Computer Science

Subject: Computer Science

Computer Science 1

Great Ideas in Computer Science (119953)

Henry Leitner

2018 Spring (4 Credits) **Schedule:** TR 1000 AM - 1129 AM

Instructor Permissions: None **Enrollment Cap:** n/a

An introduction to the most important discoveries and intellectual paradigms in computer science, designed for students with little or no previous background. Explores problem-solving using high and low-level programming languages; presents an integrated view of computer systems, from switching circuits up through compilers and GUI design. Examines theoretical and practical limitations related to unsolvable and intractable computational problems, and the social and ethical dilemmas presented by such issues as software unreliability and invasions of privacy.

Course Notes: **May not be taken for credit after completing Computer Science 50. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning.**

Additional Course Attributes:

Attribute	Value(s)
FAS: General Education	Empirical and Mathematical Reasoning
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Undergraduate Students

Computer Science 20

Discrete Mathematics for Computer Science (128073)

Rebecca Nesson

2018 Spring (4 Credits) **Schedule:** MWF 1000 AM - 1059 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Widely applicable mathematical tools for computer science, including topics from logic, set theory, combinatorics, number theory, probability theory, and graph theory. Practice in reasoning formally and proving theorems.

Course Notes: **Covers material used in Computer Science 121 and Computer Science 124. Ordinarily, not to be taken after those courses or after courses such as Applied Mathematics 106, Applied Mathematics 107, Mathematics 101, and Mathematics 153. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration

FAS: Core Curriculum	Quantitative Reasoning
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Undergraduate Students
FAS: Final Assessment Category	Three-hour Exam
FAS: General Education	Empirical and Mathematical Reasoning

Computer Science 50

Introduction to Computer Science I (152514)

David J. Malan

2017 Fall (4 Credits) **Schedule:** F 1000 AM - 1159 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Introduction to the intellectual enterprises of computer science and the art of programming. This course teaches you how to think algorithmically and solve problems efficiently. Topics include abstraction, algorithms, data structures, encapsulation, resource management, security, software engineering, and web development. Languages include C, Python, SQL, and JavaScript plus CSS and HTML. Problem sets inspired by real-world domains of biology, cryptography, finance, forensics, and gaming. Designed for concentrators and non-concentrators alike, with or without prior programming experience. 68% of CS50 students have never taken CS before.

Class Notes: **This course meets on Fridays, 10am-12pm, starting September 1. The course also meets on one Wednesday, September 6, 1pm-2:30pm. Students without conflicts are encouraged to attend all lectures in person this year; students with conflicts may watch later online. Students may simultaneously enroll in CS50 and another course that meets at the same time. To do so, students should enroll in the other course via my.harvard.edu and then email enrollment@fas.harvard.edu to have CS50 manually added to their crimson carts as well. CS50 is ordinarily graded SAT/UNS, though students taking CS50 to fulfill old Gen Ed requirements or whose concentration requires letter grades should change their grading status to letter-graded via my.harvard by the term's fifth Monday. First years may take both CS50 and a freshman seminar SAT/UNS. All students are expected to attend an orientation meeting in Science Center D on either September 6, 5: 30pm-6:30pm, or September 7, 3pm-4pm; students with conflicts may watch later online. See cs50.harvard.edu for FAQs. Required sections to be arranged. No final exam.**

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Undergraduate Students
FAS: Core Curriculum	Quantitative Reasoning
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: General Education	Empirical and Mathematical Reasoning
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 51

Introduction to Computer Science II (112960)

Stuart Shieber

2018 Spring (4 Credits) **Schedule:** T 0100 PM - 0229 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Abstraction and design in computation. Topics include functional and object-oriented styles of programming, software engineering in the small, and models of computation. Our main goal is to understand how to design large programs to make them readable, maintainable, elegant, and efficient.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Undergraduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 61

Systems Programming and Machine Organization (123623)

Eddie Kohler

2017 Fall (4 Credits) **Schedule:** TR 0230 PM - 0359 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Fundamentals of computer systems programming, machine organization, and performance tuning. This course provides a solid background in systems programming and a deep understanding of low-level machine organization and design. Topics include C and assembly language programming, program optimization, memory hierarchy and caching, virtual memory and dynamic memory management, concurrency, threads, and synchronization.

Recommended Prep: **CS50 or some experience programming in C.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Undergraduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Final Assessment Category	Three-hour Exam

Computer Science 90NBR

The Ethics and Governance of Artificial Intelligence (203578)

Jonathan Zittrain

Joichi Ito

2018 Spring (2 Credits) **Schedule:** T 0500 PM - 0759 PM

Instructor Permissions: Instructor **Enrollment Cap:** 30

This course will pursue a cross-disciplinary investigation of the development and deployment of the opaque complex adaptive systems that are increasingly in public and private use. We will explore the proliferation of algorithmic decisionmaking, autonomous systems, and machine learning and explanation; the search for balance between regulation and innovation; and the effects of AI on the dissemination of information, along with questions related to individual rights, discrimination, and architectures of control. The course will meet at MIT and will entail a diverse array of learning and teaching methods, and students will be expected to participate in a variety of activities that will involve interaction with Berkman Klein Center and Media Lab fellows. Please visit http://brk.mn/AI2018 to access the application and read more

about the course.

Course Notes: **This course is jointly listed with HLS. This course does not count for concentration credit in Computer Science.**

Class Notes: **The deadline to submit the application is 11:59pm on Monday, November 6th. The course will commence with intensive weekend sessions on February 2nd, 3rd, and 4th, 2018. Classes will meet on Tuesdays from February 6th to April 10th, 5 pm to 8 pm at MIT.**

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Undergraduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 91R

Supervised Reading and Research (113257)

Stephen Chong

Boaz Barak

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Supervised individual study of advanced topics in computer science. A student wishing to enroll in Computer Science 91r must be accepted by a faculty member who will supervise the course work. A form available from the Student Affairs Office, Pierce Hall 110, must be filled out and signed by the student and faculty supervisor. Students writing theses may enroll in this course while conducting thesis research and writing.

Course Notes: **At most two terms of Computer Science 91r may be taken for academic credit. May not be taken Pass/Fail. Students wishing more information about the range of suitable projects or faculty supervisors should consult the Director of Undergraduate Studies.**

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Undergraduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 91R

Supervised Reading and Research (113257)

Stephen Chong

Steven Gortler

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Supervised individual study of advanced topics in computer science. A student wishing to enroll in Computer Science 91r must be accepted by a faculty member who will supervise the course work. A form available from the Student Affairs Office, Pierce Hall 110, must be filled out and signed by the student and faculty supervisor. Students writing theses may enroll in this course while conducting thesis research and writing.

Course Notes: **At most two terms of Computer Science 91r may be taken for academic credit. May not be taken Pass/Fail. Students wishing more information about the range of suitable projects or faculty supervisors should consult the Director of Undergraduate Studies.**

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Undergraduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 96

System Design Projects (121508)

Stuart Shieber

2017 Fall (4 Credits) **Schedule:** MWF 0400 PM - 0559 PM

Instructor Permissions: Instructor **Enrollment Cap:** 12

Cooperative design, development, and testing of a sizable and realistic computer system. Students work as a group with a client on a real-world open-ended problem, and gain experience in problem definition, software development, and system lifecycle issues, and in the area of application. Students work in groups; both student participation in the classroom and effective group cooperation outside the classroom are stressed. This term the problem to be addressed is the fragmentation of civil discourse in the United States and abroad, often going under the terms 'polarization' and 'filter bubbles', and leading to incorrect beliefs and allegations of 'alternative facts' or 'fake news'.

Course Notes: **Course is enrollment-limited by application**

Class Notes: **Time: Mondays, Wednesdays, and Fridays 4-6pm, starting August 30, 2017. The Friday slots will be used rarely, primarily at the start of term.**

Location: First meeting (August 30, 2017) in Maxwell Dworkin Laboratory G125; thereafter in Maxwell Dworkin Laboratory 223.

Recommended Prep: **This course is primarily intended for junior and senior computer science concentrators, for whom CS51 or CS61 is recommended, though non-CS concentrators with appropriate interests and background may enroll as well.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Undergraduate Students

Computer Science 105

Privacy and Technology (125407)

James Waldo

2017 Fall (4 Credits) **Schedule:** TR 0100 PM - 0229 PM

Instructor Permissions: Instructor **Enrollment Cap:** n/a

What is privacy, and how is it affected by recent developments in technology? This course critically examines popular concepts of privacy and uses a rigorous analysis of technologies to understand the policy and ethical issues at play. Case studies: database anonymity, research ethics, wiretapping, surveillance, and others. Course relies on some technical material, but is open and accessible to all students, especially those with interest in economics, engineering, political science, computer science, sociology, biology, law, government, philosophy.

Course Notes: **This course, when taken for a letter grade, meets the General Education requirement for Culture and Belief.**

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	For Undergraduate and Graduate Students
FAS: General Education	Culture and Belief
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Core Curriculum	Social Analysis

Computer Science 108

Intelligent Systems: Design and Ethical Challenges (160419)

Barbara Grosz

Jeffrey Behrends

2017 Fall (4 Credits) **Schedule:** TR 1130 AM - 1259 PM

Instructor Permissions: Instructor **Enrollment Cap:** 24

For centuries, people have imagined smart machines in fictional stories. Computer systems now communicate in speech and text, learn, negotiate, and work in teams (with people and other systems). These intelligent-systems capabilities raise questions about the impact of such systems on people and societies. This course introduces the basic techniques of AI in the context of (science) fiction imaginings and ethical challenges. It examines the roles of design and of policy in reducing potential negative consequences. The course presumes a basic programming ability, but is accessible to concentrators in the humanities and social sciences as well as science and engineering.

Class Notes: **Enrollment limited to 24 and permission required.**

Recommended Prep: **CS50 or equivalent.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Undergraduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 109A

Data Science 1: Introduction to Data Science (109899)

Pavlos Protopapas

Kevin A. Rader

Margo Levine

2017 Fall (4 Credits) **Schedule:** MW 0100 PM - 0229 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Data Science 1 is the first half of a one-year introduction to data science. The course will focus on the analysis of messy, real life data to perform predictions using statistical and machine learning methods. Material covered will integrate the five key facets of an investigation using data: (1) data collection - data wrangling, cleaning, and sampling to get a suitable data set; (2) data management - accessing data quickly and reliably; (3) exploratory data analysis – generating hypotheses and building intuition; (4) prediction or statistical learning; and (5) communication – summarizing results through visualization, stories, and interpretable summaries. Part one of a two part series. The curriculum for this course builds throughout the academic year. Students are strongly encouraged to enroll in both the fall and spring course within the same academic year.

Course Notes: **Only one of CS 109a, AC 209a, or Stat 121a can be taken for credit. Students who have previously taken CS 109, AC 209, or Stat 121 cannot take CS 109a, AC 209a, or Stat 121a for credit.**

Recommended Prep: **Programming knowledge at the level of CS 50 or above, and statistics knowledge at the level of Stat 100 or above (Stat 110 recommended).**

Requirements: **Not to be taken in addition to Applied Computation 209, or Applied Computation 209A, or Statistics 121, or Statistics 121A.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students
GSD: MDS/MDE Rec. Elec.	MDE recommended elective
Full Year Course	Divisible Course
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 109B

Data Science 2: Advanced Topics in Data Science (203546)

Mark Glickman

Pavlos Protopapas

2018 Spring (4 Credits) **Schedule:** MW 0100 PM - 0229 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Data Science 2 is the second half of a one-year introduction to data science. Building upon the material in Data Science 1, the course introduces advanced methods for data wrangling, data visualization, and statistical modeling and prediction. Topics include big data and database management, interactive visualizations, nonlinear statistical models, and deep learning. Part two of a two part series. The curriculum for this course builds throughout the academic year. Students are strongly encouraged to enroll in both the

fall and spring course within the same academic year.

Course Notes: **Can only be taken after successful completion of CS 109a, AC 209a, Stat 121a, or equivalent. Students who have previously taken CS 109, AC 209, or Stat 121 cannot take CS 109b, AC 209b, or Stat 121b for credit.**

Recommended Prep: **CS 109a, AC 209a, or Stat 121a required.**

Requirements: **Requisite: (Must take CS 109A OR APCOMP 209A OR STAT 121A before taking CS 109B) AND (Not to be taken in addition to CS 109, OR APCOMP 209, OR APCOMP 209B, OR STAT 121, OR STAT 121B.)**

Additional Course Attributes:

Attribute	Value(s)
Full Year Course	Divisible Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Undergraduate Students
GSD: MDS/MDE Rec. Elec.	MDE recommended elective
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 121

Introduction to Theoretical Computer Science (119064)

Boaz Barak

Salil Vadhan

2017 Fall (4 Credits) **Schedule:** TR 1000 AM - 1129 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Computation occurs over a variety of substrates including silicon, neurons, DNA, the stock market, bee colonies and many others. In this course we will study the fundamental capabilities and limitations of computation, including the phenomenon of universality and the duality of code and data. Some of the questions we will touch upon include: Are there functions that cannot be computed? Are there true mathematical statements that can't be proven? Are there encryption schemes that can't be broken? Is randomness ever useful for computing? Can we use the quirks of quantum mechanics to speed up computation?

Course Notes: **Students may not receive credit for both CS 121 and CS 125.**

Recommended Prep: **Experience in formal mathematics at the level of CS 20. A "Homework Zero" will be posted on the course website cs121.boazbarak.org by July 1st. It is highly recommended that students complete it before the first lecture.**

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	For Undergraduate and Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Final Assessment Category	Three-hour Exam
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 124

Data Structures and Algorithms (115384)

Jelani Nelson

Salil Vadhan

2018 Spring (4 Credits) **Schedule:** TR 1130 AM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Design and analysis of efficient algorithms and data structures. Algorithm design methods, graph algorithms, approximation algorithms, and randomized algorithms are covered.

Course Notes: **Starting in the spring of 2013, Computer Science 124 will assume background from Computer Science 20. Students will not receive credit for both CS 124 and CS 125.**

Recommended Prep: **Computer Science 50 or equivalent; Computer Science 51 is helpful.**

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	For Undergraduate and Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Final Assessment Category	Three-hour Exam

Computer Science 126

Fairness, Privacy, and Validity in Data Analysis (204972)

Cynthia Dwork

2017 Fall (4 Credits) **Schedule:** TR 1000 AM - 1129 AM

Instructor Permissions: Instructor **Enrollment Cap:** 30

Students will learn to analyze and mitigate privacy loss, unfairness, and lack of statistical validity, in data analysis. Principal techniques will come from cryptography, differential privacy, and the newly emerging areas of adaptive data analysis and fairness in machine learning.

Course Notes: **Course enrollment limited to 30.**

Recommended Prep: **STAT 110 and COMPSCI 124**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Undergraduate Students

Computer Science 127

Cryptography (109566)

Boaz Barak

2018 Spring (4 Credits) **Schedule:** TR 1000 AM - 1129 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Cryptography is as old as human communication itself, but has undergone a revolution in the last few decades. It is now about much more than "secret writing" and includes seemingly paradoxical notions such as communicating securely without a shared secret, and computing on encrypted data. In this challenging but rewarding course we will start from the basics of private and public key cryptography and go all the way up to advanced notions such as fully homomorphic encryption and software obfuscation. This is a proof-based course that will be best appreciated by mathematically mature students.

Course Notes: **This course will be offered in both an undergraduate and graduate versions. The graduate version will involve an additional project.**

Recommended Prep: **Comfort with mathematical proofs at the level of CS121, CS124 or similar. Please contact the instructor if you're unsure if your background is sufficient.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	For Undergraduate and Graduate Students

Computer Science 134 Section: 1

Networks (160409)

Yaron Singer

2017 Fall (4 Credits) **Schedule:** MW 0230 PM - 0359 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Networks—of social relationships, economic interdependencies, and digital interactions—are critical in shaping our lives. This course introduces models and algorithms that help us understand networks. Fundamental concepts from applied mathematics, microeconomics, and computer science will be presented through the lens of network science, in order to equip students to usefully analyze the "big data" generated by online networks. Applications discussed include the viral spread of ideas, maximizing influence, and the contagion of economic downturns. Concepts and tools covered include game theory, graph theory, data mining, and machine learning.

Course Notes: **Computer Science 134 is also offered as Economics 1034. Students may not take both for credit.**

Recommended Prep: **Linear Algebra, Calculus, probability (either their courses or their equivalents): AM 21a, AM 21b, Statistics 110.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 136

Economics and Computation (128164)

David Parkes

2017 Fall (4 Credits) **Schedule:** MW 1130 AM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

The interplay between economic thinking and computational thinking as it relates to electronic commerce, social networks, collective intelligence and networked systems. Topics covered include: game theory, peer production, reputation and recommender systems, prediction markets, crowd sourcing, network influence and dynamics, auctions and mechanisms, privacy and security, matching and allocation problems, computational social choice and behavioral game theory. Emphasis will be given to core methodologies, with students engaged in theoretical, computational and empirical exercises.

Course Notes: **Formerly Computer Science 186**

Recommended Prep: **Applied Math 21b, Computer Science 51 or equivalent, Statistics 110, and one of Computer Science 181, Computer Science 182, Economics 1011a, Economics 1052, or Economics 1056.**

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students

Computer Science 141

Computing Hardware (113856)

Gu-Yeon Wei

2017 Fall (4 Credits) **Schedule:** MW 1000 AM - 1129 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Introduction to the design, structure, and operation of digital computers; logic circuits and digital electronics; computer arithmetic; computer architecture; and machine language programming. Consideration of the design interactions between hardware and software systems.

Recommended Prep: **Programming experience required.**

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students

Computer Science 143

Computer Networks (118418)

H. Kung

2017 Fall (4 Credits) **Schedule:** MW 0230 PM - 0359 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Computer networking has enabled the emergence of mobile and cloud computing, creating one of the most

important technological breakthroughs in computing of the past decade. We expect two major paradigm shifts will take place in the next ten years. First, we will witness the emergence of 5G wireless mobile networks, which will begin to replace the current 4G networks as early as 2020. Second, blockchain technology, which has powered Bitcoin, is creating a new trusted network infrastructure that will allow information to be distributed but not copied. In order to play a role in this era of network-based computing, students must have a thorough understanding of these emerging networking technologies and applications. Beyond teaching the basic networking protocols, which have become very mature and can be treated as a black box, in CS 143, we will teach new networking issues and topics of significance. This focus on upcoming wireless and blockchain advancements is the motivation for CS 143 this semester. The class will be organized into the following eight modules: (1) A view of the future: 5G and blockchain; (2) Basic networking concepts: network interoperability, decentralization, security, and robustness; (3) Radio basics: Wave propagation physics; (4) Wireless networking protocols: Wi-Fi, MAC protocols; (5) New 5G technologies: Millimeter wave, Ultra Dense Networks (UDNs), MIMO; (6) Fundamentals of blockchains: Peer-to-peer networking, distributed database, cryptography-driven consensus protocols; (7) Blockchain in mobile networks: trust economy, smart contract, blockchain-as-a-service; (8) Machine learning assisted networking: Data-driven network protocols. Students in the course will read and discuss basic material as well as the latest literature, gain hands-on experience through a programming assignment, and have the opportunity to present the concepts and insights learned through a final project.

Prerequisites: CS50 (or programming experience) and a strong interest in the subject matter. Lab sessions will be provided to give extra support.

Recommended Prep: **CS50 (or programming experience) and strong interest in the subject matter. Lab sessions will be provided to give extra support.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 144R

Networks Design Projects (112630)

H. Kung

Minlan Yu

2018 Spring (4 Credits) **Schedule:** MW 0230 PM - 0359 PM

Instructor Permissions: None **Enrollment Cap:** n/a

As networking technologies advance, networks and their applications can operate more and more by themselves without help. For example, based on blockchains, we can develop autonomous systems that will provide forever-improving peer-to-peer services. More specifically, with proper incentives provided to participants to contribute, the network will continue to improve over time. In this course, we will study core network-related technologies whose interplay will be responsible for these autonomous systems of the future, which range from the Internet of Things (IoT) to decentralized autonomous organizations. These technologies include blockchains, machine learning, IoT, datacenter networking, video-analytics over heterogeneous networks, mobile computing, and homomorphic encryption for cloud computing. We will first review these core technologies. Following this, we will illustrate novel autonomous applications such as peer-to-peer business models for machine learning systems, including the models themselves and the data on which they operate. Another application example will be the distributed classification of security attacks, including designing incentives to encourage collaboration in mitigating attacks. Students will work in pairs on projects related to autonomous technologies and business model experimentation.

Course Notes: **Preference given to upper-class undergraduates or graduate students in computer science or in business.**

Recommended Prep: **Programming experience (CS 50 should be fine) and interest in the subject matter. Importantly, CS 143 is NOT a prerequisite. Labs and extra support will provide intensive preparation in the first weeks of the semester to help students quickly obtain the networking background necessary to excel in the course.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 148

Design of VLSI Circuits and Systems (110990)

Gu-Yeon Wei

2018 Spring (4 Credits) **Schedule:** TR 1130 AM - 1259 PM

Instructor Permissions: Instructor **Enrollment Cap:** 16

Presentation of concepts and techniques for the design and fabrication of VLSI systems and digital MOS integrated circuits. Topics include: basic semiconductor theory; MOS transistors and digital MOS circuits design; synchronous machines, clocking, and timing issues; high-level description and modeling of VLSI systems; synthesis and place and route design flows; and testing of VLSI circuits and systems. Various CAD tools for design, simulation, and verification are extensively used.

Course Notes: **Offered in alternate years.**

Recommended Prep: **Computer Science 141 or permission of instructor.**

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	For Undergraduate and Graduate Students
FAS: Final Assessment Category	Three-hour Exam
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 152

Programming Languages (119629)

Stephen Chong

2018 Spring (4 Credits) **Schedule:** TR 1000 AM - 1129 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Comprehensive introduction to the principal features and overall design of both traditional and modern programming languages, including syntax, formal semantics, abstraction mechanisms, modularity, type systems, naming, polymorphism, closures, continuations, and concurrency. Provides the intellectual tools needed to design, evaluate, choose, and use programming languages.

Recommended Prep: **Computer Science 51; Computer Science 121 is recommended. Students must have good programming skills, be very comfortable with recursion, proofs, basic mathematical ideas and notations, including sets, relations, functions, and induction.**

Additional Course Attributes:

Attribute	Value(s)
FAS: Final Assessment Category	Three-hour Exam
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	For Undergraduate and Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 161

Operating Systems (113847)

Eddie Kohler

2018 Spring (4 Credits) **Schedule:** TR 0100 PM - 0229 PM

Instructor Permissions: None **Enrollment Cap:** n/a

This course focuses on the design and implementation of modern operating systems. The course discusses threads, processes, virtual memory, schedulers, and the other fundamental primitives that an OS uses to represent active computations. An exploration of the system call interface explains how applications interact with hardware and other programs which are concurrently executing. Case studies of popular file systems reveal how an OS makes IO efficient and robust in the midst of crashes and unexpected reboots. Students also learn how virtualization allows a physical machine to partition its resources across multiple virtual machines. Class topics are reinforced through a series of intensive programming assignments which use a real operating system.

Recommended Prep: **Computer Science 61.**

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	For Undergraduate and Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 165

Data Systems (119249)

Stratos Idreos

2017 Fall (4 Credits) **Schedule:** MW 0400 PM - 0529 PM

Instructor Permissions: None **Enrollment Cap:** n/a

We are in the big data era and data systems sit in the critical path of everything we do. We are going through major transformations in businesses, sciences, as well as everyday life - collecting and analyzing data changes everything and data systems provide the means to store and analyze a massive amount of data. This course is a comprehensive introduction to modern data systems. The primary focus of the course is on the modern trends that are shaping the data management industry right now: column-store and hybrid systems, shared nothing architectures, cache conscious algorithms, hardware/software co-design, main-memory systems, adaptive indexing, stream processing, scientific data management, and key-value stores. We also study the history of data systems, traditional and seminal concepts and ideas

such as the relational model, row-store database systems, optimization, indexing, concurrency control, recovery and SQL. In this way, we discuss both how and why data systems evolved over the years, as well as how these concepts apply today and how data systems might evolve in the future. We focus on understanding concepts and trends rather than specific techniques that will soon be outdated - as such the class relies largely on recent research material and on a semi-flipped class model with a lot of hands-on interaction in each class.

Recommended Prep: **Computer Science 51 and Computer Science 61.**

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	For Undergraduate and Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 171

Visualization (124364)

Johanna Beyer

2017 Fall (4 Credits) **Schedule:** TR 0230 PM - 0359 PM

Instructor Permissions: Instructor **Enrollment Cap:** 70

An introduction to key design principles and techniques for visualizing data. Covers design practices, data and image models, visual perception, interaction principles, visualization tools, and applications. Introduces programming of web-based interactive visualizations.

Course Notes: **This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning.**

Recommended Prep: **Students are expected to have basic programming experience (e.g., Computer Science 50).**

Additional Course Attributes:

Attribute	Value(s)
FAS: Core Curriculum	Quantitative Reasoning
GSD: MDS/MDE Rec. Elec.	MDE recommended elective
FAS: General Education	Empirical and Mathematical Reasoning
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 175

Computer Graphics (113410)

Steven Gortler

2017 Fall (4 Credits) **Schedule:** MW 0100 PM - 0229 PM

Instructor Permissions: None **Enrollment Cap:** n/a

This course covers the fundamentals of 3D computer graphics using a modern shader-based version of OpenGL. Main topics include: geometric coordinate systems and transformations, keyframe animation and

interpolation, camera simulation, triangle rasterization, material simulation, texture mapping, image sampling and color theory. The course also touches on ray tracing, geometric modeling and simulation-based animation.

Recommended Prep: **Computer Science 51 or 61, Applied Mathematics 21b or Mathematics 21b.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 179

Design of Useful and Usable Interactive Systems (123971)

Krzysztof Gajos

2018 Spring (4 Credits) **Schedule:** TR 0230 PM - 0359 PM

Instructor Permissions: Instructor **Enrollment Cap:** 60

The course covers skills and techniques necessary to design innovative interactive products that are useful, usable and that address important needs of people other than yourself. You will learn how to uncover needs that your customers cannot even articulate. You will also learn a range of design principles, effective creativity-related practices, and techniques for rapidly creating and evaluating product prototypes. You will also have several opportunities to formally communicate your design ideas to a variety of audiences. You will complete two large team-based design projects.

Recommended Prep: **CS 50 or web programming experience.**

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	For Undergraduate and Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration
GSD: MDS/MDE Rec. Elec.	MDE recommended elective
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 181

Machine Learning (148156)

Finale Doshi-Velez

2018 Spring (4 Credits) **Schedule:** MW 0900 AM - 1029 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Introduction to machine learning, providing a probabilistic view on artificial intelligence and reasoning under uncertainty. Topics include: supervised learning, ensemble methods and boosting, neural networks, support vector machines, kernel methods, clustering and unsupervised learning, maximum likelihood, graphical models, hidden Markov models, inference methods, and computational learning theory. Students should feel comfortable with multivariate calculus, linear algebra, probability theory, and complexity theory. Students will be required to produce non-trivial programs in Python.

Recommended Prep: **Computer Science 51, Statistics 110, Math 21a and 21b (or equivalent).**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
GSD: MDS/MDE Rec. Elec.	MDE recommended elective

Computer Science 182

Artificial Intelligence (110661)

Scott Kuindersma

2017 Fall (4 Credits) **Schedule:** TR 0100 PM - 0229 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Artificial Intelligence (AI) is an exciting field that has enabled a wide range of cutting-edge technology, from driverless cars to grandmaster-beating Go programs. The goal of this course is to introduce the ideas and techniques underlying the design of intelligent computer systems. Topics covered in this course are broadly be divided into 1) planning and search algorithms, 2) probabilistic reasoning and representations, and 3) machine learning (although, as you will see, it is impossible to separate these ideas so neatly). Within each area, the course will also present practical AI algorithms being used in the wild and, in some cases, explore the relationship to state-of-the-art techniques. The class will include lectures connecting the models and algorithms we discuss to applications in robotics, computer vision, and speech processing.

Course Notes: **Formerly Intelligent Machines: Reasoning, Actions, and Plans**

Recommended Prep: **CS 51; Stat 110 (may be taken concurrently).**

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students

Computer Science 189

Autonomous Robot Systems (127551)

Radhika Nagpal

2018 Spring (4 Credits) **Schedule:** F 0100 PM - 0359 PM

Instructor Permissions: Instructor **Enrollment Cap:** 20

Building autonomous robotic systems requires understanding how to make robots that observe, reason, and act. Each component uses many engineering principles: how to fuse, multiple, noisy sensors; how to balance short-term versus long-term goals; how to control one's actions and how to coordinate with others. This year theme will be "Robots Roam the Halls", where we will focus on kinect-based robots that move in the SEAS buildings, to do applications like navigating, map building, and interacting with people. The class format will have a mixed lecture and lab format, and have a final project component.

Recommended Prep: **The only prerequisites are CS51 or CS61, or experience with programming and using APIs. This class is appropriate for CS, EE, and**

ME students interested in robotics.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 191

Classics of Computer Science (204964)

Harry Lewis

2018 Spring (4 Credits) **Schedule:** MW 0900 AM - 1029 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Papers every computer scientist should have read, from all areas of the field and dating from its origins to the present.

Recommended Prep: **Intended for juniors and seniors in CS who have taken at least one 100 level course in Computer Science. Open to students from other concentrations who have the same background.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Undergraduate Students

Computer Science 205

Computing Foundations for Computational Science (128104)

Ignacio Martin Llorente

David Sondak

2018 Spring (4 Credits) **Schedule:** TR 0230 PM - 0359 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Computational science has become a third partner, together with theory and experimentation, in advancing scientific knowledge and practice, and an essential tool for product and process development and manufacturing in industry. Big data science adds the 'fourth pillar' to scientific advancements, providing the methods and algorithms to extract knowledge or insights from data.
The course is a journey into the foundations of Parallel Computing at the intersection of computational and big data sciences. This is an applications course highlighting the use of modern computing platforms in solving computational and data science problems, enabling simulation, modelling and real-time analysis of complex natural and social phenomena at unprecedented scales. The class emphasizes on making effective use of the diverse landscape of programming models, platforms, open-source tools and computing architectures for high performance computing and big data.

Recommended Prep: **Students are expected to have programming experience (e.g., CS50/51, fluent in Python, C/C++, or similar). Course will be taught primarily in Python and C.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 207

Systems Development for Computational Science (128105)

David Sondak

2017 Fall (4 Credits) **Schedule:** MW 1130 AM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

This is a project-based course emphasizing designing, building, testing, maintaining and modifying software for scientific computing. Students will work in groups on a number of projects, ranging from small data-transformation utilities to large-scale systems. Students will learn to use a variety of tools and languages, as well as various techniques for organizing teams. Most important, students will learn to fit tools and approaches to the problem being solved.

Recommended Prep: **Students are expected to have basic programming experience (Computer Science 50).**

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 221

Computational Complexity (111993)

Madhu Sudan

2018 Spring (4 Credits) **Schedule:** TR 0100 PM - 0229 PM

Instructor Permissions: None **Enrollment Cap:** n/a

A quantitative theory of the resources needed for computing and the impediments to efficient computation. The models of computation considered include ones that are finite or infinite, deterministic, randomized, quantum or nondeterministic, discrete or algebraic, sequential or parallel.

Recommended Prep: **Computer Science 121 or equivalent.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 226

Sketching Algorithms for Big Data (205311)

Jelani Nelson

2017 Fall (4 Credits) **Schedule:** TR 0230 PM - 0359 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Big data is data so large that it does not fit in the main memory of a single machine. The need to process big data by space-efficient algorithms arises in Internet search, machine learning, network traffic monitoring, scientific computing, signal processing, and other areas. This course will cover mathematically rigorous models for developing such algorithms, as well as some provable limitations of algorithms operating in those models. Some topics covered include streaming algorithms, dimensionality reduction and sketching, randomized algorithms for numerical linear algebra, sparse recovery and the sparse Fourier transform. The course will also cover some applications of these methods.

Recommended Prep: **CS 124; knowledge of discrete probability and linear algebra.**

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 227R

Cryptography (114490)

Boaz Barak

2018 Spring (4 Credits) **Schedule:** TR 1000 AM - 1129 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Cryptography is as old as human communication itself, but has undergone a revolution in the last few decades. It is now about much more than "secret writing" and includes seemingly paradoxical notions such as communicating securely without a shared secret, and computing on encrypted data. In this challenging but rewarding course we will start from the basics of private and public key cryptography and go all the way up to advanced notions such as fully homomorphic encryption and software obfuscation. This is a proof-based course that will be best appreciated by mathematically mature students.

Course Notes: **This course will be offered in both an undergraduate and graduate versions. The graduate version will involve an additional project.**

Recommended Prep: **Comfort with mathematical proofs at the level of CS121, CS124 or similar. Please contact the instructor if you're unsure if your background is sufficient.**

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 228

Computational Learning Theory (113296)

Leslie Valiant

2018 Spring (4 Credits) **Schedule:** TR 0230 PM - 0359 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Possibilities of and limitations to performing learning by computational agents. Topics include computational models, polynomial time learnability, learning from examples and learning from queries to oracles. Applications to Boolean functions, automata and geometric functions.

Recommended Prep: **Computer Science 121 or equivalent.**

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 229R

Topics in Theoretical Computer Science : Arithmetic Circuits (120237)

Mrinal Kumar

2017 Fall (4 Credits) **Schedule:** F 1000 AM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

The goal of this course is to provide an introduction to the area of Arithmetic Circuit Complexity and to try and get a sense of the power and limitations of arithmetic circuits as a computational model. We hope to see a combination of both classical and recent results in this area, including some upper bounds, lower bounds and questions about factoring and derandomization.

A more detailed description of the course, and tentative content can be found at https://mrinalkr.bitbucket.io/arithmeticcktsF17.html

Recommended Prep: **CS 121/124/125 or equivalents.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Graduate Students

Computer Science 234R

Topics on Computation in Networks and Crowds (109667)

Nicole Immorlica

2017 Fall (4 Credits) **Schedule:** F 0900 AM - 1159 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Topics on the design and analysis of algorithms, processes, and systems related to crowds and social

networks. Readings in AI, theoretical CS, machine learning, social science theory, economic theory, and operations research.

Recommended Prep: **Mathematics 21b, Applied Mathematics 21b, or equivalent; Computer Science 124, and 181 or 182, or equivalents; or permission of instructor.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 236R

Topics at the Interface between Computer Science and Economics (116531)

Yiling Chen

2018 Spring (4 Credits) **Schedule:** MW 0100 PM - 0229 PM

Instructor Permissions: Instructor **Enrollment Cap:** 20

Interplay between computation and economics. Topics in electronic commerce, computational social choice, computational mechanism design, peer production, prediction markets and reputation systems. Readings in AI, theoretical CS, multi-agent systems, economic theory, and operations research.

Recommended Prep: **Mathematics 21b, Applied Mathematics 21b, or equivalent; Economics 1011a, or equivalent; or permission of instructor.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Graduate Students

Computer Science 244R

Networks Design Projects (112631)

H. Kung

Minlan Yu

2018 Spring (4 Credits) **Schedule:** MW 0230 PM - 0359 PM

Instructor Permissions: None **Enrollment Cap:** n/a

The contents and course requirements are similar to those of Computer Science 144r, with the exception that students enrolled in Computer Science 244r are expected to do substantial system implementation and perform graduate-level work.

As networking technologies advance, networks and their applications can operate more and more by themselves without help. For example, based on blockchains, we can develop autonomous systems that will provide forever-improving peer-to-peer services. More specifically, with proper incentives provided to participants to contribute, the network will continue to improve over time. In this course, we will study core network-related technologies whose interplay will be responsible for these autonomous systems of

the future, which range from the Internet of Things (IoT) to decentralized autonomous organizations. These technologies include blockchains, machine learning, IoT, datacenter networking, video-analytics over heterogeneous networks, mobile computing, and homomorphic encryption for cloud computing. We will first review these core technologies. Following this, we will illustrate novel autonomous applications such as peer-to-peer business models for machine learning systems, including the models themselves and the data on which they operate. Another application example will be the distributed classification of security attacks, including designing incentives to encourage collaboration in mitigating attacks. Students will work in pairs on projects related to autonomous technologies and business model experimentation.

Course Notes: **Preference given to upper-class undergraduates or graduate students in computer science or in business who are proficient in computer programming or in business software.**

Recommended Prep: **Programming experience (CS 50 should be fine) and interest in the subject matter. Importantly, CS 143 is NOT a prerequisite. Labs and extra support will provide intensive preparation in the first weeks of the semester to help students quickly obtain the networking background necessary to excel in the course.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Graduate Students

Computer Science 248

Advanced Design of VLSI Circuits and Systems (121984)

Gu-Yeon Wei

2018 Spring (4 Credits) **Schedule:** TR 1130 AM - 1259 PM

Instructor Permissions: Instructor **Enrollment Cap:** 16

The contents and course requirements are similar to those of Computer Science 148, with the exception that students enrolled in Computer Science 248 are expected to do a substantial design project and paper discussions on advanced topics.

Course Notes: **Offered in alternate years.**

Recommended Prep: **Computer Science 141 or permission of instructor.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Graduate Students
FAS: Final Assessment Category	Three-hour Exam

Computer Science 252R

Advanced Topics in Programming Languages (114807)

Stephen Chong

2017 Fall (4 Credits) **Schedule:** MW 1130 AM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Seminar course exploring recent research in programming languages. Topics vary from year to year. Students read and present research papers, undertake a research project.

Recommended Prep: **Computer Science 152 or permission of the instructor.**

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Graduate Students

Computer Science 262

Introduction to Distributed Computing (122813)

James Waldo

2018 Spring (4 Credits) **Schedule:** MW 1130 AM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

An examination of the special problems associated with distributed computing such as partial failure, lack of global knowledge, asynchrony and coordination of time, and protocols that function in the face of these problems. Emphasis on both the theory that grounds thinking about these systems and in the ways to design and build such systems.

Recommended Prep: **Computer Science 161 or permission of instructor.**

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 263

Systems Security (160579)

James Mickens

2017 Fall (4 Credits) **Schedule:** TR 0100 PM - 0229 PM

Instructor Permissions: None **Enrollment Cap:** n/a

This course explores practical attacks on modern computer systems, explaining how those attacks can be mitigated using careful system design and the judicious application of cryptography. The course discusses topics like buffer overflows, web security, information flow control, and anonymous communication mechanisms such as Tor. The course includes several small projects which give students hands-on experience with various offensive and defensive techniques; the final, larger project is open-ended and driven by student interests.

Recommended Prep: **Computer Science 161 (Operating Systems)**

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 265

Big Data Systems (113660)

Stratos Idreos

2018 Spring (4 Credits) **Schedule:** WF 0400 PM - 0529 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Big data is everywhere. A fundamental goal across numerous modern businesses and sciences is to be able to exploit as many machines as possible, to consume as much information as possible and as fast as possible. The big challenge is "how to turn data into useful knowledge". This is far from a simple task and a moving target as both the underlying hardware and our ability to collect data evolve. In this class, we will discuss how to design data systems and algorithms that can "scale up" and "scale out". Scale up refers to the ability to use a single machine to all its potential, i.e., to exploit properly the memory hierarchy and the multiple CPU and GPU cores. Scale out refers to the ability to use more than 1 machines (typically 100s or 1000s) effectively. This is a research oriented class. Every week we will read two modern research papers; one from the scale up area and one from the scale out area. We will use examples from several areas, including relational systems and distributed databases, graph processing systems (i.e., for social networks), key value stores, noSQL and newSQL systems as well as mobile computing. Each student will work on a semester long data systems research project (in groups of 2-4 students) which can be in any of the above areas and will be based on an open research problem.

Recommended Prep: **CS 165 or permission of instructor.**

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 279

Research Topics in Human-Computer Interaction (121985)

Krzysztof Gajos

2017 Fall (4 Credits) **Schedule:** TR 1000 AM - 1129 AM

Instructor Permissions: Instructor **Enrollment Cap:** n/a

The course covers major areas of inquiry and core research methods in Human-Computer Interaction including experimental design, statistical data analysis, and qualitative methods. Activities will include discussion of primary literature, a small number of lectures, assignments (design, execution and analysis of both lab-based and on-line experiments), and a research project. Special focus this year is on social computing and crowd-powered systems. Specifically, we will look at the design and analysis of systems, in which crowds of intrinsically motivated volunteers contribute to meaningful and non-trivial human computation tasks as a byproduct of doing something that they are motivated to do anyway.

Course Notes: **Designed for first year grads from all areas. Advanced undergraduates welcome, particularly those who wish to do research (or write a thesis) in an area related to Human-Computer Interaction.**

Recommended Prep: **None for graduate students; for undergrads CS 179 or CS 171 is strongly recommended and permission of the instructor is required. Basic web hacking is required to implement and deploy web-based experiments.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
GSD: MDS/MDE Rec. Elec.	MDE recommended elective
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 281

Advanced Machine Learning (107677)

Alexander Rush

2017 Fall (4 Credits) **Schedule:** MW 0100 PM - 0229 PM

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Advanced statistical machine learning and probabilistic data analysis. Topics include: Variational inference, graphical models, deep learning, text modeling, unsupervised learning, dimensionality reduction and visualization. Requires a major final project.

Recommended Prep: **Students should feel comfortable with linear algebra and probability theory. Students will be expected to implement algorithms in Python.**

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Graduate Students

Computer Science 282R

Topics in Machine Learning: Robust Machine Learning (156936)

Yaron Singer

2018 Spring (4 Credits) **Schedule:** R 0900 AM - 1159 AM

Instructor Permissions: Instructor **Enrollment Cap:** 20

This is a graduate-level seminar course on robust machine learning. In recent years, advances in machine learning have brought forth unprecedented progress in artificial intelligence and predictive data analytics. Despite the empirical success of recent machine learning methods however, there is a growing concern regarding their sensitivity to noise and general instability. The goal of this course is to explore novel techniques that can lead to advances in seemingly unrelated areas of machine learning. These areas include robust classification, stable clustering, as well as reliable network analysis techniques.

Recommended Prep: **Students are expected to be fluent in basic linear algebra (matrix**

manipulation), basic statistics (e.g. rules of expectations, importance sampling), algorithms (e.g. dynamic programming), and software engineering/numerical computing (e.g. programming in Python and numpy, working with data with 100,000+ rows).

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 282R

Topics in Machine Learning: Reinforcement Learning for Healthcare (156936)

Finale Doshi-Velez

2017 Fall (4 Credits) **Schedule:** MW 0900 AM - 1029 AM

Instructor Permissions: Instructor **Enrollment Cap:** 20

Sequential decision making is at the core of many healthcare problems: a clinician observes a patient, determines a treatment, and based on the response and the patient's previous history, determines what to try next. Reinforcement learning is a formal framework for thinking about such problems. This course will first cover the fundamentals of reinforcement learning through lectures, readings, and coding assignments. Topics will include Markov decision process and partially observable Markov decision processes, planning under uncertainty, model-free and model-based reinforcement learning, function approximation in reinforcement learning, and batch reinforcement learning. Students will also engage in a semester-long project applying these techniques to clinical decision making in intensive care units.

Recommended Prep: **Students are expected to be fluent in basic linear algebra (matrix manipulation), basic statistics (e.g. rules of expectations, importance sampling), algorithms (e.g. dynamic programming), and software engineering/numerical computing (e.g. programming in Python and numpy, working with data with 100,000+ rows).**

Additional Course Attributes:

Attribute	Value(s)
GSD: MDS/MDE Rec. Elec.	MDE recommended elective
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Graduate Students

Computer Science 283

Computer Vision (113944)

Todd Zickler

2017 Fall (4 Credits) **Schedule:** TR 1130 AM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Vision as an ill-posed inverse problem: image formation, two-dimensional signal processing; feature analysis; image segmentation; color, texture, and shading; multiple-view geometry; object and scene recognition; and applications.

Course Notes: **Offered jointly with the Design School as SCI-06275.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
GSD: MDS/MDE Rec. Elec.	MDE recommended elective
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 284

Optimization Algorithms for Robotics (160954)

Scott Kuindersma

2018 Spring (4 Credits) **Schedule:** TR 0230 PM - 0359 PM

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Numerical methods have revolutionized the way we control dynamic motions in complex robots. In this course, we study a variety of optimization algorithms for designing and stabilizing trajectories for walking, manipulating, and flying systems. Topics will include optimal control, nonlinear programming, trajectory planning and stabilization, model-predictive control, Lyapunov analysis via sums-of-squares programming, legged systems, and estimation and control through frictional contact. Students will gain practical experience implementing modern algorithms to control a variety of simulated systems using the Drake MATLAB software toolbox.

Recommended Prep: **Linear algebra and multivariable calculus. Prior exposure to robotics and dynamics is helpful, but not required. Students will be expected to complete significant programming assignments in MATLAB.**

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Graduate Students

Computer Science 287R

Machine Learning for Natural Language (112867)

Alexander Rush

2018 Spring (4 Credits) **Schedule:** TR 0100 PM - 0229 PM

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Machine learning for natural language processing, with a focus on supervised deep learning methods based on recurrent neural networks. Topics include language modelling, information extraction, question answering, text generation, and machine translation. Requires comfort with reading ML research papers and completion of a major final project.

Recommended Prep: **CS 181 required. Students will be expected to implement algorithms in Python.**

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 289

Biologically-inspired Multi-agent Systems (120238)

Radhika Nagpal

2017 Fall (4 Credits) **Schedule:** TR 1130 AM - 1259 PM

Instructor Permissions: Instructor **Enrollment Cap:** 20

Surveys biologically-inspired approaches to designing distributed systems. Focus is on algorithms, analysis, and programming paradigms. Topics: swarm intelligence, amorphous computing, immune-inspired systems, synthetic biology. Discussion of research papers and a research project required.

Course Notes: **Geared toward graduate students of all levels as well as advanced undergraduates. Preference given to graduate students or upper-level concentrators.**

Recommended Prep: **Experience with algorithms (e.g. Computer Science 124) and programming (e.g. Computer Science 51).**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Graduate Students

Computer Science 290HFA

Computer Science Research Seminar (204012)

Stuart Shieber

2017 Fall (2 Credits) **Schedule:** M 0400 PM - 0459 PM
R 0400 PM - 0529 PM

Instructor Permissions: Instructor **Enrollment Cap:** n/a

This course introduces first year Computer Science PhD students to the CS colloquium series. Required for G1 PhDs in CS.

Course Notes: **Limited to CS PhD G1 students only. Instructor permission required.**

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Graduate Students
Full Year Course	Indivisible Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 290HFB

Computer Science Research Seminar (204013)

Leslie Valiant

2018 Spring (2 Credits) **Schedule:** R 0400 PM - 0529 PM
M 0400 PM - 0459 PM

Instructor Permissions: Instructor **Enrollment Cap:** n/a

This course introduces first year Computer Science PhD students to the CS colloquium series. Required for G1 PhDs in CS.

Course Notes: **Limited to CS PhD G1 students only. Instructor permission required.**

Additional Course Attributes:

Attribute	Value(s)
Full Year Course	Indivisible Course
Course Search Attributes	Display Only in Course Search
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Primarily for Graduate Students

Computer Science 299R

Special Topics in Computer Science (114035)

Salil Vadhan

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: None **Enrollment Cap:** n/a

Supervision of experimental or theoretical research on acceptable computer science problems and supervision of reading on topics not covered by regular courses of instruction.

Course Notes: **Open to graduate students and AB/SM candidates only. Students must arrange such work with a member of the School of Engineering and Applied Sciences. This course is graded and is ordinarily taken with the approval of the Committee on Higher Degrees. Applicants must file a project sheet before study cards are filed. Project sheets may be obtained from the Academic Office, Pierce Hall 110.**

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 299R

Special Topics in Computer Science (114035)

Salil Vadhan

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: None **Enrollment Cap:** n/a

Supervision of experimental or theoretical research on acceptable computer science problems and supervision of reading on topics not covered by regular courses of instruction.

Course Notes: **Open to graduate students and AB/SM candidates only. Students must arrange such work with a member of the School of Engineering and Applied Sciences. This course is graded and is ordinarily taken with the approval of the Committee on Higher Degrees. Applicants must file a project sheet before study cards are filed. Project sheets may be obtained from the Academic Office, Pierce Hall 110.**

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	None

Computer Science 306

Readable, Extensible, High-Performance Software Systems (109278)

Eddie Kohler

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Computer Science 306

Readable, Extensible, High-Performance Software Systems (109278)

Eddie Kohler

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course

Computer Science 308

Biologically-Inspired Multi-Agent Systems, Distributed Systems, and Computational Biology (119252)

Radhika Nagpal

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Computer Science 308

Biologically-Inspired Multi-Agent Systems, Distributed Systems, and Computational Biology (119252)

Radhika Nagpal

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 310

Computational Mechanism Design, Electronic Marketplaces, and Multi-Agent Systems (116301)

David Parkes

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course

Computer Science 310

Computational Mechanism Design, Electronic Marketplaces, and Multi-Agent Systems (116301)

David Parkes

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Computer Science 312

Collaborative Systems, AI Planning, and Natural Language Processing (143299)

Barbara Grosz

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Computer Science 312

Collaborative Systems, AI Planning, and Natural Language Processing (143299)

Barbara Grosz

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Computer Science 314

Visual Computing (124155)

Hanspeter Pfister

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Computer Science 314

Visual Computing (124155)

Hanspeter Pfister

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Computer Science 316

Social Computing: Computation and Economics (125388)

Yiling Chen

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Computer Science 316

Social Computing: Computation and Economics (125388)

Yiling Chen

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 320

Data Systems Design (156744)

Stratos Idreos

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Computer Science 320

Data Systems Design (156744)

Stratos Idreos

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course

Computer Science 322

Databases, Operating System, and Software Design (113643)

Margo Seltzer

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Computer Science 322

Databases, Operating System, and Software Design (113643)

Margo Seltzer

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 324

Human-Computer Communication through Natural, Graphical, and Artificial Languages (111666)

Stuart Shieber

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Computer Science 324

Human-Computer Communication through Natural, Graphical, and Artificial Languages (111666)

Stuart Shieber

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course

Computer Science 326

Intelligent Interactive Systems and Human-Computer (126331)

Krzysztof Gajos

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Computer Science 326

Intelligent Interactive Systems and Human-Computer (126331)

Krzysztof Gajos

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 327

Tools for Reliable Meaningful Efficient Communication (160962)

Madhu Sudan

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Computer Science 327

Tools for Reliable Meaningful Efficient Communication (160962)

Madhu Sudan

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Computer Science 328

Mathematical Logic, Theory of Computation (133437)

Harry Lewis

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Computer Science 328

Mathematical Logic, Theory of Computation (133437)

Harry Lewis

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Computer Science 335

Complexity, Algorithms, Cryptography, and Convex Programming (206566)

Boaz Barak

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 335

Complexity, Algorithms, Cryptography, and Convex Programming (206566)

Boaz Barak

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 344

Computer Architecture: Modeling and Design (116858)

David Brooks

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Computer Science 344

Computer Architecture: Modeling and Design (116858)

David Brooks

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course

Computer Science 346

High-Performance Computer Systems (117841)

Michael Smith

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Computer Science 346

High-Performance Computer Systems (117841)

Michael Smith

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course

Computer Science 348

Computer Vision (120091)

Todd Zickler

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 348

Computer Vision (120091)

Todd Zickler

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Computer Science 356

Computational Complexity, Parallel Computation, Computational Learning, Neural Computation (113027)

Leslie Valiant

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Computer Science 356

Computational Complexity, Parallel Computation, Computational Learning, Neural Computation (113027)

Leslie Valiant

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Computer Science 358

Computational Complexity, Cryptography, and Pseudorandomness (115136)

Salil Vadhan

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Computer Science 358

Computational Complexity, Cryptography, and Pseudorandomness (115136)

Salil Vadhan

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course

Computer Science 360

On-line Algorithms and Randomized Algorithms (109883)

Michael Mitzenmacher

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 360

On-line Algorithms and Randomized Algorithms (109883)

Michael Mitzenmacher

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Computer Science 362

Software Systems: Security, Performance, and Robustness (160959)

James Mickens

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 362

Software Systems: Security, Performance, and Robustness (160959)

James Mickens

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Computer Science 364

Programming Languages and Security (126329)

Stephen Chong

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 364

Programming Languages and Security (126329)

Stephen Chong

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Computer Science 365

SEAS Teaching Practicum (125374)

John Girash

2017 Fall (4 Credits) **Schedule:** W 0230 PM - 0429 PM

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Practicum emphasizing an active but reflective approach to teaching applied sciences and engineering; there is nothing in the course that is specific to Computer Science. Topics: presentation and communication; in-class teaching and interaction; developing, grading and giving feedback on assignments; course head / TF relations and expectations; cognition and learning. Seminar style with an emphasis on observation, practice, feedback, discussion, and reflection. While the primary context of the course is classroom-style teaching, those interested in developing instructional communication skills in other contexts within science and engineering -- labs/studios, presentations, etc. -- are quite welcome, and course tasks can be adjusted for such.

Course Notes: **Unlike most 300-level courses at SEAS, this is a class with a regular meeting time and some assignments. Graduate students from all science and engineering fields within Harvard are welcome. Postdocs and motivated undergraduates may audit, doing the same work as enrolled graduate students.**

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course

Computer Science 372

Topics in Theory for Society (204561)

Cynthia Dwork

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Not Available for Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Graduate Course

Computer Science 372

Topics in Theory for Society (204561)

Cynthia Dwork

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration

FAS: Course Level	Graduate Course
FAS Divisional Distribution	Science & Engineering & Applied Science

Computer Science 376

Computer Graphics (121071)

Steven Gortler

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 376

Computer Graphics (121071)

Steven Gortler

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 378

Sketching Algorithms for Massive Data (110261)

Jelani Nelson

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 378

Sketching Algorithms for Massive Data (110261)

Jelani Nelson

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 380

Algorithms for Social Data (110263)

Yaron Singer

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course

Computer Science 380

Algorithms for Social Data (110263)

Yaron Singer

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 382

Natural Language Understanding and Generation (160961)

Alexander Rush

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course

Computer Science 382

Natural Language Understanding and Generation (160961)

Alexander Rush

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 384

Advanced Control, Estimation, and Analysis of Robots and Dynamical Systems (160963)

Scott Kuindersma

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 384

Advanced Control, Estimation, and Analysis of Robots and Dynamical Systems (160963)

Scott Kuindersma

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Computer Science 386

Machine Learning (160970)

Finale Doshi-Velez

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Computer Science 386

Machine Learning (160970)

Finale Doshi-Velez

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course