050.370/670 — Formal Methods in Cognitive Science: Language

Fall 2006
ThF 12:00-1:30
134A Krieger
http://www.cog.jhu.edu/courses/370

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Overview

This course will be devoted to the study of formal systems that have proven useful in the cognitive science of language. We will discuss a wide range of mathematical structures and techniques and demonstrate their applications in theories of grammatical competence and performance. A major goal of this course is bringing students to a point where they can evaluate the strengths and weaknesses of existing formal theories of cognitive capacities, as well as profitably engage in such formalization, constructing precise and coherent definitions and rigorous proofs.

Course Requirements

Learning this material is a bit like learning to dance: you can't do it by just watching. Rather, in learning mathematics, it is absolutely crucial that you do some mathematics. To this end, there will be (roughly) weekly problem sets. These will in general be assigned on wednesday and will be due one week later. These problem sets will account for 60% of the grade. At approximately midway through the course and at the end of the term (precise dates to be announced), I will assign longer problem sets with broader coverage, call them take-home exams if you like. Each of these will count for 15% of the grade. The remaining 10% of the grade will be given on the basis of constructive class participation.

I encourage/implore you to work together with your fellow students on the weekly problem sets. Not only will working together make the process of doing the problems more fun, but it will also give you helpful insights into other ways of thinking about the material. Once you have finished your discussions, however, you are required to write up your answers on your own. For the take-home exams, however, I expect that you will work entirely on your own. Any evidence of collaboration on these exams or obtaining answers from another source will result in no credit on the assignment and/or failure in the course, depending on the severity of the situation. Ignorance of these rules is not an excuse.

Reading

The textbook for the course is:

> *Mathematical Methods in Linguistics*, Barbara Partee, Alice ter Meulen and Robert Wall, Kluwer, 1993

This is available in the bookstore (as well as from a variety of on-line booksellers). Much of the material in this text is covered in greater depth in other sources. Some good ones are:

> *Stories about Sets*, N. Ya. Vilenkin, Academic Press, 1968.
>
> *Naive Set Theory*, P.R. Halmos, Van Nostrand, 1960.
>
> *Structures for Semantics*, Fred Landman, Kluwer, 1991.
>
> *Introduction to the Theory of Computation*, Michael Sipser, Thomson Course Technology, 2006.
>
> *Introduction to Automata Theory, Languages and Computation*, John Hopcroft and Jeffrey Ullman, Addison-Wesley, 1979.

At various points in the term, I may assign sections from these other texts or from other materials, in which case I will make them available in the Cognitive Science department.

(Tentative) Course Outline and (Partial) Reading List

This overly ambitious outline will almost certainly be revised depending upon our rate of progress. A partial reading list is provided for certain topics. More will be added during the course of the term. Numbers following *PMW* refer to chapters from the Partee et al. text.

Topic	Subtopic	Readings
Mathematical Preliminaries	Sets	PMW 1; *Stories about Sets*, chapters 1–2.
	Relations and Functions	PMW 2.
	Finite and Infinite Cardinalities	PMW 4; *Stories about Sets*, chapter 3.
Discrete Structures	Partitions, Orders	PMW 3.
	Graphs, Structural equivalence	
	Trees	PMW 16 pp.439-446.
	Algebras, Morphisms	PMW 9, 10.
	Lattices	PMW 11

Formal Languages, Grammars and Automata	Basic Concepts: Automata and Grammars	PMW 16
	Regular languages, Finite State Automata	PMW 17
	Finite State Phonology/Morphology	
	Pushdown Automata, Context-Free Grammars	PMW 18
	Context-Free Parsing, Psycholinguistic Implications	
	Beyond Context-Free Languages: Tree Adjoining Grammars.	PMW 21; A. Joshi and Y. Schabes (1997) Tree-adjoining grammars. In G. Rozenberg and A. Salomaa (editors), *Handbook of Formal Languages, Volume 3: Beyond Words*, pp. 69–124. Springer, New York.
	Turing Machines and Church's Thesis, Type-0 Grammars. Peters and Ritchie on Transformational Grammars.	PMW 19.1-19.4, 22
	Complexity theory, NP completeness	