentation may also be required. May be taken over more than one term, in which case the grade is deferred until all 6 points have been completed. Consult the department for section assignment.

COMS W3995 Special Topics in Computer Science. 3 points.
Lect: 3.

Prerequisites: the instructor’s permission. Consult the department for section assignment. Special topics arranged as the need and availability arise. Topics are usually offered on a one-time basis. Since the content of this course changes each time it is offered, it may be repeated for credit.

COMS W3998 Undergraduate Projects in Computer Science. 1-3 points.
Prerequisites: Approval by a faculty member who agrees to supervise the work. Independent project involving laboratory work, computer programming, analytical investigation, or engineering design. May be repeated for credit, but not for a total of more than 3 points of degree credit. Consult the department for section assignment.

COMS W4111 Introduction to Databases. 3 points.
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: (COMS W3134) or (COMS W3137) or (COMS W3136) and (COMS W3134) and fluency in Java; or the instructor’s permission.
Prerequisites: (COMS W3134) or (COMS W3137) or (COMS W3136) and fluency in Java; or the instructor’s permission. The fundamentals of database design and application development using databases: entity-relationship modeling, logical design of relational databases, relational data definition and manipulation languages, SQL, XML, query processing, physical database tuning, transaction processing, security. Programming projects are required.
COMS W4113 Fundamentals of Large-Scale Distributed Systems. 3 points.
Prerequisites: (COMS W3134 or COMS W3136 or COMS W3137) and (COMS W3157 or COMS W4118 or CSEE W4119)
Design and implementation of large-scale distributed and cloud systems. Teaches abstractions, design and implementation techniques that enable the building of fast, scalable, fault-tolerant distributed systems. Topics include distributed communication models (e.g., sockets, remote procedure calls, distributed shared memory), distributed synchronization (clock synchronization, logical clocks, distributed mutex), distributed file systems, replication, consistency models, fault tolerance, distributed transactions, agreement and commitment, Paxos-based consensus, MapReduce infrastructures, scalable distributed databases. Combines concepts and algorithms with descriptions of real-world implementations at Google, Facebook, Yahoo, Microsoft, LinkedIn, etc.

COMS W4115 Programming Languages and Translators. 3 points.
Lect: 3.
Prerequisites: (COMS W3134 or COMS W3136 or COMS W3137) and (COMS W3261) and (CSEE W3827) or equivalent, or the instructor’s permission.
Modern programming languages and compiler design. Imperative, object-oriented, declarative, functional, and scripting languages. Language syntax, control structures, data types, procedures and parameters, binding, scope, run-time organization, and exception handling. Implementation of language translation tools including compilers and interpreters. Lexical, syntactic and semantic analysis; code generation; introduction to code optimization. Teams implement a language and its compiler.

COMS W4118 Operating Systems I. 3 points.
Lect: 3.
Prerequisites: (CSEE W3827) and knowledge of C and programming tools as covered in COMS W3136, W3157, or W3101, or the instructor’s permission.
Design and implementation of operating systems. Topics include process management, process synchronization and interprocess communication, memory management, virtual memory, interrupt handling, processor scheduling, device management, I/O, and file systems. Case study of the UNIX operating system. A programming project is required.

COMS W4121 Computer Systems for Data Science. 3 points.
Prerequisites: background in Computer System Organization and good working knowledge of C/C++ Corequisites: CSOR W4246,STAT GU4203
An introduction to computer architecture and distributed systems with an emphasis on warehouse scale computing systems. Topics will include fundamental tradeoffs in computer systems, hardware and software techniques for exploiting instruction-level parallelism, data-level parallelism and task level parallelism, scheduling, caching, prefetching, network and memory architecture, latency and throughput optimizations, specialization, and an introduction to programming data center computers.

COMS W4130 Principles and Practice of Parallel Programming. 3 points.
CC/GS: Partial Fulfillment of Science Requirement
Prerequisites: (COMS W3134 or COMS W3137 or COMS W3136 and experience in Java) and basic understanding of analysis of algorithms. Principles of parallel software design. Topics include task and data decomposition, load-balancing, reasoning about correctness, determinacy, safety, and deadlock-freedom. Application of techniques through semester-long design project implementing performant, parallel application in a modern parallel programming language.
COMS W4156 Advanced Software Engineering. 3 points.
Lect: 3.
Prerequisites: (COMS W3157) or equivalent. Software lifecycle using frameworks, libraries and services. Major emphasis on software testing. Centers on a team project.

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<tr>
<th>Spring 2020: COMS W4156 Course</th>
<th>Number</th>
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<th>Instructor</th>
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<tr>
<td>COMS 4156</td>
<td>001/16219</td>
<td></td>
<td>T 12:10pm - 2:00pm 411 International Affairs Bldg</td>
<td>Junfeng Yang</td>
<td>3</td>
<td>64/72</td>
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<th>Fall 2020: COMS W4156 Course</th>
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<th>Section/Call</th>
<th>Times/Location</th>
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<tr>
<td>COMS 4156</td>
<td>001/10072</td>
<td></td>
<td>T Th 10:10am - 11:25am Room TBA</td>
<td>Gail Kaiser</td>
<td>3</td>
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</tr>
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</table>

COMS W4160 Computer Graphics. 3 points.
Lect: 3.
Prerequisites: (COMS W3134) or (COMS W3136) or (COMS W3137) COMS W4156 is recommended. Strong programming background and some mathematical familiarity including linear algebra is required. Introduction to computer graphics. Topics include 3D viewing and projections, geometric modeling using spline curves, graphics systems such as OpenGL, lighting and shading, and global illumination. Significant implementation is required: the final project involves writing an interactive 3D video game in OpenGL.

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<tr>
<th>Spring 2020: COMS W4160 Course</th>
<th>Number</th>
<th>Section/Call</th>
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<tr>
<td>COMS 4160</td>
<td>001/12627</td>
<td></td>
<td>T Th 5:40pm - 6:55pm 1127 Seeley W. Mudd Building</td>
<td>Changxi Zheng</td>
<td>3</td>
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<tr>
<td>COMS 4160</td>
<td>V01/34916</td>
<td></td>
<td></td>
<td>Changxi Zheng</td>
<td>3</td>
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</table>

COMS W4162 Advanced Computer Graphics. 3 points.
Lect: 3.
Prerequisites: (COMS W4160) or equivalent, or the instructor’s permission.
A second course in computer graphics covering more advanced topics including image and signal processing, geometric modeling with meshes, advanced image synthesis including ray tracing and global illumination, and other topics as time permits. Emphasis will be placed both on implementation of systems and important mathematical and geometric concepts such as Fourier analysis, mesh algorithms and subdivision, and Monte Carlo sampling for rendering. Note: Course will be taught every two years.

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<tr>
<th>Fall 2020: COMS W4162 Course</th>
<th>Number</th>
<th>Section/Call</th>
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<tr>
<td>COMS 4167</td>
<td>001/11388</td>
<td></td>
<td>T Th 5:40pm - 6:55pm Room TBA</td>
<td>Changxi Zheng</td>
<td>3</td>
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</table>

COMS W4167 Computer Animation. 3 points.
Lect: 3.
Prerequisites: Multivariable calculus, linear algebra, C++ programming proficiency. COMS W4156 recommended. Theory and practice of physics-based animation algorithms, including animated clothing, hair, smoke, water, collisions, impact, and kitchen sinks. Topics covered: Integration of ordinary differential equations, formulation of physical models, treatment of discontinuities including collisions/contact, animation control, constrained Lagrangian Mechanics, friction/dissipation, continuum mechanics, finite elements, rigid bodies, thin shells, discretization of Navier-Stokes equations. General education requirement: quantitative and deductive reasoning (QUA).

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<tr>
<th>Spring 2020: COMS W4170 Course</th>
<th>Number</th>
<th>Section/Call</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
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<tr>
<td>COMS 4170</td>
<td>001/12628</td>
<td></td>
<td>M W 4:10pm - 5:25pm 451 Computer Science Bldg</td>
<td>Lydia Chilton</td>
<td>3</td>
<td>108/100</td>
</tr>
<tr>
<td>COMS 4170</td>
<td>002/36445</td>
<td></td>
<td>F 10:10am - 12:40pm 451 Computer Science Bldg</td>
<td>Lydia Chilton</td>
<td>3</td>
<td>107/100</td>
</tr>
<tr>
<td>COMS 4170</td>
<td>V01/25144</td>
<td></td>
<td></td>
<td>Lydia Chilton</td>
<td>3</td>
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</table>

COMS W4170 User Interface Design. 3 points.
CC/GS: Partial Fulfillment of Science Requirement
Prerequisites: (COMS W3134 or COMS W3136 or COMS W3137)
Introduction to the theory and practice of computer user interface design, emphasizing the software design of graphical user interfaces. Topics include basic interaction devices and techniques, human factors, interaction styles, dialogue design, and software infrastructure. Design and programming projects are required.

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<tr>
<th>Fall 2020: COMS W4170 Course</th>
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<tr>
<td>COMS 4170</td>
<td>001/10073</td>
<td></td>
<td>M W 2:40pm - 3:55pm Room TBA</td>
<td>Brian Smith</td>
<td>3</td>
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</tr>
</tbody>
</table>

COMS W4172 3D User Interfaces and Augmented Reality. 3 points.
CC/GS: Partial Fulfillment of Science Requirement
Prerequisites: (COMS W4160) or (COMS W4170) or the instructor’s permission.

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<tr>
<th>Spring 2020: COMS W4172 Course</th>
<th>Number</th>
<th>Section/Call</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
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<tbody>
<tr>
<td>COMS 4172</td>
<td>001/12629</td>
<td></td>
<td>T Th 1:10pm - 2:25pm 520 Mathematics Building</td>
<td>Steven Feiner</td>
<td>3</td>
<td>32/40</td>
</tr>
</tbody>
</table>
COMS W4180 Network Security. *3 points.*
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: (COMS W3134 or COMS W3136 or COMS W3137) and (CSEE W4119) or COMS W3134, W3136, or W3137 and W4119, or the instructor’s permission.

Introduction to network security concepts and mechanisms. Foundations of network security and an in-depth review of commonly-used security mechanisms and techniques, security threats and network-based attacks, applications of cryptography, authentication, access control, intrusion detection and response, security protocols (IPsec, SSL, Kerberos), denial of service, viruses and worms, software vulnerabilities, web security, wireless security, and privacy.

COMS W4181 Security I. *3 points.*
Not offered during 2019-20 academic year.

Prerequisites: COMS W3157 or equivalent.

COMS W4182 Security II. *3 points.*
Not offered during 2019-20 academic year.

Prerequisites: COMS W4181, COMS W4118, COMS W4119

COMS W4186 Malware Analysis and Reverse Engineering. *3 points.*
Not offered during 2019-20 academic year.

Prerequisites: COMS W3157 or equivalent. COMS W3827

COMS W4187 Security Architecture and Engineering. *3 points.*
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: (COMS W4118) COMS W4118, W4180 and/or W4119 recommended.

COMS W4203 Graph Theory. *3 points.*
Lect: 3.

Prerequisites: (COMS W3203)
General introduction to graph theory. Isomorphism testing, algebraic specification, symmetries, spanning trees, traversability, planarity, drawings on higher-order surfaces, colorings, extremal graphs, random graphs, graphical measurement, directed graphs, Burnside-Polya counting, voltage graph theory.

COMS W4205 Combinatorial Theory. *3 points.*

Prerequisites: (COMS W3203) and course in calculus.
Sequences and recursions, calculus of finite differences and sums, elementary number theory, permutation group structures, binomial coefficients, Stirling numbers, harmonic numbers, generating functions.

COMS W4236 Introduction to Computational Complexity. *3 points.*
Lect: 3.

Prerequisites: (COMS W3261)
Develops a quantitative theory of the computational difficulty of problems in terms of the resources (e.g. time, space) needed to solve them. Classification of problems into complexity classes, reductions, and completeness. Power and limitations of different modes of computation such as nondeterminism, randomization, interaction, and parallelism.

Lect: 3.

Prerequisites: Knowledge of a programming language. Some knowledge of scientific computation is desirable.
Modern theory and practice of computation on digital computers. Introduction to concepts of computational complexity. Design and analysis of numerical algorithms. Applications to computational finance, computational science, and computational engineering.

COMS W4242 Numerical Algorithms and Their Complexity II. *3 points.*
Prerequisites: COMS W4241.
A continuation of COMS W4241.

COMS W4252 Introduction to Computational Learning Theory. *3 points.*
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: (CSOR W4231) or (COMS W4236) or COMS W2203 and the instructor’s permission, or COMS W3261 and the instructor’s permission.
Possibilities and limitations of performing learning by computational agents. Topics include computational models of learning, polynomial time learnability, learning from examples and learning from queries to oracles. Computational and statistical limitations of learning. Applications to Boolean functions, geometric functions, automata.
COMS W4261 Introduction to Cryptography. 3 points.
Lect: 2.5.
Prerequisites: Comfort with basic discrete math and probability. Recommended: COMS W3261 or CSOR W4231. An introduction to modern cryptography, focusing on the complexity-theoretic foundations of secure computation and communication in adversarial environments; a rigorous approach, based on precise definitions and provably secure protocols. Topics include private and public key encryption schemes, digital signatures, authentication, pseudorandom generators and functions, one-way functions, trapdoor functions, number theory and computational hardness, identification and zero knowledge protocols.

COMS W4281 Introduction to Quantum Computing. 3 points.
Lect: 3.
Prerequisites: Knowledge of linear algebra. Prior knowledge of quantum mechanics is not required although helpful. Introduction to quantum computing, Shor's factoring algorithm, Grover's database search algorithm, the quantum summation algorithm. Relationship between classical and quantum computing. Potential power of quantum computers.

COMS W4419 Internet Technology, Economics, and Policy. 3 points. Not offered during 2019-20 academic year.
Technology, economic and policy aspects of the Internet. Summarizes how the Internet works technically, including protocols, standards, radio spectrum, global infrastructure and interconnection. Micro-economics with a focus on media and telecommunication economic concerns, including competition and monopolies, platforms, and behavioral economics. US constitution, freedom of speech, administrative procedures act and regulatory process, universal service, role of FCC. Not a substitute for CSEE4119. Suitable for non-majors. May not be used as a track elective for the computer science major.

COMS W4444 Programming and Problem Solving. 3 points.
CC/GS: Partial Fulfillment of Science Requirement
Prerequisites: (COMS W3134 or COMS W3136 or COMS W3137) and (CSEE W3827) Hands-on introduction to solving open-ended computational problems. Emphasis on creativity, cooperation, and collaboration. Projects spanning a variety of areas within computer science, typically requiring the development of computer programs. Generalization of solutions to broader problems, and specialization of complex problems to make them manageable. Team-oriented projects, student presentations, and in-class participation required.

COMS W4460 Principles of Innovation and Entrepreneurship. 3 points.
CC/GS: Partial Fulfillment of Science Requirement
Prerequisites: (COMS W3134 or COMS W3136 or COMS W3137) or the instructor's permission. Team project centered course focused on principles of planning, creating, and growing a technology venture. Topics include: identifying and analyzing opportunities created by technology paradigm shifts, designing innovative products, protecting intellectual property, engineering innovative business models.

COMS W4560 Introduction to Computer Applications in Health Care and Biomedicine. 3 points.
Prerequisites: Experience with computers and a passing familiarity with medicine and biology. Undergraduates in their senior or junior years may take this course only if they have adequate background in mathematics and receive the instructor's permission. An overview of the field of biomedical informatics, combining perspectives from medicine, computer science and social science. Use of computers and information in health care and the biomedical sciences, covering specific applications and general methods, current issues, capabilities and limitations of biomedical informatics. Biomedical Informatics studies the organization of medical information, the effective management of information using computer technology, and the impact of such technology on medical research, education, and patient care. The field explores techniques for assessing current information practices, determining the information needs of health care providers and patients, developing interventions using computer technology, and evaluating the impact of those interventions.

COMS W4701 Artificial Intelligence. 3 points.
CC/GS: Partial Fulfillment of Science Requirement
Prerequisites: (COMS W3134 or COMS W3136 or COMS W3137) and any course on probability. Prior knowledge of Python is recommended. Provides a broad understanding of the basic techniques for building intelligent computer systems. Topics include state-space problem representations, problem reduction and and-or graphs, game playing and heuristic search, predicate calculus, and resolution theorem proving, AI systems and languages for knowledge representation, machine learning and concept formation and other topics such as natural language processing may be included as time permits.

COMS W4701 Artificial Intelligence. 3 points.
CC/GS: Partial Fulfillment of Science Requirement
Prerequisites: (COMS W3134 or COMS W3136 or COMS W3137) and any course on probability. Prior knowledge of Python is recommended. Provides a broad understanding of the basic techniques for building intelligent computer systems. Topics include state-space problem representations, problem reduction and and-or graphs, game playing and heuristic search, predicate calculus, and resolution theorem proving, AI systems and languages for knowledge representation, machine learning and concept formation and other topics such as natural language processing may be included as time permits.
COMS W4705 Natural Language Processing. 3 points.
Lect: 3.

Prerequisites: (COMS W3134 or COMS W3136 or COMS W3137) or the instructor's permission.
Computational approaches to natural language generation and understanding. Recommended preparation: some previous or concurrent exposure to AI or Machine Learning. Topics include information extraction, summarization, machine translation, dialogue systems, and emotional speech. Particular attention is given to robust techniques that can handle understanding and generation for the large amounts of text on the Web or in other large corpora. Programming exercises in several of these areas.

Spring 2020: COMS W4705

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<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
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<td>COMS 4705</td>
<td>001/12632</td>
<td>F 1:10pm - 3:40pm 402 Chandler</td>
<td>Yassine Benajiba</td>
<td>3</td>
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<td>COMS 4705</td>
<td>002/13588</td>
<td>T Th 4:10pm - 5:25pm 1127 Seeley W. Mudd Building</td>
<td>Michael Collins</td>
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COMS W4706 Spoken Language Processing. 3 points.
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: (COMS W3134 or COMS W3136 or COMS W3137) or the instructor's permission.
Computational approaches to speech generation and understanding. Topics include speech recognition and understanding, speech analysis for computational linguistics research, and speech synthesis. Speech applications including dialogue systems, data mining, summarization, and translation. Exercises involve data analysis and building a small text-to-speech system.

COMS W4725 Knowledge representation and reasoning. 3 points.

Prerequisites: (COMS W4701)
General aspects of knowledge representation (KR). The two fundamental paradigms (semantic networks and frames) and illustrative systems. Topics include hybrid systems, time, action/plans, defaults, abduction, and case-based reasoning. Throughout the course particular attention is paid to design trade-offs between language expressiveness and reasoning complexity, and issues relating to the use of KR systems in larger applications.

COMS W4731 Computer Vision. 3 points.
Lect: 3.

Prerequisites: Fundamentals of calculus, linear algebra, and C programming. Students without any of these prerequisites are advised to contact the instructor prior to taking the course.
Introductory course in computer vision. Topics include image formation and optics, image sensing, binary images, image processing and filtering, edge extraction and boundary detection, region growing and segmentation, pattern classification methods, brightness and reflectance, shape from shading and photometric stereo, texture, binocular stereo, optical flow and motion, 2D and 3D object representation, object recognition, vision systems and applications.

COMS W4733 Computational Aspects of Robotics. 3 points.
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: (COMS W3134 or COMS W3136COMS W3137)
Introduction to robotics from a computer science perspective. Topics include coordinate frames and kinematics, computer architectures for robotics, integration and use of sensors, world modeling systems, design and use of robotic programming languages, and applications of artificial intelligence for planning, assembly, and manipulation.

COMS W4735 Visual Interfaces to Computers. 3 points.
Lect: 3.

Prerequisites: (COMS W3134 or COMS W3136 or COMS W3137)
Visual input as data and for control of computer systems. Survey and analysis of architecture, algorithms, and underlying assumptions of commercial and research systems that recognize and interpret human gestures, analyze imagery such as fingerprint or iris patterns, generate natural language descriptions of medical or map imagery. Explores foundations in human psychophysics, cognitive science, and artificial intelligence.
COMS W4737 Biometrics. 3 points.
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: a background at the sophomore level in computer science, engineering, or like discipline.

In this course, we will explore the latest advances in biometrics as well as the machine learning techniques behind them. Students will learn how these technologies work and how they are sometimes defeated. Grading will be based on homework assignments and a final project. There will be no midterm or final exam. This course shares lectures with COMS E6737. Students taking COMS E6737 are required to complete additional homework problems and undertake a more rigorous final project. Students will only be allowed to earn credit for COMS W4737 or COMS E6737 and not both.

COMS W4771 Machine Learning. 3 points.
Lect: 3.

Prerequisites: Any introductory course in linear algebra and any introductory course in statistics are both required. Highly recommended: COMS W4701 or knowledge of Artificial Intelligence.

Topics from generative and discriminative machine learning including least squares methods, support vector machines, kernel methods, neural networks, Gaussian distributions, linear classification, linear regression, maximum likelihood, exponential family distributions, Bayesian networks, Bayesian inference, mixture models, the EM algorithm, graphical models and hidden Markov models. Algorithms implemented in MATLAB.

Spring 2020: COMS W4771  
Course Number | Section/Call Number | Times/Location | Instructor | Points | Enrollment  
COMS 4771 | 001/12636 | T Th 2:40pm - 3:55pm, 501 Northwest Corner | Nakul Verma | 3 | 174/164  
COMS 4771 | H01/25038 | T Th 1:10pm - 2:25pm, 451 Computer Science Bldg | Nakul Verma | 3 | 33/50  
COMS 4771 | V01/25156 | T Th 2:40pm - 3:55pm, Room TBA | Nakul Verma | 3 | 5/99  

Fall 2020: COMS W4771  
Course Number | Section/Call Number | Times/Location | Instructor | Points | Enrollment  
COMS 4771 | 001/10078 | M W 8:40am - 9:55am, Room TBA | Daniel Hsu | 3 | 0/50  
COMS 4771 | 002/10079 | T Th 1:10pm - 2:25pm, Room TBA | Nakul Verma | 3 | 0/110  

COMS W4772 Advanced Machine Learning. 3 points.
Lect: 3.

Prerequisites: (COMS W4771) or instructor's permission; knowledge of linear algebra & introductory probability or statistics is required. An exploration of advanced machine learning tools for perception and behavior learning. How can machines perceive, learn from, and classify human activity computationally? Topics include appearance-based models, principal and independent components analysis, dimensionality reduction, kernel methods, manifold learning, latent models, regression, classification, Bayesian methods, maximum entropy methods, real-time tracking, extended Kalman filters, time series prediction, hidden Markov models, factorial HMMS, input-output HMMS, Markov random fields, variational methods, dynamic Bayesian networks, and Gaussian/Dirichlet processes. Links to cognitive science.

Spring 2020: COMS W4772  
Course Number | Section/Call Number | Times/Location | Instructor | Points | Enrollment  
COMS 4772 | 001/12637 | T Th 1:10pm - 2:25pm, 451 Computer Science Bldg | Nakul Verma | 3 | 35/110  

COMS W4776 Machine Learning for Data Science. 3 points.
Lect: 3.

Prerequisites: (STAT GU4001 or IEOR E4150) and linear algebra. Introduction to machine learning, emphasis on data science. Topics include least square methods, Gaussian distributions, linear classification, linear regression, maximum likelihood, exponential family distributions, Bayesian networks, Bayesian inference, mixture models, the EM algorithm, graphical models, hidden Markov models, support vector machines kernel methods. Emphasizes methods and problems relevant to big data. Students may not receive credit for both COMS W4771 and W4776.

COMS W4901 Projects in Computer Science. 1-3 points.
Prerequisites: Approval by a faculty member who agrees to supervise the work. A second-level independent project involving laboratory work, computer programming, analytical investigation, or engineering design. May be repeated for credit, but not for a total of more than 3 points of degree credit. Consult the department for section assignment.

COMS W4910 Curricular Practical Training. 1 point.
Prerequisites: obtained internship and approval from faculty advisor. Only for M.S. students in the Computer Science department who need relevant work experience as part of their program of study. Final report required. This course may not be taken for pass/fail credit or audited.
**COMS W4995** Special topics in computer science, I. 3 points.
Lect: 3.

Prerequisites: Instructor's permission.
Special topics arranged as the need and availability arises. Topics are usually offered on a one-time basis. Since the content of this course changes each time it is offered, it may be repeated for credit. Consult the department for section assignment.

### Spring 2020: COMS W4995

<table>
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<th>Course Number</th>
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<th>Times/Location</th>
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<td>M W 8:40am - 9:55am 417 Mathematics Building</td>
<td>Daniel Hsu</td>
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<td>T Th 2:40pm - 3:55pm 1024 Seeley W. Mudd Building</td>
<td>Alexandr Andoni</td>
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<td>COMS 4995</td>
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<td>F 10:10am - 12:00pm 327 Seeley W. Mudd Building</td>
<td>Bjarme Stroustrup</td>
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<td>Th 6:10pm - 8:00pm 313 Fayerweather</td>
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<td>Andreas Mueller</td>
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<td>Adam Kelleher</td>
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### Fall 2020: COMS W4995

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<td>Paul Blaer</td>
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<td>Peter Belhumeur</td>
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<td>David Knowles</td>
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**COMS W4996** Special topics in computer science, II. 3 points.

Prerequisites: Instructor's permission.
A continuation of COMS W4995 when the special topic extends over two terms.