CS 505: Computability and Complexity Theory August 25, 2003

CS 505 Course Information

Prof. Robert H. Sloan *Handout 1*

Class: Mondays and Wednesdays, 2:00–3:15. Lecture Center A3.
Instructor: Prof. Robert H. Sloan
Office hours: Tuesdays, 1:30–3:30, Wednesdays, 9:45–11:00, and by appointment.[1]
Email: `sloan@uic.edu`

This course will have a home page off of my home page at `http://www.cs.uic.edu/~sloan`

However, at the moment it has only the information in this handout (with a few links, like to the site for the textbook).

The course will have a UIC Blackboard site.

I intend to use it rather lightly: I will post handouts that I have in electronic form (e.g., problem sets), homework grades, and a few interesting web links there.

1 Prerequisites

In fact, perhaps all but one or two lecture topics will be self contained, so the main thing that you really need is mathematical maturity. Basically, if you are happy to get homework problems that say, "Prove the following theorem," then you are in the right course; and if not, then not.

The normal prerequisite is an undergraduate course in automata theory, such as CS 301. You should be familiar with the basics of regular and context free languages, and the machines that accept them, though we will probably only explicitly refer to them in one or two lectures.

We will begin with a fast review of Turing machines.

See me if you want to discuss your background.

2 Material Covered

1. Overview of the history of the subject (0.5–1 lecture)

   Hilbert's 1900 lecture, Gödel, Turing, and Church, etc.

[1] I enjoy company; feel free to ask for an appointment most anytime, or just drop by—I'm around a lot.

2. Computability theory: What can we compute? (2.5–3 weeks)

   Turing machines, Church-Turing thesis, decidability, halting problem, Reductions between problems, Rice's Theorem. (Sipser text, Chapters 3, 4, and parts of 5 and 6).

3. Complexity theory: How fast can we compute it?

   (a) Classic time and space classes (6 weeks)

   Sipser text, Chapters 7–9

   Roughly speaking, the hierarchy

   $$\mathrm{L} \subseteq \mathrm{NL} \subseteq \mathrm{P} \subseteq \mathrm{NP} \subseteq \mathrm{PSPACE}$$

   Specific topics will include

   - Complexity measures—especially time, also space
   - P and NP, SAT, poly-time reducibility
   - NP-completeness
   - Cook-Levin theorem
   - PSPACE, TQBF, Savitch's theorem
   - Games, Generalized Geography
   - L and NL, NL = coNL
   - Hierarchy theorems
   - Provably intractable problems, oracles

   (b) Probabilistic and alternating classes (1.5–2 weeks)

   Sipser text Chapter 10.2–10.3 has a brief overview; Papadimitriou has more.

   - Alternating time and space and the polynomial hierarchy
   - Probabilistic Computation
   - BPP

4. Advanced topics as time allows selected from (hoping for 3–5.5 weeks):

   (a) Approximation algorithms.

   (b) Intro to computational learning theory.

   (c) Interactive proofs.

   (d) Intro to modern cryptography.

3 Textbooks

The required textbook for the course is *Introduction to the Theory of Computation* by Michael Sipser, PWS, 1997.

That book does an excellent job with the material for at least the first 60% of the course. (One of the things it does an excellent job with is going over things somewhat lightly, so we can cover that material in only 60% of the course and move on to some more advanced material.)

There are two optional texts:

- Christos Papadimitriou, *Computational Complexity*
- Garey and Johnson, *Computers and Intractability: A Guide to the Theory of NP-completeness*

4 Problem sets

Problem sets will be assigned on a continuing basis every week or two.

Late homework will *not* be accepted, because I will often use the last half hour of class on the day they're due to go over the solutions. If you can't make a class when a problem set is due, turn it in early at my office.

Cooperation policy: You may collaborate in study groups on the solution of the homeworks. You must, however, write up solutions on your own (not copy). If you do collaborate, acknowledge your collaborators in the write-up for each problem.

You are encouraged *not* to seek online materials, etc. If you do obtain a solution with help (e.g., through web search or library work), acknowledge your source, and write up the solution on your own.

You must acknowledge in writing any source you use for help.

5 Grading

Besides the problem sets, there will be a mid-term quiz and a final exam. (One or both might be take-home, or might not.)

If the class is small enough, I may have students present some of the optional topics at the very end.

The problem sets are worth about 33–45% of the grade.

The midterm quiz will be worth about 20–33% of the grade.

The final exam will be worth about 33–40% of the grade.

This policy is subject to change at any time for any reason.

6 First homework assignment

The first problem set is due Wednesday, September 6 (i.e., Wednesday of the second week of classes) . I will provide hard copy in class on the first day of the course, and it will also be posted as a PDF to the course's UIC Blackboard site.