CSCI 599: Complexity
Units: 4
 Spring 2023 Friday 1:00-4:20pm

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Course Description
Computational complexity theory focuses on understanding the fundamental limitations and capabilities of *efficient computation.* For example, which computational problems inherently require a huge amount of computational resources to solve, no matter how clever the algorithm? Typical resources include running time, running space/memory, and randomness. The most basic question of computational complexity is how to classify computational problems according to their difficulty. For example, the famous P vs. NP question asks whether the 3-SAT problem can be solved in polynomial time.

In this course, we will introduce some complexity classes, including P, NP, BPP, P/poly, and IP. We will also learn connections between complexity classes, and how to classify problems into appropriate classes. This course might be interesting to graduate students or advanced undergraduates, and in particular those who plan to do research in theoretical computer science.

Learning Objectives
The course is designed to enable students to:

1. Understand complexity classes, including P, NP, PSPACE, BPP, and classify computational problems into appropriate classes.
2. Understand reductions between computational problems, and understand NP completeness.
3. Learn hardness results of some computational problems.

Recommended Preparation:
Knowledge of the material covered in CSCI 270 (or the equivalent). If you do not formally have this knowledge and still wish to take this course, please send me an email to discuss whether you should enroll in this course. The most important topics that we will assume from CSCI 270 are reductions, asymptotic running time, and NP-completeness. General mathematical skills including basic probability and combinatorics will also be assumed.

Textbook
We will use the book *Computational Complexity: A Modern Approach* by Sanjeev Arora and
Boaz Barak.

Course Notes
Grading includes two parts:

   • Three homework sets. (60%)
   • A take-home final exam. (40%)

The problem sets will be challenging, so be sure to start them early. You are encouraged
to collaborate the homework problems with each other in small groups (3 people), as long
as you list all discussion partners on your problem set. Each group only needs to submit
one copy of the solution. The take-home final exam should be solved independently.

Grading Breakdown

Assessment Tool (assignments)	Points	% of Grade
Homework	60	60%
Final exam	40	40%
TOTAL	100	100%

Assignment Submission Policy
Homework and final exam should be submitted electronically.

Grading Timeline
Grading of each homework will be ready one week after submission.

Course Schedule: A Weekly Breakdown

	Topics/Daily Activities	Readings/Preparation	Deliverables
Week 1	Introduction Computational models	Textbook: Section 1	
Week 2	Time complexity Hierarchy theorems	Textbook: Section 3	

Week 3	Reduction NP-completeness	Textbook: Section 2	
Week 4	Space complexity PSPACE = NPSPACE	Textbook: Section 4	HW 1: Due on Friday
Week 5	Log-space NL = coNL	Textbook: Section 4	
Week 6	Boolean circuit	Textbook: Section 6	
Week 7	Circuit lower bounds	Textbook: Section 6	
Week 8	Circuit lower bounds	Textbook: Section 6	HW 2: Due on Friday
Week 9	Randomness in computation	Textbook: Section 7	
Week 10	Randomness in computation	Textbook: Section 7	
Week 11	Randomness in computation	Textbook: Section 7	
Week 12	Interactive proofs	Textbook: Section 8	HW 3: Due on Friday

Week 13	IP = PSPACE	Textbook: Section 8	
Week 14	Average-hardness One-way functions	Textbook: Section 10	
Week 15	Pseudorandom generators	Textbook: Section 16	
FINAL	Final Exam	Final: Due on Friday	Refer to the final exam schedule in the USC *Schedule of Classes* at classes.usc.edu.

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Support Systems:

Counseling and Mental Health - (213) 740-9355 – 24/7 on call
studenthealth.usc.edu/counseling
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
suicidepreventionlifeline.org
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention and Services (RSVP) - (213) 740-9355(WELL), press "0" after hours – 24/7 on call
studenthealth.usc.edu/sexual-assault
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED)- (213) 740-5086 | Title IX – (213) 821-8298
equity.usc.edu, titleix.usc.edu

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following *protected characteristics*: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations. The university also prohibits sexual assault, non-consensual sexual contact, sexual misconduct, intimate partner violence, stalking, malicious dissuasion, retaliation, and violation of interim measures.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298
usc-advocate.symplicity.com/care_report
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity |Title IX for appropriate investigation, supportive measures, and response.

The Office of Disability Services and Programs - (213) 740-0776
dsp.usc.edu
Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy - (213) 821-4710
uscsa.usc.edu
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101
diversity.usc.edu
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
dps.usc.edu, emergency.usc.edu
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call
dps.usc.edu
Non-emergency assistance or information.