# CS221: Artificial Intelligence: Principles and Techniques

**Stanford / Spring 2022-2023**

**[Calendar] [Coursework] [Schedule] [Lecture Slides]**

- Lectures: Mon/Wed 10:30am-11:50am in NVIDIA Auditorium.
- Problem sessions: Fri 3:00pm-4:20pm in Skilling Auditorium.
- Office hours, homework parties: see the Calendar.
- To contact the teaching staff, please use Ed; for more personal/sensitive matters, email cs221-spr2223-staff@lists.stanford.edu.

## Teaching Staff

Moses Charikar
Instructor

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## Activities

- **Lectures:** All lectures will be recorded and available on Canvas.
- **Problem sessions:** CAs work through practice homework and exam problems.
- **Homework parties**: CAs help students work through homework problems in small groups.
- **Office Hours:** Meet with instructors and CAs. There are two types of CAoffice hours: homework OH (for help with homework questions) and general OH (to ask questions about course content from lecture).

Homework parties and most office hours are in person in Huang Basement, but we will have some remote office hours (for SCPD students) on Zoom. See class calendar for the exact times and locations of all activities.

## Policies

**Communication:** We will use Ed for all communications, which you can access via Canvas. SCPD students: please email scpd-gradstudents@stanford.edu if you need general assistance. Make a public Ed post whenever possible. For private matters, make a private Ed post, which will be visible to only the instructors and all CAs. For extra sensitive matters, you can also email cs221-spr2223-staff@lists.stanford.edu, which is visible by only the instructors, head CA, and student liaison.

**Video access disclaimer:** Lectures and sections will be recorded and available on Canvas. These recordings might be reused in other Stanford

courses, viewed by other Stanford students, faculty, or staff, or used for other education and research purposes. If you have questions or concerns, please contact us.

**Academic accommodations:** If you need an academic accommodation, contact the Office of Accessible Education (OAE). The OAE will then prepare an OAE letter with the recommended accommodations. Send this letter to cs221-spr2223-staff@lists.stanford.edu by **Friday, April 21 (week 3)**.

**Collaboration policy and honor code:** Please read Stanford's honor code policy. In the context of CS221, you are free to form study groups and discuss homeworks and projects. However, you must write up homeworks and code from scratch independently, and you must acknowledge in your submission all the students you discussed with. The following are considered to be honor code violations:

- Looking at the writeup or code of another student.
- Showing your writeup or code to another student.
- Discussing homework problems in such detail that your solution (writeup or code) is almost identical to another student's solution.
- Uploading your writeup or code to a public repository (e.g., GitHub) so that it can be accessed by other students.
- Looking at solutions from previous years, either official or written up by another student, or found online.

When debugging code together, you are only allowed to look at the input-output behavior of each other's programs (so you should write good test cases!). We periodically run similarity-detection software over all submitted student programs, including programs from past quarters and any solutions found online on public websites.

*Generative AI Policy:* Each student is expected to submit their own solutions to the CS221 Homeworks. The use of generative AI tools such as Co-Pilot and ChatGPT to substantially complete an assignment or exam (e.g by entering exam or assignment questions) is strictly prohibited and will result in honor code violations. We will be checking students' Homework submissions for honor code violations. Generative AI tools will only be allowed for completing the final projects. Please refer to Stanford's Generative AI Policy Guidelines for more details.

Anyone violating the honor code policy will be referred to the Office of Judicial Affairs. If you think you violated the policy (it can happen, especially under time pressure!), please reach out to us; the consequences will be much less severe than if we approach you.

**Inclusion:** The CS221 teaching staff is committed to creating an inclusive and supportive learning environment for *all* students. Please be respectful to your fellow students, course CAs, and instructors. If you see any problems, please reach out to us early.

## Content

**What is this course about?** The goal of artificial intelligence (AI) is to tackle complex real-world problems with rigorous mathematical tools. In this course, you will learn the foundational principles and practice implementing various AI systems. Specific topics include machine learning, search, Markov decision processes, game playing, constraint satisfaction, graphical models, and logic.

**Prerequisites:** This course is fast-paced and covers a lot of ground, so it is important that you have a solid foundation in a number of areas. Here are the basic skills that you need and the classes that teach those skills:

- Programming (ideally Python): CS 106A, CS 106B, CS 107
- Discrete math, mathematical rigor: CS 103
- Probability: CS 109
- Linear algebra: Math 51

It is less important that you know particular things (e.g., we don't use eigenvectors in this course even though that's a pillar of any linear algebra course), and more important that you've done enough related things that you feel at ease with it. While it is possible to fill in the gaps, this course does move quickly, and ideally you want to be focusing your energy on learning AI rather than catching up on prerequisites. We have made a few prerequisite modules that you can review to refresh your memory, and the first homework (foundations) will allow you to also get some practice on these basics.

**Further reading:** There are no required textbooks for this class, and you should be able to learn everything from the lecture notes and homeworks. However, if you would like to pursue more advanced topics or get another perspective on the same material, here are some great resources:

- Russell and Norvig. Artificial Intelligence: AModern Approach. Acomprehensive reference for all the AI topics that we will cover.
- Koller and Friedman. Probabilistic Graphical Models. Covers factor graphs and Bayesian networks (this is the textbook for CS228).
- Sutton and Barto. Reinforcement Learning: An Introduction. Covers Markov decision processes and reinforcement learning (free online).
- Hastie, Tibshirani, and Friedman. The Elements of Statistical Learning. Covers machine learning from a rigorous statistical perspective (free online).
- Tsang. Foundations of Constraint Satisfaction. Covers constraint satisfaction problems (free online).

Note that some of these books use different notation and terminology from this course, so it may may take some effort to make the appropriate connections.

## Coursework

- **Homeworks** (60%): There are weekly homeworks. Each homework is usually centered around an application and has both written and programming parts.

  Homeworks must be typeset and submitted on Gradescope as a PDF. The coding portion will be autograded; you get only feedback on a subset of the test cases. Autograding is strict, so check your outputs carefully! Read more about the policies around late days (7 total, max 2 per homework), regrades, and submission.

- **Exams** (40%):
  - **Exam 1 (20%): Wednesday, 5/10 at 6-8 PM PT**.
  - **Exam 2 (20%): Friday, 6/9 at 3:30-5:30 PM PT**.

  Both exams will be closed-book and closed-source, except you are allowed one double-sided sheet (US letter or A4) of notes.

  *Non-SCPD Students:* Since final exam times are scheduled by the registrar, we will not be accommodating alternate final exam times. All enrolled, non-SCPD students must take the final exam in person on the given date.

  *SCPD Students:* SCPD students will need to nominate exam monitors for both exams and coordinate the exam process with the SCPD exams team. Please refer to this link for more information on the process. For any additional questions, please reach out to the SCPD exams team.

- **Project** (optional, up to 2% extra credit): Use the tools from class to build something interesting of your choice!
  - Projects should be done in groups of 1-4 students.
  - Each project group will be assigned a CAmentor who will give feedback and answer questions.
  - For inspiration, check out previous CS221 projects.

- See the project page for more details.

The project will be something that you work on throughout the quarter and we have set up some milestones to help you along the way:

- Project interest form [p-interest] (due **April 21**)
- Project proposal [p-proposal] (due **May 5**)
- Project progress report [p-progress] (due **May 19**)
- Project final report and video [p-final] (due **June 5**)

- **Ed** (up to 2% extra credit): Please help answer your classmates's questions on Ed! You will be awarded extra credit depending on how substantial and helpful you were on Ed.

## Schedule

| | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|---|
| Week 1 | Apr 3 | Apr 4 | Apr 5 | Apr 6 | Apr 7 | Apr 8 | Apr 9 |
| Homework [Foundations]<br>Module [Prerequisites] [Machine Learning I] | Lecture: Introduction (Sanmi) 10:30am-11:50am | | Lecture: Machine Learning I (Sanmi) 10:30am-11:50am | | Problem Session 3:00pm-4:20pm<br>[Solutions] [Video] | | |
| Week 2 | Apr 10 | Apr 11 | Apr 12 | Apr 13 | Apr 14 | Apr 15 | Apr 16 |
| Homework [Sentiment]<br>Module [Machine Learning II] | Lecture: Machine Learning II (Sanmi) 10:30am-11:50am | Foundations HW due | Lecture: Machine Learning III (Sanmi) 10:30am-11:50am | | Problem Session 3:00pm-4:20pm<br>[Problems] [Solutions] [Video] | | |
| Week 3 | Apr 17 | Apr 18 | Apr 19 | Apr 20 | Apr 21 | Apr 22 | Apr 23 |
| Homework [Route]<br>Module [Search] | Lecture: Search (Moses) 10:30am-11:50am | Sentiment HW due | Lecture: Search & Heuristics (Moses) 10:30am-11:50am | | Final Study List Deadline<br>Problem Session 3:00pm-4:20pm<br>[Problems] [Solutions] [Video] | | |
| Week 4 | Apr 24 | Apr 25 | Apr 26 | Apr 27 | Apr 28 | Apr 29 | Apr 30 |
| Homework [Blackjack]<br>Module [MDPs] | Lecture: MDPs I (Moses) 10:30am-11:50am | Route HW due | Lecture: MDPs II (Moses) 10:30am-11:50am | | Problem Session 3:00pm-4:20pm<br>[Problems] [Solutions] [Slides] [Video] | | |
| Week 5 | May 1 | May 2 | May 3 | May 4 | May 5 | May 6 | May 7 |
| Homework [Pacman]<br>Module [Games] | Lecture: Games I (Moses) 10:30am-11:50am | Blackjack HW due | Lecture: Games II (Moses) 10:30am-11:50am | | Problem Session 3:00pm-4:20pm<br>[Problems] [Solutions] [Video]<br>Project Proposal due | | |
| Week 6 | May 8 | May 9 | May 10 | May 11 | May 12 | May 13 | May 14 |
| Module [CSPs] | Lecture: Factor Graphs (Sanmi) | | Lecture: Beam Search (Moses) | | Problem Session 3:00pm-4:20pm | | |

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| | 10:30am-11:50am | | 10:30am-11:50am<br><br>**Exam I: 6pm-8pm** | | [Problems]<br>[Solutions]<br>[Slides]<br>[Video] | | |
| Week 7 | May 15 | May 16 | May 17 | May 18 | May 19 | May 20 | May 21 |
| Homework [Scheduling]<br><br>Module [Bayesian Nets] | Lecture: Bayesian Nets I (Sanmi) 10:30am-11:50am | Pacman HW due | Lecture: Bayesian Nets II (Sanmi) 10:30am-11:50am | | Problem Session 3:00pm-4:20pm<br><br>[Problems]<br>[Solutions]<br>[Slides]<br>[Video]<br>Project Progress Report due | | |
| Week 8 | May 22 | May 23 | May 24 | May 25 | May 26 | May 27 | May 28 |
| Homework [Car]<br><br>Module [Bayesian Nets III / Logic I] | Lecture: Bayesian Nets III (Sanmi) 10:30am-11:50am | Scheduling HW due | Lecture: Logic I (Moses) 10:30am-11:50am | | Course Withdrawal / Change of Grading Basis Deadline<br><br>Problem Session 3:00pm-4:20pm<br><br>[Problems]<br>[Solutions]<br>[Slides]<br>[Video] | | |
| Week 9 | May 29 | May 30 | May 31 | Jun 1 | Jun 2 | Jun 3 | Jun 4 |
| Homework [Logic]<br><br>Module [Logic II] | *Memorial Day* | Car HW due | Lecture: Logic II (Moses) 10:30am-11:50am | | Problem Session 3:00pm-4:20pm<br><br>[Problems]<br>[Solutions]<br>[Slides]<br>[Video] | | |
| Week 10 | Jun 5 | Jun 6 | Jun 7 | Jun 8 | Jun 9 | Jun 10 | Jun 11 |
| | Lecture: Conclusion 10:30am-11:50am<br><br>Project Final Report due | Logic HW due | Lecture: Exam review session 10:30am-12:20pm<br><br>[Problems]<br>[Solutions]<br>[Video] | | **Exam II: 3:30-5:30pm** | | |