**CS 151 Complexity Theory** **Spring 2019**

# Course Summary and Syllabus

*Lecturer: Chris Umans* *Date: April 2*

**Course summary:**

Complexity Theory attempts to answer the question: What is computationally feasible given limited computational resources? In this course we will lay out a surprisingly rich landscape of complexity classes that are used to classify problems according to the resources (such as time, space, randomness, or parallelism) required for their solution.

We will build a detailed picture of how these classes are believed to fit together, and we will prove that some pieces of this picture are indeed correct. The question of whether the remainder of this picture is correct encompasses some of the deepest and most fundamental open problems in computer science, including $P \stackrel{?}{=} NP$ and many others.

**Course Information:**

- Instructor: Chris Umans (`umans@cs.caltech.edu`)
- TAs: Andrew Ding (`ading@caltech.edu`), Gideon Leeper (`gleeper@caltech.edu`), and Siddharth Prasad (`sprasad@caltech.edu`)
- Lectures: Tuesdays and Thursdays 1:00 – 2:25 in Annenberg 314
- Office hours: TBD
- Webpage: `http://www.cs.caltech.edu/~umans/cs151/`

**Prerequisite:** CS 21 and CS 38 or permission of the instructor.

**Optional text:** *Computational Complexity* by Christos H. Papadimitriou. Addison-Wesley. 1995.

**Problem sets:** The problem sets are extremely important – for this material, the best way to learn is by doing. I strongly encourage you to work in groups of two or three on the homework. However, you must each turn in your own write-up (preferably LaTeXed) and note with whom you worked. The rules on problem sets are:

- There are 7 problem sets. They are handed out at the end of the Thursday lecture, and they are due at the beginning of the following Thursday lecture.
- The quality (clarity, conciseness, neatness) of your write-up counts. I will provide a LaTeX template as well as LaTeX source for the problem sets to encourage you to prepare your solutions using LaTeX.
- You may elect to take a three-day extension (until 9am Monday) on *one* problem set without penalty. Other problem sets turned in late, but before 9am Monday, receive half credit. Late problem sets should be turned in by putting them into my mailbox on the 3rd floor of Annenberg.

**Exams:** There will be a midterm and final exam. They will be indistinguishable from the problem sets, except that they will be cumulative, and you may not work with others on the exams. The problem-set rules apply to exams as well. There are no extensions for the exams, and no partial credit for exams that are turned in late.

**Honor code:** For homework and exams, you may consult *only* the following material: (1) lecture slides and problem sets posted on the class webpage, (2) solution sets for problem sets you have already turned in, (3) course notes you or others took during lecture, and (4) the optional text (Papadimitriou). **I am well aware that there is material from past iterations of this course readily available (online and elsewhere). You may not seek out, study from, or otherwise consult this material during the term, starting now (April 2, 2019).** Please feel free to ask me for clarification if any of these guidelines are unclear.

**Collaboration policy:** Collaboration on problem sets is encouraged, and you may work together in small groups to figure out a solution, including working out details of parts that are challenging or may require a clever trick. You must however turn in your own writeup that may draw on *ideas* from your group, even in detail, but *you may not use or look at the completed work of others.* The writeup should note with whom you worked. You are individually responsible for learning and understanding the course material in preparation for the exams, and this is not likely to happen if you rely too heavily on your collaborators!

**Feedback:** If you have any comments or concerns on issues like: the pace of the lectures, the difficulty of the material, time spent on problem sets, or anything else, please let me or the TAs know!.

**Evaluation and Grades:** Your grade will be based on the following (weighted) components:

Homework 60%; Participation 10%; Midterm 15%; Final 15%.

If you earn 90% of the available (weighted) points you are guaranteed at least an A of some form, 80% guarantees at least a B of some form, 70% guarantees at least a C of some form, etc... If you are taking the course pass/fail, you need to earn a C- or higher to pass.

**Tentative schedule of topics:**

| Lecture | Date | Topic | Assignments |
|---|---|---|---|
| 1 | April 2 | intro and review | |
| 2 | April 4 | time and space classes | Problem Set 1 |
| 3 | April 9 | nondeterminism | |
| 4 | April 11 | nondeterminism | Problem Set 2 |
| 5 | April 16 | nonuniformity and circuit complexity | |
| 6 | April 18 | nonuniformity and circuit complexity | Problem Set 3 |
| 7 | April 23 | randomness | |
| 8 | April 25 | randomness | Problem Set 4 |
| 9 | April 30 | randomness | |
| 10 | May 2 | randomness | Midterm |
| 11 | May 7 | alternation and the PH | |
| 12 | May 9 | alternation and the PH | Problem Set 5 |
| 13 | May 14 | interaction | |
| 14 | May 16 | interaction | Problem Set 6 |
| 15 | May 21 | PCPs and hardness of approximation [Drop Day is May 22] | |
| 16 | May 23 | PCPs and hardness of approximation | Problem Set 7 |
| 17 | May 28 | counting classes | |
| 18 | May 30 | relativization and natural proofs | Final Exam |
| - | June 6 | | Final Exam due |