

CS 8803 LCS: Logic in Computer Science

Course Syllabus

Course Information

Instructor	Suguman Bansal (suguman@gatech.edu)
Course Number	CS 8803 LCS
Term	Fall 2026

Course Description

This course provides a rigorous introduction to logic as a foundational tool in computer science. Students will study propositional logic, first-order logic, temporal logic, and automata theory, with applications to formal verification, databases, and trustworthy AI. The course emphasizes formal proof techniques, algorithmic reasoning, and the connections between logic and computational complexity.

Course Learning Outcomes

By the end of this course, students will be able to:

1. Define and manipulate the syntax and semantics of propositional logic, first-order logic, and linear temporal logic.
2. Apply SAT solving techniques including the DPLL procedure, unit propagation, and resolution.
3. Reason about computational complexity classes (P, NP, Co-NP, PSPACE, EXPTIME) and use polynomial-time reductions.
4. Construct and analyze deterministic and nondeterministic finite automata over finite and infinite words.
5. Translate LTL formulas to generalized Büchi automata and apply the translation to model checking and synthesis.
6. Formulate relational database queries using first-order logic and analyze their complexity.
7. Model decision-making problems as Markov Decision Processes and reason about optimal policies and reinforcement learning with logical specifications.

Required Course Materials

No textbook is required. Lecture notes will be provided by the instructor and serve as the primary reference. Supplementary resources will be shared in consultation with students as topics are covered.

Course Schedule

The following schedule is approximate and subject to revision. Any changes will be announced in class.

Week	Topic	Content
1–2	Propositional Logic	Syntax and grammar of propositional logic; unique readability theorem; semantics and truth assignments; satisfiability and validity
3	SAT Solving	Naive SAT algorithm; DPLL procedure; unit propagation and polarity heuristics; encoding 3-colorability as SAT
4	Resolution	Resolution rule; soundness and completeness of resolution; resolution refutation; pigeonhole principle; DPLL vs. refutation
5–6	Computational Complexity	Turing machines and algorithmic complexity; PTIME, PSPACE, NP, Co-NP, EXPTIME, EXPSPACE; Cook-Levin theorem; NP-completeness; polynomial-time reductions; time hierarchy theorem
7–8	First-Order Logic	Motivation and syntax of FOL; semantics and mathematical structures; free and bound variables; relevance lemma; evaluating FOL formulas; complexity of evaluation
9	FOL Applications	Relational databases; SQL as FOL; query complexity vs. data complexity; limitations of FOL; motivation for richer logics
10–11	Automata Theory	Deterministic and nondeterministic finite automata (DFA/NFA); closure properties; Büchi automata (DBA/NBA); ω -regular languages; DBA vs. NBA expressivity
12–13	Linear Temporal Logic	LTL syntax and semantics; temporal operators (X, U, F, G); LTL-to-automata translation; generalized Büchi automata (GNBA); satisfiability and model checking
14	Verification & Synthesis	Model checking: correctness and complexity; Vardi-Wolper theorem; LTL synthesis; game-theoretic formulation; winning strategy computation
15	Reinforcement Learning	Markov decision processes (MDPs); policies and probability of satisfaction; optimal policy computation; reinforcement learning with LTL specifications

Grading Policy

This course is graded on a letter grade basis. The final grade will be based on the following components:

Component	Weight
Project 1	40%
Project 2	40%
Assignments	20%

Bonus: Class Performance	Bonus
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The grade will be assigned based on agreed-upon objectives commensurate with the difficulty and scope of the work. It is the joint responsibility of the instructor and students to discuss expectations. The grading process will be clearly articulated to allow reasonable prediction of progress toward the final grade throughout the semester. Bonus points for class performance may be awarded at the instructor's discretion based on active and constructive participation.

Attendance Policy

Regular attendance is expected and contributes to active participation in the course. Students who cannot attend a scheduled lecture are responsible for obtaining notes and catching up on material. Any adjustments to attendance expectations will be communicated in advance.

Academic and Research Honesty/Integrity Statement

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. Please review the Student Code of Conduct and the Academic Honor Code, especially Appendix A: Graduate Addendum to the Academic Honor Code.

Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services as soon as possible to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail the instructor as soon as possible in order to set up a time to discuss your learning needs.

Student-Faculty Expectations

At Georgia Tech, we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. The Student-Faculty Expectations document articulates some basic expectations that you can have of the instructor and that the instructor has of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Students are encouraged to remain committed to the ideals of Georgia Tech while in this class.