Syllabus for CS 498: Logic in Computer Science

Pre-requisites: Students should have taken CS 173 and CS 374 or their equivalents, prior to taking this class. In particular, students should be familiar with inductive proofs, propositional logic syntax, ability to use quantifiers (forall and exists) to express simple properties in first-order logic, basic properties of finite graphs, simple graph algorithms, finite automata and regular languages, deterministic and non-deterministic computational models, and complexity classes like NP.

Textbook: There is no single textbook that covers all the material in the class and so there is no required textbook. Lecture notes will be the primary source of material and they will be posted on the course Compass page. In addition the following recommended texts (with the topics they cover) might be useful.

- Propositional logic and its proof theory, and first order logic

- Decision procedures for fragments of First Order Logic

- Automata Theory and Logic

- Finite Model Theory

- Parametric Complexity
Syllabus: The following is the list of topics likely to be covered, and the number of lectures spent on each; each lecture is 75 minutes long.

- Automata Theory, Computability Theory and Complexity Theory Recap. \textit{2 lectures}
- Propositional Logic: Syntax and Semantics; Proof Theory, Soundess, Completeness, and Compactness. \textit{3 lectures}
- SAT solvers. \textit{1 lecture}
- First Order Logic: Syntax and Semantics; Resolution proof system. \textit{1 lecture}
- Gödel’s Completeness Theorem, Church-Turing Theorem. \textit{1 lecture}
- Gödel’s Incompleteness Theorem. \textit{1 lecture}
- Second Order Logic: Syntax and Semantics; Consequences of the Incompleteness theorem. \textit{1 lecture}
- Büchi-Elgot-Trakhtenbrot Theorem and its consequences. \textit{2 lectures}
- Linear Temporal Logic and First Order Logic on Words. \textit{1 lecture}
- Tree Automata and Monadic Second Order Logic with two successors. \textit{2 lectures}
- Two player games and Ground Rewrite Systems. \textit{1 lecture}
- Parametric Complexity and MSO interpretations: Series-Parallel graphs, tree width and dynamic programming, Courcelle’s Theorem and its applications. \textit{4 lectures}
- Finite Model Theory. \textit{2 lectures}
- Ehrenfeucht-Fraisse games and first-order expressiveness. \textit{1 lecture}
- Descriptive Complexity. \textit{2 lectures}
- Additional Optional topics include: automata on infinite words, proof complexity, decision procedures for fragments of first order logic, SAT modulo theory solvers. \textit{3 lectures}

Graded Work: The course will have two 75 minute lectures each week. There will be roughly 5 homeworks (once every 2 weeks) and a final exam.