

Lecture 25: Conclusions

*Harvard SEAS - Fall 2024**2024-12-03*

1 Announcements

- Anurag OH after class; Salil no OH this Thurs.
- Fill out Q evaluation.
- Problem set 9 due tomorrow 12/4; see Salil's Ed post for a definitional correction.
- Problem sets 8/9 revision videos and late revision videos (for half credit) due 12/11.
- Final exam 12/19, 9am. Cheat sheet allowed; stay tuned for details.
- Stay tuned for Ed post about review sessions, extra OH/sections, practice exams.
- Votes on T-shirt designs due 12/4.

Recommended Reading:

- Roughgarden IV, Epilogue
- McCormick, Chapter 18

2 An Algorithmicist's Workflow

When confronted with a real-world algorithmic problem (like Web Search, Interval Scheduling, Population demographics, Shortest routes on maps, ChessboardWithBombs, Register Allocation, Wireless spectrum allocation, Kidney Exchange, Lyber, Arithmetic Overflow, etc.), you can tackle it using the skills from CS1200 (and future classes) by looping through the following steps:

1. Mathematically model

2. Look for related problems (in class, in the literature, on the web) and try to obtain an algorithm by **reduction to** other problems

3. Try to apply **algorithmic techniques**

4. Try to show hardness/unsolvability by **reduction from** other problems

5. And/or settle for weaker guarantees

6. Importantly, keep the landscape of complexity classes in view:

3 Other Takeaways

Universality.

A Rigorous Mathematical Theory.

Open Problems.

4 CS1200 Learning Outcomes

It is a good time to reflect on the extent to which you have acquired the skills we set out to develop (as enumerated in the Syllabus):

- To mathematically abstract computational problems and models of computation
- To design and implement algorithms using a toolkit of algorithmic techniques
- To recognize and formalize inherent limitations of computation
- To rigorously analyze algorithms and their limitations via mathematical proof
- To appreciate the technology-independent mathematical theory of computation as an intellectual endeavor as well as its relationship with the practice of computing.
- To engage effectively in a collaborative theoretical computer science learning community, supporting your peers' learning as well as your own
- To clearly communicate mathematical proofs about computation to peers, conveying both high-level intuition and formal details.

5 Algorithms in a World of AI

How will the massive advances in AI and ML affect theoretical computer science and the theory of algorithms as we have seen it in CS1200?

AI/ML systems differ substantially from what we have studied in CS1200 in several respects:

Possibility: ML will eventually replace some of the manual design of algorithms as we have studied in CS1200. Nevertheless, the theory of algorithms and skills from CS1200 likely to remain very valuable for several reasons:

The *limits* of algorithms apply to ML systems. Also continue to be important as basis for cryptography, privacy, security.

Many CS1200 skills are useful throughout CS (not just to study algorithms), including in ML. Intrinsic mathematical beauty and philosophical value.

6 Where to Learn More

- Theory of Computation seminar: <https://toc.seas.harvard.edu/events-seminars>
- Many other CS courses, especially x2x0. Look at grad (2xx0) courses as well. (CS1200 may serve as a sufficient substitute for CS1210/CS1240 in some of them.)
- Read more of our textbooks (Roughgarden, MacCormick, CLRS, and the references therein)
- Come talk to us in office hours!