



# Syllabus



*All information here is subject to change. Changes will be announced in class and on Canvas.*

## 1. FUNDAMENTALS

*Instructor:* Stephen Siegel, [siegel@udel.edu](mailto:siegel@udel.edu). Office hours: Mon/Wed 3:00–4:00 PM, or by appointment, Smith Hall 432.

*Teaching Assistant:* Alex Wilton, [awilton@udel.edu](mailto:awilton@udel.edu). Office hours: Tue. 10:00 AM–12:00 PM, and Fri. 9:00–11:00 AM, Smith Hall 102A.



*Class meetings:* Brown Lab, Room 205, 5:20–6:40 PM, Mon/Wed from Wed. Aug. 30 to Mon. Dec. 11, except Mon. Sep. 4, Mon. Nov. 20, and Wed. Nov. 22. Total number of classes: 25.

*Midterm exam:* In class, Wed. Oct. 18.

*Final exam:* Brown Lab 205, Sunday, Dec. 17, 4:30–6:30 PM.

*Texts:* There is no required text. I will be handing out class notes in place of a text. However, the following are good supplemental references:

- (1) Huth & Ryan, *Logic in Computer Science: Modeling and Reasoning About Systems*, 2nd ed., Cambridge University Press, 2004. <https://www.cs.bham.ac.uk/research/projects/lics/>
- (2) Almeida, Frade, Pinto, & de Sousa, *Rigorous Software Development: An Introduction to Program Verification*, Springer, 2011. <https://www.springer.com/gp/book/9780857290175>. *Free for UD associates via SpringerLink.* The general approach of this text is closest to mine. However the chapters on Propositional and First Order Logic are very succinct; my notes will go into greater detail.
- (3) Leary & Kristiansen, *A Friendly Introduction to Mathematical Logic*, 2nd ed., 2015. <https://milneopentextbooks.org/a-friendly-introduction-to-mathematical-logic/>. *Free.*

Note: there are many different approaches to logic and variations on every definition, theorem, and algorithm. It can be confusing to students new to the subject to read different texts and see what appear to be statements that are inconsistent. To avoid this confusion, my notes, or what I say in class, are the only authoritative source of information for this course.

*Course Canvas page:* <https://udel.instructure.com/courses/1731043>. The name of the site is 23F-CISC404-010. Canvas will be used to share documents and for grades.

*Slack workspace:* <https://logic-cs.slack.com>. To sign up, go to <https://join.slack.com/t/logic-cs/signup>. We will use Slack for asynchronous discussion of material and to ask and answer questions. Do not use Slack for discussion involving any confidential information, such as your grades or academic record—for these things, use email, phone, or Zoom conference.

## 2. COURSE ABSTRACT

Logic is fundamental to computer science. Boolean algebra was the theoretical basis for the development of digital circuits. In Turing's classic 1936 paper that introduced Turing machines and the halting problem, *On computable numbers, with an application to the Entscheidungsproblem*, the main application is to an open problem in first order logic. Model checking, theorem proving, SAT and SMT solvers, formal specification and verification of systems are all important computer science areas intimately connected to logic.

This class is a formal, rigorous introduction to first-order logic with emphasis on its relevance to computer science. Topics include syntax, semantics, models, formal proofs and results on soundness, consistency, completeness, compactness and undecidability. The Alloy logic and verifier will also be used. Modal logic, second order logic, and Hoare logic may also be discussed.

## 3. TOPICS

Here is an approximate ordered list of topics we will cover, subject to change:

- (1) Propositional logic
  - (a) syntax of propositional logic
  - (b) semantics, entailment
  - (c) equivalences
  - (d) proof systems: natural deduction
  - (e) soundness
  - (f) completeness
  - (g) satisfiability and validity problems
  - (h) normal forms
  - (i) SAT solving: DPLL and Tseytin's Transformation
- (2) First Order Logic
  - (a) syntax: signatures (vocabulary), formulas and terms
  - (b) semantics: models, interpretation
  - (c) equivalences
  - (d) FOL + Equality
  - (e) natural deduction for FOL
  - (f) soundness
  - (g) completeness and Gentzen's Model Existence Theorem
  - (h) compactness and applications
  - (i) undecidability of FOL (using Turing Machines)
  - (j) normal forms
  - (k) semidecidability
  - (l) first order theories
- (3) More logical systems
  - (a) Alloy logic: FOL + transitive closure
  - (b) second order logic
  - (c) modal Logic
  - (d) Hoare Logic

## 4. HOW THIS CLASS WILL OPERATE

Classes will be rather traditional lectures with discussion. I will distribute notes for each class at least one week preceding the class. You should read these before the class and come with questions.

There will be approximately 6 homework assignments. You may work on the homework with other students in this class only. By "work on...with" I mean each student is contributing and collaborating in the solution to each problem. It is *not acceptable* to just copy another student's

solution to a problem. It is *not acceptable* to divide the problems up and say you work on these while I work on those. It is acceptable to work on a problem yourself for a while, and, after getting stuck, ask if someone can give you a hint. It is acceptable—in fact, encouraged—to sit down together (perhaps virtually), discuss the problem, exchange ideas, and collaboratively come up with a solution. However, in the end, each student should write up the solution him or herself, in their own words/language and in their own handwriting/latex/word processing. And of course, you must at a minimum understand what you submit.

At this time, I don't have any objection to using Chat-GPT and the like for help on the homework, *as long as you clearly explain how you used it*. Of course, the answers still have to be correct. Show me what you asked, and what it answered. Honestly, I'm not sure it will help—in my experience it gives a lot of wrong answers to logic questions. Also, Chat-GPT likes to *plagiarize* and if you submit plagiarized text, using Chat-GPT is no excuse. I reserve the right to change my mind on this policy if I think it's not working.

There will be a midterm and a final exam. In both cases, I will distribute a list of problems at least one week beforehand. The problems on the exam will be some subset of the problems from the list, perhaps with small variations (like changing a formula). There should be no surprises on the exam.

The Slack workspace may be used to ask and answer questions, post interesting thoughts, or discuss anything related to this class or logic generally. It is recommended that everyone install the Slack tool (or use it through the web browser) and check the workspace regularly. Important announcements will also be posted on Canvas.

## 5. GRADING

Participation: 10%. Participation grade is based on: showing up, asking or answering questions (including electronically or in office hours), and submitting the final course evaluation. Attendance will be taken at each class. *Note*: if you are *sick*, even if you think it is just a cold, don't come to class. Just send me an email before class and your attendance will be excused. For the exams, you should show up unless you really are too sick to take the exam.

Homework: 40%.

Midterm: 20%.

Final: 30%.

*Late policy for Homework*: The deadline for HW is the beginning of class (i.e., 5:20 PM sharp). If you turn in HW after deadline but before start of next class, it will be graded with 10% penalty. Everyone gets one free exception, and other exceptions might be granted for special situations (but speak to me first).

*Letter grades* are obtained from the numerical score as follows:

Minimum score	93	90	87	83	80	77	73	70	67	63	60	0
Letter Grade	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F

## 6. ACADEMIC HONESTY

You should not attempt to search for answers to homework problems on the internet or anywhere else. You may use Chat-GPT and the like for homework as explained above. You should not discuss the problems with anyone outside of class. As explained above, you may work with other students in the class on the homework.

Copying any other person's work (off the Internet, for example) without proper acknowledgment is **plagiarism**, a serious offense, and will result in charges filed in accord with the University's Policy on Academic Honesty.