# Computer Science

## Subject: Computer Science

### Computer Science 1

Great Ideas in Computer Science (119953)

*Henry Leitner*

2021 Spring (4 Credits) **Schedule:** TR 1030 AM - 1145 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 and data analysis using the Python programming language; presents an integrated view of computer systems, from switching circuits up through compilers and object-oriented 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, algorithmic bias, and invasions of privacy.**

**Course Notes:** **May not be taken for credit after completing Computer Science 50.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| Local offset from Cambridge MA | +10 +11 |
| Local offset from Cambridge MA | +9:45 |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| Local offset from Cambridge MA | +7 |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| Local offset from Cambridge MA | +8 +9 |
| FAS: Course Level | Primarily for Undergraduate Students |
| FAS Course Roll | FAS Course Roll |

### Computer Science 10

Elements of Data Science (212950)

*Hanspeter Pfister*

*Liberty Vittert*

2021 Spring (4 Credits) **Schedule:** TR 0130 PM - 0245 PM

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

**Data science combines data, statistical analysis, and computation to gain insights and make useful inferences and predictions. This course will take a holistic approach to helping students understand the key factors involved, from data collection and exploratory data analysis to modeling, evaluation, and communication of results. Working on case studies and a final project in teams will provide students with hands-on experience with the data science process using state-of-the-art tools. Emphasis will be given to the strengths, trade-offs, and limitations of each method to highlight the importance of merging analytical skills with critical quantitative thinking.**

**Course Notes:** **Also offered as STAT 10. Students may not take both for credit.**

**Please note that the enrollment cap of 60 is a combined total for both**

**STAT 10 and COMPSCI 10.**

**Requirements:** **Anti-requisite: Cannot be taken for credit if AC 209A or CS 109A or STAT10 or STAT 121A is already complete.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS: Course Level | Primarily for Undergraduate Students |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| Local offset from Cambridge MA | -6 |
| Local offset from Cambridge MA | +7 |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| Quantitative Reasoning with Data | Yes |
| FAS Course Roll | FAS Course Roll |

## Computer Science 20

Discrete Mathematics for Computer Science (128073)

*Rebecca Nesson*

2021 Spring (4 Credits) **Schedule:** MWF 1030 AM - 1145 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.**

**Class Notes:** **Students in other time zones or with scheduling conflicts will be allowed to attend the Harvard Extension School evening sessions, T/Th 7:20pm-9:20pm.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS Course Roll | FAS Course Roll |
| FAS: Course Level | Primarily for Undergraduate Students |
| Local offset from Cambridge MA | +9:45 |
| Local offset from Cambridge MA | +10 +11 |
| FAS: Live Shopping Event | Live Shopping Event |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| Local offset from Cambridge MA | +8 +9 |
| Local offset from Cambridge MA | +7 |

## Computer Science 50

Introduction to Computer Science (152514)

*David Malan*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Introduction to the intellectual enterprises of computer science and the art of programming. This course teaches students how to think algorithmically and solve problems efficiently. Topics include abstraction, algorithms, data structures, encapsulation, resource management, security, software engineering, and web programming. Languages include C, Python, and SQL plus HTML, CSS, and JavaScript. Problem sets inspired by the arts, humanities, social sciences, and sciences. Course culminates in a final project. Designed for concentrators and non-concentrators alike, with or without prior programming experience. Two thirds of CS50 students have never taken CS before. Among the overarching goals of this course are to inspire students to explore unfamiliar waters, without fear of failure, create an intensive, shared experience, accessible to all students, and build community among students.**

**Class Notes:** **This course ordinarily meets for lectures via Zoom on Mondays at 1:30pm–4:15pm, but the course's first lecture will be Wednesday, 9/2/20. Students may simultaneously enroll in CS50 and another course that meets at the same time, watching recordings of CS50's lectures and attending the other course via Zoom. The Ad Board has already granted this exception for CS50; no other steps are required. CS50 is ordinarily graded SAT/UNS, though students whose concentration requires letter grades should change their grading status to letter-graded by the term's fifth Monday. Students may take CS50 SAT/UNS to fulfill the Science and Engineering and Applied Science distribution requirement or the Quantitative Reasoning with Data requirement, but not both. First years may take both CS50 and a freshman seminar SAT/UNS. Graduate students are welcome to cross-register for CS50. All students are expected to attend an orientation meeting via Zoom during the second week of term; students with conflicts may watch a recording thereof. Required sections via Zoom to be arranged. See cs50.harvard.edu for FAQs, syllabus, and what's new for Fall 2020.**

**Class Notes:**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| GSD: Required Course | Required by MDE program |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| FAS: Course Level | For Undergraduate and Graduate Students |
| FAS Course Roll | FAS Course Roll |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| Quantitative Reasoning with Data | Yes |

## Computer Science 50

Introduction to Computer Science (152514)

*David Malan*

*Brian Yu*

2021 Spring (4 Credits) **Schedule:** T 0300 PM - 0545 PM

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

**Introduction to the intellectual enterprises of computer science and the art of programming. This course teaches students how to think algorithmically and solve problems efficiently. Topics include abstraction, algorithms, data structures, encapsulation, resource management, security, software engineering, and web programming. Languages include C, Python, and SQL plus HTML, CSS, and JavaScript. Problem sets**

**inspired by the arts, humanities, social sciences, and sciences. Course culminates in a final project.**

**Class Notes:** **This spring version of CS50 is for SEAS concentrators (or secondaries) who were unable to take the course in Fall 2020. Enrollment limited; apply at cs50.harvard.edu/petition. All students, including concentrators and non-concentrators, are encouraged to take CS50 in fall term instead. See cs50.harvard.edu/spring for differences between fall term and spring term. Students must register via my.harvard.edu for and attend weekly class meetings via Zoom on Tuesdays, 3pm–5pm ET. Instructor-led tutorials to be arranged. CS50 is ordinarily graded SAT/UNS, though students whose concentration requires letter grades should change their grading status to letter-graded by the term's fifth Monday. Students may take CS50 SAT/UNS to fulfill the Science and Engineering and Applied Science distribution requirement or the Quantitative Reasoning with Data requirement, but not both. First years may take both CS50 and a freshman seminar SAT/UNS.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS: Course Level | For Undergraduate and Graduate Students |
| Quantitative Reasoning with Data | Yes |
| Local offset from Cambridge MA | -6 |
| Local offset from Cambridge MA | +17 |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| FAS Course Roll | FAS Course Roll |

## Computer Science 51

Abstraction and Design in Computation (112960)

*Stuart Shieber*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Fundamental concepts in the design of computer programs, emphasizing the crucial role of abstraction. The goal of the course is to give students insight into the difference between programming and programming well. To emphasize the differing approaches to expressing programming solutions, you will learn to program in a variety of paradigms -- including functional, imperative, and object-oriented. Important ideas from software engineering and models of computation will inform these different views of programming.**

**Class Notes:** **Times: All times shown are Eastern Standard Time**

**Lectures: January 26 and 28, March 9, April 20 and 27 at 10:30–11:45am, via Zoom.**

**Labs: All other Tuesdays and Thursdays during the term in one of two slots – 10:30–11:45am and 4:30–5:45pm – via Zoom.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Divisional Distribution | Science & Engineering & Applied Science |

| | |
|---|---|
| GSD: MDS/MDE Rec. Elec. | MDE approved SEAS 100 level course |
| FAS Course Roll | FAS Course Roll |
| FAS: Course Level | Primarily for Undergraduate Students |
| All: Cross Reg Availability | Available for Harvard Cross Registration |

## Computer Science 61

Systems Programming and Machine Organization (123623)

*Eddie Kohler*

*Minlan Yu*

2020 Fall (4 Credits) **Schedule:** TBD

**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) |
|---|---|
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| FAS: Course Level | Primarily for Undergraduate Students |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS Course Roll | FAS Course Roll |

## Computer Science 91R

Supervised Reading and Research (113257)

*Boaz Barak*

*Stephen Chong*

*Adam Hesterberg*

2021 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. Additional information and a form are available via https://harvardcs.info/forms/#cs-91r-form. The form 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 |

| | |
|---|---|
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS: Course Level | Primarily for Undergraduate Students |
| FAS Course Roll | FAS Course Roll |
| Course Evaluation | Course Evaluation exempt |

## Computer Science 91R

Supervised Reading and Research (113257)

*Boaz Barak*

*Stephen Chong*

*Adam Hesterberg*

2020 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. Additional information and a form are available via https://harvardcs.info/forms/#cs-91r-form. The form 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 Roll | FAS Course Roll |
| Course Evaluation | Course Evaluation exempt |
| FAS: Course Level | Primarily for Undergraduate Students |
| All: Cross Reg Availability | Available for Harvard Cross Registration |

## Computer Science 96

System Design Projects (121508)

*Krzysztof Gajos*

2020 Fall (4 Credits) **Schedule:** MW 0130 PM - 0245 PM

**Instructor Permissions:** Instructor **Enrollment Cap:** 15

**Cooperative formative research, design, development, and testing of a sizable and realistic sociotechnical system, i.e., a solution to a real-world problem that includes both technical and human components. Students work as a team with a client on a real-world open-ended problem, and gain experience in Computer Science (problem definition, software development, iterative design), and in other fields relevant to the problem. Both student participation in the classroom and effective teamwork outside the classroom are stressed. The specific challenge for Fall 2020 will be announced on the course website.**

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

**Recommended Prep:** **This course is primarily intended for juniors and seniors. Students from any field of study are welcome, though some prior exposure to**

**CS is helpful.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS: Course Level | Primarily for Undergraduate Students |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| GSD: MDS/MDE Rec. Elec. | MDE approved SEAS 100 level course |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS Course Roll | FAS Course Roll |

## Computer Science 105

Privacy and Technology (125407)

*James Waldo*

2020 Fall (4 Credits) **Schedule:** TR 0130 PM - 0245 PM

**Instructor Permissions:** Instructor **Enrollment Cap:** 48

**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.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| GSD: MDS/MDE Rec. Elec. | MDE approved SEAS 100 level course |
| FAS Course Roll | FAS Course Roll |
| 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 107

Systems Development for Computational Science (216324)

*David Sondak*

2020 Fall (4 Credits) **Schedule:** TR 1200 PM - 0115 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.**

**Class Notes:** **Students who previously took CS207 are not eligible to enroll in CS107 or AC207.**

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

**Additional Course Attributes:**

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

## Computer Science 109A

Data Science 1: Introduction to Data Science (109899)

*Pavlos Protopapas*

*Kevin A. Rader*

*Christopher Tanner*

2020 Fall (4 Credits) **Schedule:** MWF 0900 AM - 1015 AM

**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 |
| Quantitative Reasoning with Data | Yes |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| FAS Course Roll | FAS Course Roll |
| GSD: MDS/MDE Rec. Elec. | MDE approved SEAS 100 level course |
| Full Year Course | Divisible Course |
| FAS: Course Level | For Undergraduate and Graduate Students |

## Computer Science 109A Section: 002

Data Science 1: Introduction to Data Science (109899)

*Pavlos Protopapas*

*Kevin A. Rader*

*Christopher Tanner*

2020 Fall (4 Credits) **Schedule:** MWF 0300 PM - 0415 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) |
|---|---|
| FAS: Course Level | For Undergraduate and Graduate Students |
| Quantitative Reasoning with Data | Yes |
| Full Year Course | Divisible Course |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS Course Roll | FAS Course Roll |

## Computer Science 109B

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

*Pavlos Protopapas*

*Mark Glickman*

*Christopher Tanner*

2021 Spring (4 Credits) **Schedule:** MWF 0900 AM - 1015 AM

**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) |
|---|---|
| GSD: MDS/MDE Rec. Elec. | MDE approved SEAS 100 level course |
| Local offset from Cambridge MA | +7 |
| Full Year Course | Divisible Course |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| Local offset from Cambridge MA | +8 +9 |
| Local offset from Cambridge MA | +12 |
| Local offset from Cambridge MA | +13 |
| FAS Course Roll | FAS Course Roll |
| Local offset from Cambridge MA | +10 +11 |
| Local offset from Cambridge MA | +9:45 |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS: Course Level | For Undergraduate and Graduate Students |
| Quantitative Reasoning with Data | Yes |

## Computer Science 121

Introduction to Theoretical Computer Science (119064)

*Madhu Sudan*

*Adam Hesterberg*

2020 Fall (4 Credits) **Schedule:** TR 1030 AM - 1145 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 <a href="http://madhu.seas.harvard.edu/courses/Fall2020">http://madhu.seas.harvard.edu/courses/Fall2020</a> by July 31st. It is highly recommended that students complete it before the first lecture.**

**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 |
| FAS Course Roll | FAS Course Roll |

## Computer Science 124

Data Structures and Algorithms (115384)

*Michael Mitzenmacher*

*Adam Hesterberg*

2021 Spring (4 Credits) **Schedule:** MW 1200 PM - 0115 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:** **Students will not receive credit for both CS 124 and CS 125.**

**Recommended Prep:** **Computer Science 50 or equivalent is strongly recommended; Computer Science 20 or equivalent mathematical background, including knowledge of how to write proofs, is strongly recommended; Computer Science 51 or 61 is helpful.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| GSD: MDS/MDE Rec. Elec. | MDE approved SEAS 100 level course |
| Local offset from Cambridge MA | +7 |
| Quantitative Reasoning with Data | Yes |
| FAS: Course Level | For Undergraduate and Graduate Students |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| Local offset from Cambridge MA | +8 +9 |
| FAS Course Roll | FAS Course Roll |
| FAS: Live Shopping Event | Live Shopping Event |

## Computer Science 126

Fairness and Privacy: Perspectives of Law and Probability (204972)

*Cynthia Dwork*

*Martha Minow*

2020 Fall (4 Credits) **Schedule:** MW 0900 AM - 1015 AM

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

**Students will learn to analyze and mitigate privacy loss, overfitting, and unfairness in data analysis. Principal techniques will come from cryptography, differential privacy, and the newly emerging areas of adaptive data analysis and algorithmic fairness.**

**Class Notes:** **Course enrollment limited. Offered jointly by HLS and SEAS, with interwoven tracks emphasizing, respectively, law and computer science, the tracks will meet jointly and separately every week. Admission is by permission of instructors.**

**Recommended Prep:** **Experience with writing proofs.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| FAS Course Roll | FAS Course Roll |
| FAS: Course Level | For Undergraduate and Graduate Students |
| GSD: MDS/MDE Rec. Elec. | MDE approved SEAS 100 level course |
| All: Cross Reg Availability | Available for Harvard Cross Registration |

## Computer Science 141

Computing Hardware (113856)

*Vijay Janapa Reddi*

2021 Spring (4 Credits) **Schedule:** TR 0130 PM - 0245 PM

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

**This course introduces fundamentals in designing and building modern information devices and systems that interface with the real world. It focuses on *digital* devices and systems, and it complements ENG-SCI 152, which focuses on devices and systems that use analog electronics. Topics include: combinational and sequential logic; computer architecture; machine code; and altogether the infrastructure and computational framework composing a MIPS processor. Consideration is given in design to interactions between hardware and software systems. Students will design application specific hardware for an embedded system.**

**Recommended Prep:** **CS50 or programming experience required.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| Local offset from Cambridge MA | -6 |
| FAS Course Roll | FAS Course Roll |
| FAS: Live Shopping Event | Live Shopping Event |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| Local offset from Cambridge MA | +7 |
| GSD: MDS/MDE Rec. Elec. | MDE approved SEAS 100 level course |
| 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*

2020 Fall (4 Credits) **Schedule:** MW 0430 PM - 0545 PM

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

**Computer networking has enabled the emergence of mobile and cloud computing, creating two of the most significant technological breakthroughs in computing. Computer networks have become even more critical these days since remote activities have become a new norm. We expect several focuses in the coming years. First, we will witness the emergence of 5G wireless mobile networks, which have already begun to replace the current 4G networks. Second, cybersecurity and privacy will receive unprecedented attention from the industry. Third, blockchain technology, which underlies Bitcoin, creates a new trusted network infrastructure for many new distributed applications. Fourth, distance learning and virtual meetings will**

**push the limits of current multicast and network management technologies. In this course, students will learn basic networking protocols as well as these timely topics.**

**Class Notes:** **This course will take place remotely and use synchronized remote lectures and Zoom breakout sessions along with Piazza, Slack, and other collaboration tools. The teaching staff will hold frequent office hours.**

**Recommended Prep:** **CS50 (or programming experience) and a 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 |
| GSD: MDS/MDE Rec. Elec. | MDE approved SEAS 100 level course |
| FAS: Course Level | For Undergraduate and Graduate Students |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| FAS Course Roll | FAS Course Roll |

## Computer Science 145

Networking at Scale (208314)

*Minlan Yu*

2021 Spring (4 Credits) **Schedule:** MW 0130 PM - 0245 PM

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

**Modern networks have grown to extremely large scale (connecting millions of servers) and high speed (with Terabits per second) to meet the needs of a variety of cloud applications in business and society (e.g., social media, public health, and entertainment). In this course, we will study not only basic concepts in networking but also how these concepts get applied and extended for networking at scale. We will discuss the recent technology trends and design choices of performance, scalability, manageability, and cost faced by companies who own large-scale networks such as Amazon, Google, Microsoft, and Facebook. This course includes lectures and system programming projects. More information can be found at https://github.com/minlanyu/cs145-site.**

**Recommended Prep:** **System programming at the level of CS 61.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Course Roll | FAS Course Roll |
| Local offset from Cambridge MA | +7 |
| FAS: Course Level | For Undergraduate and Graduate Students |
| GSD: MDS/MDE Rec. Elec. | MDE approved SEAS 100 level course |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| Local offset from Cambridge MA | -6 |

## Computer Science 146

Computer Architecture (113270)

*David Brooks*

2021 Spring (4 Credits) **Schedule:** TR 0130 PM - 0245 PM

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

**Review of the fundamental structures in modern processor design. Topics include computer organization, memory system design, pipelining, and other techniques to exploit parallelism. Discussion of modern topics including GPU architectures, datacenter architecture, mobile/embedded SoC architectures, and machine learning acceleration as time permits. Emphasis on a quantitative evaluation of design alternatives and an understanding of performance and energy consumption issues.**

**Recommended Prep:** **Computer Science 61**

**Requirements:** **Prerequisite: Computer Science 141**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| Local offset from Cambridge MA | -6 |
| GSD: MDS/MDE Rec. Elec. | MDE approved SEAS 100 level course |
| FAS: Live Shopping Event | Live Shopping Event |
| FAS: Course Level | For Undergraduate and Graduate Students |
| FAS Course Roll | FAS Course Roll |
| Local offset from Cambridge MA | +7 |

## Computer Science 152

Programming Languages (119629)

*Nada Amin*

2021 Spring (4 Credits) **Schedule:** TR 0130 PM - 0245 PM

**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) |
|---|---|
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| GSD: MDS/MDE Rec. Elec. | MDE approved SEAS 100 level course |
| Local offset from Cambridge MA | -6 |
| Local offset from Cambridge MA | +7 |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| FAS Course Roll | FAS Course Roll |
| FAS: Course Level | For Undergraduate and Graduate Students |

## Computer Science 161

Operating Systems (113847)

*James Mickens*

2021 Spring (4 Credits) **Schedule:** MW 0130 PM - 0245 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 |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| GSD: MDS/MDE Rec. Elec. | MDE approved SEAS 100 level course |
| FAS Course Roll | FAS Course Roll |
| Local offset from Cambridge MA | -6 |
| Local offset from Cambridge MA | +7 |

## Computer Science 171

Visualization (124364)

*Hanspeter Pfister*

2020 Fall (4 Credits) **Schedule:** W 0900 AM - 1015 AM

**Instructor Permissions:** Instructor **Enrollment Cap:** 80

**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:** **Enrollment limited to 80 students.**

**Recommended Prep:** **Students are required to have basic programming experience (e.g., Computer Science 50). Web programming experience (HTML, CSS, JS) is a plus.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| GSD: MDS/MDE Rec. Elec. | MDE approved SEAS 100 level course |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS Course Roll | FAS Course Roll |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| FAS: Course Level | For Undergraduate and Graduate Students |

## Computer Science 171 Section: 002

Visualization (124364)

*Hanspeter Pfister*

2020 Fall (4 Credits) **Schedule:** W 0430 PM - 0545 PM

**Instructor Permissions:** Instructor **Enrollment Cap:** 80

**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:** **Enrollment limited to 80 students.**

**Recommended Prep:** **Students are required to have basic programming experience (e.g., Computer Science 50). Web programming experience (HTML, CSS, JS) is a plus.**

**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 approved SEAS 100 level course |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| FAS Course Roll | FAS Course Roll |

## Computer Science 175

Computer Graphics (113410)

*Steven Gortler*

2021 Spring (4 Credits) **Schedule:** TR 1200 PM - 0115 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 22a 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 |
| Local offset from Cambridge MA | +8 +9 |
| FAS: Live Shopping Event | Live Shopping Event |
| FAS Course Roll | FAS Course Roll |
| Local offset from Cambridge MA | +7 |

## Computer Science 179

Design of Useful and Usable Interactive Systems (123971)

*Elena Glassman*

2021 Spring (4 Credits) **Schedule:** MW 0300 PM - 0415 PM

**Instructor Permissions:** Instructor **Enrollment Cap:** 71

**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.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| Local offset from Cambridge MA | -6 |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| GSD: MDS/MDE Rec. Elec. | MDE approved SEAS 100 level course |
| FAS Course Roll | FAS Course Roll |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS: Course Level | For Undergraduate and Graduate Students |
| Local offset from Cambridge MA | +17 |

## Computer Science 181

Machine Learning (148156)

*David Parkes*

*Finale Doshi-Velez*

2021 Spring (4 Credits) **Schedule:** TR 1030 AM - 1145 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 or 61, Statistics 110, Applied Math 22a or Math 21ab (or equivalent).**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Course Roll | FAS Course Roll |
| GSD: MDS/MDE Rec. Elec. | MDE approved SEAS 100 level course |
| Local offset from Cambridge MA | +9:45 |
| Quantitative Reasoning with Data | Yes |
| Local offset from Cambridge MA | +7 |
| FAS: Course Level | For Undergraduate and Graduate Students |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| Local offset from Cambridge MA | +10 +11 |

| | |
|---|---|
| Local offset from Cambridge MA | +8 +9 |
| FAS: Live Shopping Event | Live Shopping Event |
| All: Cross Reg Availability | Available for Harvard Cross Registration |

## Computer Science 182

Artificial Intelligence (110661)

*Milind Tambe*

*Boaz Barak*

2020 Fall (4 Credits) **Schedule:** MW 1200 PM - 0115 PM

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

**Artificial Intelligence (AI) is an exciting field that has had a tremendous impact on life and society. The goal of this course is to introduce the ideas and techniques underlying the design of computer systems that make intelligent decisions based on data. Topics covered in this course are broadly divided into 1) planning and search algorithms, 2) probabilistic reasoning and representations, and 3) machine learning (although, as we 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 real-world, with a special focus on the recent emergence of applications in "AI for Social Good", i.e., areas of direct societal benefit. The class will include lectures connecting the models and algorithms we discuss to applications in areas such as public health, conservation, social work, education, public safety and also discuss ethical challenges faced in applications of AI in society.**

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

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Course Roll | FAS Course Roll |
| 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 187

Introduction to Computational Linguistics and Natural-language Processing (117372)

*Stuart Shieber*

2020 Fall (4 Credits) **Schedule:** TR 1030 AM - 1145 AM

**Instructor Permissions:** Instructor **Enrollment Cap:** 36

**Natural-language-processing applications are ubiquitous: Alexa can set a reminder if you ask; Google Translate can make emails readable across languages; Watson outplays world Jeopardy champions; Grover can generate fake news, and recognize it as well. How do such systems work? This course provides an introduction to the field of computational linguistics, the study of human language using the tools and techniques of computer science, with applications to a variety of natural-language-processing problems such as these. You will work with ideas from linguistics, statistical modeling, and machine learning, with emphasis on their application, limitations, and implications. The course is lab- and project-based, primarily in small teams, and culminates in the building and testing of a question-answering system.**

**Course Notes:** **Enrollment limited to 36 students.**

**Recommended Prep:** **Programming ability and computer science knowledge at the level of CS51; knowledge of discrete mathematics, including basic probability,**

**statistics, and logic at the level of CS20; some familiarity with Python programming.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Course Roll | FAS Course Roll |
| 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 191

Classics of Computer Science (204964)

*Harry Lewis*

2021 Spring (4 Credits) **Schedule:** MW 1030 AM - 1145 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) |
|---|---|
| FAS Course Roll | FAS Course Roll |
| Local offset from Cambridge MA | +10 +11 |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| Local offset from Cambridge MA | +8 +9 |
| FAS: Live Shopping Event | Live Shopping Event |
| GSD: MDS/MDE Rec. Elec. | MDE approved SEAS 100 level course |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS: Course Level | For Undergraduate and Graduate Students |
| Local offset from Cambridge MA | +9:45 |
| Local offset from Cambridge MA | +7 |

## Computer Science 205

Computing Foundations for Computational Science (128104)

*David Sondak*

2021 Spring (4 Credits) **Schedule:** TR 0130 PM - 0245 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 large-scale computational science and big data analytics. Many science communities are combining high performance computing and high-end data analysis platforms and methods in workflows that orchestrate large-scale simulations or incorporate them**

**into the stages of large-scale analysis pipelines for data generated by simulations, experiments, or observations. This is an applications course highlighting the use of modern computing platforms in solving computational and data science problems, enabling simulation, modeling 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, computing architectures and cloud services for high performance computing and high-end data analytics.**

**Recommended Prep:** **Students are expected to have basic programming experience and understanding of algorithms (e.g. CS50/CS51/CS207), familiarity with Python, C or similar, and basic knowledge of Linux including using the command line.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| Local offset from Cambridge MA | -6 |
| FAS Course Roll | FAS Course Roll |
| FAS: Course Level | Primarily for Graduate Students |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| Local offset from Cambridge MA | +7 |

## Computer Science 221

Computational Complexity (111993)

*Madhu Sudan*

2021 Spring (4 Credits) **Schedule:** MW 0300 PM - 0415 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) |
|---|---|
| FAS: Course Level | Primarily for Graduate Students |
| FAS Course Roll | FAS Course Roll |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| Local offset from Cambridge MA | +17 |
| Local offset from Cambridge MA | -6 |
| FAS: Live Shopping Event | Live Shopping Event |
| All: Cross Reg Availability | Available for Harvard Cross Registration |

## Computer Science 222

Algorithms at the Ends of the Wire (111994)

*Michael Mitzenmacher*

2020 Fall (4 Credits) **Schedule:** TR 1200 PM - 0115 PM

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

**Covers topics related to algorithms for big data, especially related to networks and database systems. Themes include sketch-based data structures, compression, graph and link information, and information theory. Requires a major final research-based project.**

**Recommended Prep:** **Computer Science 124.**

**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 |
| FAS Course Roll | FAS Course Roll |

## Computer Science 229BR

Advanced Topics in the Theory of Machine Learning (207862)

*Boaz Barak*

2021 Spring (4 Credits) **Schedule:** M 1200 PM - 0245 PM

**Instructor Permissions:** Instructor **Enrollment Cap:** 80

**This will be a graduate level course on recent advances and open questions in the theory of machine learning and specifically deep learning. We will review both classical results as well as recent papers in areas including classifiers and generalization gaps, representation learning, generative models, adversarial robustness and out of distribution performance, and more.**

**This is a fast-moving area and it will be a fast-moving course. We will aim to cover both state-of-art results, as well as the intellectual foundations for them, and have a substantive discussion on both the "big picture" and technical details of the papers. In addition to the theoretical lectures, the course will involve a programming component aiming to get students to the point where they can both reproduce results from papers and work on their own research. This component will be largely self-directed and we expect students to be proficient in Python and in picking up technologies and libraries on their own (aka "Stack Overflow oriented programming"). We will ensure students have access to the appropriate computational resources (i.e., GPUs).**

**This Harvard seminar will be coordinated with a "sister seminar" at MIT, taught by Ankur Moitra. Details will be announced later.**

**Class Notes:** **There will be an application process to the course, details of which will be announced on the course webpage--https://boazbk.github.io/mltheoryseminar/.**

**Recommended Prep:** **The course will require mathematical maturity, and proficiency with proofs, probability, and information theory, as well as the basics of machine learning. We expect that students will have both theory background (CS 121 and 124 or similar) as well as machine learning background (CS 181 or 183 or similar).**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS: Course Level | Primarily for Graduate Students |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| Local offset from Cambridge MA | +8 +9 |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| Local offset from Cambridge MA | +7 |
| FAS Course Roll | FAS Course Roll |

## Computer Science 229R

Topics in Theoretical Computer Science: Spectral Graph Theory in CS (120237)

*Salil Vadhan*

2020 Fall (4 Credits) **Schedule:** TR 0130 PM - 0245 PM

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

**Eigenvectors and eigenvalues of graphs and their applications to computer science problems, such as clustering, solving linear systems, derandomization, sampling via MCMC, counting, web search, and maximum flow.**

**Recommended Prep:** **CS 124 and linear algebra at the level of AM 22a or Math 21b.**

**Additional Course Attributes:**

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

## Computer Science 229R

Topics in Theoretical Computer Science: Biology and Complexity (120237)

*Leslie Valiant*

2021 Spring (4 Credits) **Schedule:** TR 0130 PM - 0245 PM

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

**Many processes in biology consist of step by step processes, whether in evolution, neural activity, development, or protein circuits. In many of these processes the actual steps taken by biological systems are not currently understood. Further, even the outcomes that are being realized by these processes are not well understood. In general current understanding of most aspects of biology is not complete or specific enough to provide theories in which predictions can be made by analysis or computer simulation. Computer science is the study of step by step processes and of specifications of the outcomes that such processes can realize. For many computational outcome specifications it is known or believed that no mechanism with feasible resources can realize them. Computer science therefore offers a top-down approach to understanding what could possibly be computed in biology, and how. In this course we shall pursue this computational complexity approach, whose origins go back to Turing and von Neumann. Emphasis will be on evolution and neuroscience, but other topics such as development will be also discussed. Research papers that address some aspect of the complexity question, whether by mathematical analysis, computer simulations or experimental findings will be discussed.**

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

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| Local offset from Cambridge MA | -6 |
| Local offset from Cambridge MA | +7 |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS: Course Level | Primarily for Graduate Students |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| FAS Course Roll | FAS Course Roll |

## Computer Science 234R

Topics on Computation in Networks and Crowds (109667)

*Nicole Immorlica*

*Brendan Lucier*

2021 Spring (4 Credits) **Schedule:** TR 0300 PM - 0415 PM

**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 |
| Local offset from Cambridge MA | -6 |
| FAS: Course Level | Primarily for Graduate Students |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| FAS Course Roll | FAS Course Roll |
| Local offset from Cambridge MA | +17 |

## Computer Science 238

Optimized Democracy (217635)

*Ariel Procaccia*

2021 Spring (4 Credits) **Schedule:** MW 1030 AM - 1145 AM

**Instructor Permissions:** Instructor **Enrollment Cap:** 40

**The course examines the mathematical and algorithmic foundations of democracy, running the gamut from theory to applications. The goal is to provide students with a rigorous perspective on, and a technical toolbox for, the design of better democratic systems. Topics include computational social choice (identifying optimal voting rules), fair division with applications to political redistricting (avoiding gerrymandering) and apportionment (allocating seats on a representative body), sortition (randomly selecting citizens' assemblies), liquid democracy (transitively delegating votes), and weighted voting games (analyzing legislative power through cooperative game theory).**

**The course website can be found here: https://sites.google.com/view/optdemocracy**

**Class Notes:** **Course enrollment limited. Offered jointly with HKS as DPI 612.**

**Recommended Prep:** **Students should have a basic understanding of probability theory and algorithms. Examples of concepts that are useful to know include Markov chains, concentration inequalities, NP-hardness and linear programming. Mathematical maturity (following proof sketches in real time) is expected. Although this is primarily a graduate course, undergraduate students who have previously taken Stat 110 and CS 124 (or similar courses) are very welcome.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| Local offset from Cambridge MA | +7 |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS: Course Level | Primarily for Graduate Students |
| Local offset from Cambridge MA | +9:45 |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| FAS Course Roll | FAS Course Roll |
| Local offset from Cambridge MA | +10 +11 |
| Local offset from Cambridge MA | +8 +9 |
| FAS: Live Shopping Event | Live Shopping Event |

## Computer Science 242

Computing at Scale (160624)

*H. Kung*

2021 Spring (4 Credits) **Schedule:** MW 0430 PM - 0545 PM

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

**Scaling computation over parallel and distributed computing systems is a rapidly advancing area of research receiving high levels of interest from both academia and industry. The objective can be for high---performance computing and energy---efficient computing ("green" data center servers as well as small embedded devices). In this course, students will learn principled methods of mapping prototypical computations used in machine learning, the Internet of Things, and scientific computing onto parallel and distributed compute nodes of various forms. These techniques will lay the foundation for future computational libraries and packages for both high---performance computing and energy---efficient devices. To master the subject, students will need to appreciate the close interactions between computational algorithms, software abstractions, and computer organizations. After having successfully taken this course, students will acquire an integrated understanding of these issues. The class will be organized into the following modules: Big picture: use of parallel and distributed computing to achieve high performance and energy efficiency; End---to---end example 1: mapping nearest neighbor computation onto parallel computing units in the forms of CPU, GPU, ASIC and FPGA; Communication and I/O: latency hiding with prediction, computational intensity, lower bounds; Computer architectures and implications to computing: multi---cores, CPU, GPU, clusters, accelerators, and virtualization; End---to---end example 2: mapping convolutional neural networks onto parallel computing units in the forms of CPU, GPU, ASIC, FPGA and clusters; Great inner loops and parallelization for feature extraction, data clustering and dimension reduction: PCA, random projection, clustering (K---means, GMM---EM), sparse coding (K---SVD), compressive sensing, FFT, etc.; Software abstractions and programming models: MapReduce (PageRank, etc.), GraphX/Apache Spark, OpenCL and TensorFlow; Advanced topics: autotuning and neuromorphic spike---based computing. Students will learn the subject through lectures/quizzes, programming assignments, labs, research paper presentations, and a final project. Students will have latitude in choosing a final project they are passionate about. They will formulate their projects early in the course, so there will be sufficient time for discussion and iterations with the teaching staff, as well as for system design and implementation. Industry partners will support the course by giving guest lectures and providing resources. The course will use server clusters at Harvard as well as external resources in the cloud. In addition, labs will have access to state---of---the---art IoT devices and 3D cameras for data acquisition. Students will use open source tools and libraries and apply them to data analysis, modeling, and visualization problems.**

**Recommended Prep:** **(1) programming experience (Python, MatLab or C/C++ should be fine); (2) basic knowledge in systems and machine organization; (3) familiarity in data structures and algorithms; and (4) maturity in mathematics (e.g., undergraduate linear algebra and statistics). For**

**students with strong interest in the subject matter and related research topics, one of these four requirements may be waived. Labs and extra support will provide preparation in the first weeks of the semester to help students quickly obtain the 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 |
| Local offset from Cambridge MA | +17 |
| FAS Course Roll | FAS Course Roll |
| FAS: Course Level | Primarily for Graduate Students |
| Local offset from Cambridge MA | +15 |
| FAS: Live Shopping Event | Live Shopping Event |
| Local offset from Cambridge MA | -6 |

## Computer Science 246

Advanced Computer Architecture (127937)

*David Brooks*

2021 Spring (4 Credits) **Schedule:** TR 0130 PM - 0245 PM

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

**Review of the fundamental structures in modern processor design. Topics include computer organization, memory system design, pipelining, and other techniques to exploit parallelism. Discussion of modern topics including GPU architectures, datacenter architecture, mobile/embedded SoC architectures, and machine learning acceleration as time permits. Emphasis on a quantitative evaluation of design alternatives and an understanding of performance and energy consumption issues.**

**Course Notes:** **The contents and course requirements are similar to those of Computer Science 146, with the exception that students enrolled in Computer Science 246 are expected to undertake a course project appropriate for a graduate course.**

**Recommended Prep:** **Computer Science 141.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS: Live Shopping Event | Live Shopping Event |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| FAS Course Roll | FAS Course Roll |
| Local offset from Cambridge MA | -6 |
| FAS: Course Level | Primarily for Graduate Students |
| Local offset from Cambridge MA | +7 |

## Computer Science 249R

Tiny Machine Learning (212687)

*Vijay Janapa Reddi*

2020 Fall (4 Credits) **Schedule:** MW 1030 AM - 1145 AM

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

**Tiny machine learning (TinyML) is defined as a fast-growing field of machine learning technologies and applications including hardware (dedicated integrated circuits), algorithms and software capable of performing on-device sensor (vision, audio, IMU, biomedical, etc.) data analytics at extremely low power, typically in the mW range and below, and hence enabling a variety of always-on use-cases and targeting battery-operated devices. The pervasiveness of ultra-low-power embedded devices, coupled with the introduction of embedded machine learning frameworks like TensorFlow Lite for Microcontrollers, will enable the mass proliferation of AI-powered IoT devices. The explosive growth in machine learning and the ease of use of platforms like TensorFlow (TF) make it an indispensable topic of study for modern computer science and electrical engineering students.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Course Roll | FAS Course Roll |
| 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 252R

Advanced Topics in Programming Languages (114807)

*Nada Amin*

2020 Fall (4 Credits) **Schedule:** TR 1200 PM - 0115 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.**

**Fall 2020: We will explore programming languages for artificial intelligence. Programming Languages drive the way we communicate with computers, including how we make them intelligent and reasonable. In this advanced topic course, we will look at artificial intelligence broadly construed from the point of view of programming languages. We gain clarity of semantics, algorithms and purpose. Topics include differentiable programming, neuro-symbolic systems, constraint and probabilistic programming, interpretable AI and more. Reading and discussion will be based on a selection of papers, suggested collectively. Grading is based on participation, presentation and final project. For more course information can be found at http://pl-ai-seminar.seas.harvard.edu/**

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

**Additional Course Attributes:**

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

## Computer Science 252R

Advanced Topics in Programming Languages (114807)

*Stephen Chong*

2021 Spring (4 Credits) **Schedule:** TR 1030 AM - 1145 AM

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

**Seminar course exploring recent research in programming languages. Topics vary from year to year. Students typically read and present research papers, undertake a research project.**
**For Spring 2021, we will examine a variety of advanced topics, including dependent types, logical relations, and module systems.**

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

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| Local offset from Cambridge MA | +8 +9 |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| Local offset from Cambridge MA | +7 |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| Local offset from Cambridge MA | +10 +11 |
| FAS Course Roll | FAS Course Roll |
| FAS: Course Level | Primarily for Graduate Students |
| Local offset from Cambridge MA | +9:45 |
| FAS: Live Shopping Event | Live Shopping Event |

## Computer Science 261

Research Topics in Operating Systems (143667)

*Eddie Kohler*

2021 Spring (4 Credits) **Schedule:** TR 1030 AM - 1145 AM

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

**An introduction to operating systems research. Paper-based seminar course that introduces students to the state of the art in systems research through historical and quantitative lenses. Students will read and discuss research papers and complete a final research project.**

**Recommended Prep:** **Computer Science 161, or equivalent.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| Local offset from Cambridge MA | +10 +11 |
| Local offset from Cambridge MA | +8 +9 |
| FAS: Course Level | Primarily for Graduate Students |
| Local offset from Cambridge MA | +7 |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS Course Roll | FAS Course Roll |
| Local offset from Cambridge MA | +9:45 |

## Computer Science 262

Introduction to Distributed Computing (122813)

*James Waldo*

2021 Spring (4 Credits) **Schedule:** TR 1200 PM - 0115 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 Roll | FAS Course Roll |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS: Course Level | Primarily for Graduate Students |
| Local offset from Cambridge MA | +8 +9 |
| Local offset from Cambridge MA | +7 |

## Computer Science 263

Systems Security (160579)

*James Mickens*

2020 Fall (4 Credits) **Schedule:** TR 1200 PM - 0115 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 |
| FAS Course Roll | FAS Course Roll |

## Computer Science 271

Topics in Data Visualization (211349)

*Johanna Beyer*

2021 Spring (4 Credits) **Schedule:** MW 0130 PM - 0245 PM

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

**This course covers advanced topics in data visualization. Over the course of the semester, we will examine seminal works and recent state-of-the-art research in information visualization, scientific visualization and visual analytics. Students will work on a semester-long visualization project that will allow them to visualize their own data sets and write a short paper about their project. We will**

**employ peer-feedback and formal design critiques to analyze each other's work.**

**Course Notes:** **Enrollment limited to 30 students. Instructor permission needed.**

**Recommended Prep:** **CS 171, CS 179, CS 279, or some data visualization experience. Please contact course staff if you are unsure about the course pre-requisites.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| Local offset from Cambridge MA | -6 |
| FAS: Live Shopping Event | Live Shopping Event |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| Local offset from Cambridge MA | +7 |
| FAS: Course Level | Primarily for Graduate Students |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| FAS Course Roll | FAS Course Roll |

## Computer Science 279R

Research Topics in Human-Computer Interaction (121985)

*Elena Glassman*

2020 Fall (4 Credits) **Schedule:** MW 1200 PM - 0115 PM

**Instructor Permissions:** Instructor **Enrollment Cap:** 25

**This year only: Students will read and discuss HCI papers about computers working with---or clashing against---the strengths and weakness of human cognition, e.g., the positive and negative impacts of AI recommendation systems and the impact of interruptions on continuity of thought. Activities will include a small number of lectures, discussion of relevant literature in each field, and a project, in which students will work together in groups to design and carry out HCI research.**

**Course Notes:** **Designed for PhD students from all areas. Masters students and advanced undergraduates are welcome, particularly those who wish to do research (or write a thesis) in an area related to Human-Computer Interaction.**

**Recommended Prep:** **None for PhD students; for undergrads CS 179 or CS 171.**

**Additional Course Attributes:**

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

## Computer Science 282BR

Topics in Machine Learning: Interpretability and Explainability (213653)

*Hima Lakkaraju*

2021 Spring (4 Credits) **Schedule:** TR 0300 PM - 0415 PM

**Instructor Permissions:** Instructor **Enrollment Cap:** 25

**As machine learning models are increasingly being employed to aid decision makers in high-stakes settings such as healthcare and criminal justice, it is important to ensure that the decision makers (end users) correctly understand and consequent trust the functionality of these models. This graduate level course aims to familiarize students with the recent advances in the emerging field of explainable ML. In this course, we will review seminal position papers of the field, understand the notion of model interpretability from the perspective of decision makers (end users), discuss in detail different classes of interpretable models (e.g., case (prototype) based approaches, sparse linear models, rule-based techniques, saliency maps, generalized additive models, and counterfactual explanations), and explore the connections between model interpretability and causality, debugging, and fairness. The course will also emphasize on various applications which can immensely benefit from model interpretability including medical imaging and judicial decision making.**

**Class Notes:** **Total class capacity of 25 includes students in both CS 282BR and HBSDOC 4914. Interested students should submit the application form at that can be found here.**

**Recommended Prep:** **Knowledge of machine learning, convex optimization, probability and statistics, basic computer science and programming skills.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| Local offset from Cambridge MA | -6 |
| FAS: Course Level | Primarily for Graduate Students |
| Local offset from Cambridge MA | +17 |
| FAS Course Roll | FAS Course Roll |
| FAS: Live Shopping Event | Live Shopping Event |
| All: Cross Reg Availability | Available for Harvard Cross Registration |

## Computer Science 286

Multi-Robot Systems: Control, Communication, and Security (216508)

*Stephanie Gil*

2020 Fall (4 Credits) **Schedule:** MW 0300 PM - 0415 PM

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

**The ability to connect devices over long distances, via the internet, changed our world. The second phase of this revolution, that we are still living in today, came about when these devices became wireless. Now we are at the cusp of a new phase of this evolution where devices are connected, wireless, and controlled – i.e. the robot revolution.**

**Multi-robot systems are becoming more pervasive; from future autonomous vehicle fleets, to drones, to manufacturing robots. As a result, the question of how to control, coordinate, and secure these systems has been a growing topic in the robotics literature in recent years. In this seminar-style course we will do a deep dive into this topic by reviewing classic and recent results in multi-agent planning and control literature. We will cover a wide gamut of applications from control of groups of flying drones, to decision making in autonomous car networks, to space exploring CubeSats.**

**This class will treat both the theory and the practical applications behind multi-robot systems. Students with mathematical inclinations and exposure to graph theory, probability theory, linear algebra, and algorithms will derive the most benefit from this course.**

**Course Notes:** **This course is a graduate-level seminar course. Motivated advanced undergraduate students are also welcomed!**

**Recommended Prep:** **It will be assumed that students have a strong command of calculus and basic probability theory. An understanding of mathematical optimization methods is preferable. A background in algorithms, dynamics/controls, and intro to robotics would be beneficial.**

**Additional Course Attributes:**

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

## Computer Science 288 Section: 001`

AI for Social Impact (217643)

*Milind Tambe*

2021 Spring (4 Credits) **Schedule:** TR 1030 AM - 1145 AM

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

**Recent years have seen AI successfully applied to societal challenge problems; indeed, it has a great potential to provide tremendous social good in the future. In this course, we will discuss the successful deployments and the potential use of AI in various topics that are essential for social good, including but not limited to health, environmental sustainability, public safety and public welfare. We will focus on challenges in "AI for Social Impact" (AI4SI), what makes projects successful, and why projects fail. A key part of this course will be to start AI4SI projects with local area non-profits.**

**Course Notes:** **Only advanced undergraduates who have demonstrated significant knowledge of AI may enroll. Enrollment capped at 30. Students must have adequate background in AI. Students who have previous experience in AI for Social Impact will be given priority.**

**Recommended Prep:** **A graduate level course in AI.**

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| Local offset from Cambridge MA | +9:45 |
| FAS: Course Level | Primarily for Graduate Students |
| FAS Course Roll | FAS Course Roll |
| Local offset from Cambridge MA | +8 +9 |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| Local offset from Cambridge MA | +7 |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| Local offset from Cambridge MA | +10 +11 |

## Computer Science 290

PhD Grad Cohort Research Seminar (216811)

*David Brooks*

2020 Fall (4 Credits) **Schedule:** TBD

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

**In lieu of typical on-campus interactions that normally occur during the first year of the PhD program, this course provides an opportunity for entering CS PhD students to engage with the Harvard CS community and to build a cohort among the entering PhD students. The class is intended for first-year students and students transferring into the Harvard CS PhD program. The class will include an introduction to the community through virtual talks and interactive Q&As with regular course guests. We plan to bring in a broad mixture of CS faculty, current PhD students, and PhD alumni. The course will also include an off-line component primarily consisting of select broad-interest CS research readings and writing assignments.**

**Course Notes:** **We will meet synchronously twice a week (two, one-hour meeting slots) at times that accommodate the time zones of students. CS290 will satisfy a CS 200-level technical elective (one of the 10 required classes for the CS PhD degree).**

**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 |
| FAS Course Roll | FAS Course Roll |

## Computer Science 299R

Special Topics in Computer Science (114035)

*David Brooks*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Supervision of experimental or theoretical research on acceptable problems in computer science 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 or at https://www.seas.harvard.edu/office-academic-programs/graduate-policies-procedures-and-forms/graduate-student-forms.**

**Additional Course Attributes:**

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

## Computer Science 299R

Special Topics in Computer Science (114035)

*Leslie Valiant*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Supervision of experimental or theoretical research on acceptable problems in computer science 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 or at https://www.seas.harvard.edu/office-academic-programs/graduate-policies-procedures-and-forms/graduate-student-forms.**

**Additional Course Attributes:**

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

## Computer Science 306

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

*Eddie Kohler*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS: Course Level | Graduate Course |
| Course Evaluation | Course Evaluation exempt |
| FAS Divisional Distribution | None |
| FAS Course Roll | FAS Course Roll |
| All: Cross Reg Availability | Not Available for Cross Registration |

## Computer Science 306

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

*Eddie Kohler*

2020 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 |
| FAS Course Roll | FAS Course Roll |
| Course Evaluation | Course Evaluation exempt |
| All: Cross Reg Availability | Available for Harvard Cross Registration |

## Computer Science 308

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

*Radhika Nagpal*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| Course Evaluation | Course Evaluation exempt |
| FAS: Course Level | Graduate Course |
| FAS Course Roll | FAS Course Roll |
| FAS Divisional Distribution | None |
| All: Cross Reg Availability | Not Available for Cross Registration |

## Computer Science 308

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

*Radhika Nagpal*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 310

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

*David Parkes*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| Course Evaluation | Course Evaluation exempt |

| | |
|---|---|
| FAS: Course Level | Graduate Course |
| All: Cross Reg Availability | Not Available for Cross Registration |
| FAS Divisional Distribution | None |
| FAS Course Roll | FAS Course Roll |

## Computer Science 310

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

*David Parkes*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 312

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

*Barbara Grosz*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 312

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

*Barbara Grosz*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Divisional Distribution | None |
| FAS Course Roll | FAS Course Roll |

| | |
|---|---|
| Course Evaluation | Course Evaluation exempt |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS: Course Level | Graduate Course |

## Computer Science 314

Visual Computing (124155)

*Hanspeter Pfister*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 314

Visual Computing (124155)

*Hanspeter Pfister*

2021 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 |
| Course Evaluation | Course Evaluation exempt |
| FAS Divisional Distribution | None |
| FAS Course Roll | FAS Course Roll |
| FAS: Course Level | Graduate Course |

## Computer Science 316

Social Computing: Computation and Economics (125388)

*Yiling Chen*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Divisional Distribution | None |
| Course Evaluation | Course Evaluation exempt |

| | |
|---|---|
| FAS Course Roll | FAS Course Roll |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS: Course Level | Graduate Course |

## Computer Science 316

Social Computing: Computation and Economics (125388)

*Yiling Chen*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 320

Data Systems Design (156744)

*Stratos Idreos*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 320

Data Systems Design (156744)

*Stratos Idreos*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS: Course Level | Graduate Course |
| FAS Course Roll | FAS Course Roll |

| | |
|---|---|
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| Course Evaluation | Course Evaluation exempt |
| FAS Divisional Distribution | None |

## Computer Science 321

Graduate Research with Procaccia (216720)

*Ariel Procaccia*

2021 Spring (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: Course Level | Graduate Course |
| FAS Divisional Distribution | None |
| FAS Course Roll | FAS Course Roll |
| Course Evaluation | Course Evaluation exempt |

## Computer Science 321

A Computational Lens on Democracy and Fairness (216720)

*Ariel Procaccia*

2020 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: Course Level | Graduate Course |
| FAS Divisional Distribution | None |
| FAS Course Roll | FAS Course Roll |

## Computer Science 324

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

*Stuart Shieber*

2020 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 |
| Course Evaluation | Course Evaluation exempt |
| FAS Divisional Distribution | None |

| | |
|---|---|
| FAS Course Roll | FAS Course Roll |

## Computer Science 324

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

*Stuart Shieber*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 325

Communicating with Machines About Data (212951)

*Elena Glassman*

2020 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 |
| FAS Course Roll | FAS Course Roll |
| All: Cross Reg Availability | Not Available for Cross Registration |

## Computer Science 325

Communicating with Machines About Data (212951)

*Elena Glassman*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| Course Evaluation | Course Evaluation exempt |
| FAS Course Roll | FAS Course Roll |
| FAS: Course Level | Graduate Course |
| FAS Divisional Distribution | None |
| All: Cross Reg Availability | Not Available for Cross Registration |

## Computer Science 326

Intelligent Interactive Systems and Human-Computer (126331)

*Krzysztof Gajos*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 326

Intelligent Interactive Systems and Human-Computer (126331)

*Krzysztof Gajos*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Course Roll | FAS Course Roll |
| Course Evaluation | Course Evaluation exempt |
| 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*

2020 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 |
| Course Evaluation | Course Evaluation exempt |
| FAS Divisional Distribution | None |
| FAS Course Roll | FAS Course Roll |

## Computer Science 327

Tools for Reliable Meaningful Efficient Communication (160962)

*Madhu Sudan*

2021 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 |
| Course Evaluation | Course Evaluation exempt |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| FAS Course Roll | FAS Course Roll |

## Computer Science 328

Mathematical Logic, Theory of Computation (133437)

*Harry Lewis*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 328

Mathematical Logic, Theory of Computation (133437)

*Harry Lewis*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 333

Individual Risk (216384)

*Cynthia Dwork*

*Joseph Blitzstein*

2020 Fall (4 Credits) **Schedule:** F 1245 PM - 0245 PM

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

**Risk assessment tools are increasingly deployed in high-stakes settings: What is the probability that the tumor will metastasize? What is the chance that this individual will commit a violent crime in the next two years? What is the probability that the student will graduate within 4 years? But what is the probability of a non-repeatable event? What is the mathematical meaning of "individual risk" and what should we require of a risk assessment algorithm? This reading course will explore different notions of risk, based on different notions of probability, and will connect this literature to notions of regret and indistinguishability from computer science.**

**Course Notes:** **Also offered as Stat 333. Only one of CS 333 or Stat 333 may be taken for credit.**

**Recommended Prep:** **Familiarity with probability (e.g., Stat 110 and/or exposure through theoretical computer science). Exposure to theoretical computer science will be helpful but is not mandatory.**

**Additional Course Attributes:**

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

## Computer Science 335

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

*Boaz Barak*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 335

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

*Boaz Barak*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 344

Computer Architecture: Modeling and Design (116858)

*David Brooks*

2021 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 |
| Course Evaluation | Course Evaluation exempt |
| FAS: Course Level | Graduate Course |
| FAS Divisional Distribution | None |
| FAS Course Roll | FAS Course Roll |

## Computer Science 344

Computer Architecture: Modeling and Design (116858)

*David Brooks*

2020 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 |
| FAS Course Roll | FAS Course Roll |
| Course Evaluation | Course Evaluation exempt |
| All: Cross Reg Availability | Available for Harvard Cross Registration |

## Computer Science 345

Datacenter networking (117839)

*Minlan Yu*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 345

Datacenter networking (117839)

*Minlan Yu*

2021 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 |
| FAS Course Roll | FAS Course Roll |
| Course Evaluation | Course Evaluation exempt |

## Computer Science 346

High-Performance Computer Systems (117841)

*Michael Smith*

2020 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 Roll | FAS Course Roll |
| FAS: Course Level | Graduate Course |

## Computer Science 346

High-Performance Computer Systems (117841)

*Michael Smith*

2021 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 Course Roll | FAS Course Roll |
| FAS Divisional Distribution | None |
| Course Evaluation | Course Evaluation exempt |

## Computer Science 348

Computer Vision (120091)

*Todd Zickler*

2021 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 |
| Course Evaluation | Course Evaluation exempt |
| FAS: Course Level | Graduate Course |
| FAS Course Roll | FAS Course Roll |

## Computer Science 348

Computer Vision (120091)

*Todd Zickler*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 351

Research in Programming Languages, Design and Implementation (216721)

*Nada Amin*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Course Roll | FAS Course Roll |
| FAS Divisional Distribution | None |
| All: Cross Reg Availability | Not Available for Cross Registration |
| Course Evaluation | Course Evaluation exempt |
| FAS: Course Level | Graduate Course |

## Computer Science 351

Research in Programming Languages, Design and Implementation (216721)

*Nada Amin*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Course Roll | FAS Course Roll |
| FAS: Course Level | Graduate Course |
| All: Cross Reg Availability | Not Available for Cross Registration |
| FAS Divisional Distribution | None |

## Computer Science 356

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

*Leslie Valiant*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 356

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

*Leslie Valiant*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 358

Computational Complexity, Cryptography, and Pseudorandomness (115136)

*Salil Vadhan*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 358

Computational Complexity, Cryptography, and Pseudorandomness (115136)

*Salil Vadhan*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 360

On-line Algorithms and Randomized Algorithms (109883)

*Michael Mitzenmacher*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 360

On-line Algorithms and Randomized Algorithms (109883)

*Michael Mitzenmacher*

2021 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 |
| FAS Course Roll | FAS Course Roll |
| Course Evaluation | Course Evaluation exempt |
| All: Cross Reg Availability | Available for Harvard Cross Registration |

## Computer Science 361

Topics in Distributed Systems (119043)

*James Waldo*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Course Roll | FAS Course Roll |
| Course Evaluation | Course Evaluation exempt |
| FAS: Course Level | Graduate Course |
| All: Cross Reg Availability | Not Available for Cross Registration |
| FAS Divisional Distribution | None |

## Computer Science 361

Topics in Distributed Systems (119043)

*James Waldo*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Divisional Distribution | None |
| FAS Course Roll | FAS Course Roll |
| All: Cross Reg Availability | Not Available for Cross Registration |
| FAS: Course Level | Graduate Course |

## Computer Science 362

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

*James Mickens*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 362

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

*James Mickens*

2021 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 |
| Course Evaluation | Course Evaluation exempt |
| FAS Divisional Distribution | None |
| FAS: Course Level | Graduate Course |
| FAS Course Roll | FAS Course Roll |

## Computer Science 364

Programming Languages and Security (126329)

*Stephen Chong*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 364

Programming Languages and Security (126329)

*Stephen Chong*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 372

Topics in Theory for Society (204561)

*Cynthia Dwork*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Course Roll | FAS Course Roll |
| FAS Divisional Distribution | Science & Engineering & Applied Science |
| Course Evaluation | Course Evaluation exempt |
| 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*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 376

Computer Graphics (121071)

*Steven Gortler*

2020 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 Roll | FAS Course Roll |
| FAS: Course Level | Graduate Course |

## Computer Science 376

Computer Graphics (121071)

*Steven Gortler*

2021 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 |
| FAS Course Roll | FAS Course Roll |
| Course Evaluation | Course Evaluation exempt |

## Computer Science 378

Sketching Algorithms for Massive Data (110261)

*Jelani Nelson*

2020 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 |
| FAS Course Roll | FAS Course Roll |
| All: Cross Reg Availability | Available for Harvard Cross Registration |

## Computer Science 378

Sketching Algorithms for Massive Data (110261)

*Jelani Nelson*

2021 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 |
| Course Evaluation | Course Evaluation exempt |
| FAS Divisional Distribution | None |
| FAS: Course Level | Graduate Course |
| FAS Course Roll | FAS Course Roll |

## Computer Science 380

Algorithms for Social Data (110263)

*Yaron Singer*

2020 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 |
| FAS Course Roll | FAS Course Roll |
| Course Evaluation | Course Evaluation exempt |
| All: Cross Reg Availability | Available for Harvard Cross Registration |

## Computer Science 380

Algorithms for Social Data (110263)

*Yaron Singer*

2021 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 Roll | FAS Course Roll |
| Course Evaluation | Course Evaluation exempt |
| FAS: Course Level | Graduate Course |

## Computer Science 382

Natural Language Understanding and Generation (160961)

*Alexander Rush*

2021 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 |
| FAS Course Roll | FAS Course Roll |
| All: Cross Reg Availability | Available for Harvard Cross Registration |
| Course Evaluation | Course Evaluation exempt |

## Computer Science 382

Natural Language Understanding and Generation (160961)

*Alexander Rush*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Course Roll | FAS Course Roll |
| 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*

2020 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 Course Roll | FAS Course Roll |
| FAS Divisional Distribution | None |

## Computer Science 384

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

*Scott Kuindersma*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 385

Artificial Intelligence for Social Good (213680)

*Milind Tambe*

2020 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 |
| Course Evaluation | Course Evaluation exempt |
| FAS: Course Level | Graduate Course |
| FAS Course Roll | FAS Course Roll |
| FAS Divisional Distribution | None |

## Computer Science 385

Artificial Intelligence for Social Good (213680)

*Milind Tambe*

2021 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 | Not Available for Cross Registration |
| FAS Course Roll | FAS Course Roll |
| Course Evaluation | Course Evaluation exempt |
| FAS: Course Level | Graduate Course |

## Computer Science 386

Machine Learning (160970)

*Finale Doshi-Velez*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 386

Machine Learning (160970)

*Finale Doshi-Velez*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

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

## Computer Science 387

Statistical Reinforcement Learning (214477)

*Susan Murphy*

2020 Fall (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS: Course Level | Graduate Course |
| Course Evaluation | Course Evaluation exempt |
| All: Cross Reg Availability | Not Available for Cross Registration |
| FAS Course Roll | FAS Course Roll |
| FAS Divisional Distribution | None |

## Computer Science 387

Statistical Reinforcement Learning (214477)

*Susan Murphy*

2021 Spring (4 Credits) **Schedule:** TBD

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

**Additional Course Attributes:**

| Attribute | Value(s) |
|---|---|
| FAS Divisional Distribution | None |
| Course Evaluation | Course Evaluation exempt |
| FAS: Course Level | Graduate Course |
| All: Cross Reg Availability | Not Available for Cross Registration |
| FAS Course Roll | FAS Course Roll |

## Computer Science 388

Multi-Robot Systems Coordination and Control (216671)

*Stephanie Gil*

2021 Spring (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 Course Roll | FAS Course Roll |
| FAS: Course Level | Graduate Course |
| Course Evaluation | Course Evaluation exempt |
| FAS Divisional Distribution | None |

## Computer Science 388

Multi-Robot Systems Coordination and Control (216671)

*Stephanie Gil*

2020 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 | Not Available for Cross Registration |
| FAS Divisional Distribution | None |
| FAS Course Roll | FAS Course Roll |