



## THEORY

# CISC 401/601: Elements of the Theory of Computation

University of Delaware, Spring 2023



## Syllabus

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

### 1. FUNDAMENTALS

*Class meeting times:* 2:30–3:20 PM, Mon/Wed/Fri from Mon. Feb. 5 to Mon. May 15, except Mar. 27–31 (Spring Break). Total number of classes: 40.

*Class room:* Ewing Hall, Room 204. Some classes may be held via Zoom; these will be announced in advance.

*Instructor:* Stephen Siegel, [siegel@udel.edu](mailto:siegel@udel.edu). Office hours: Mon/Wed 3:30–4:30 PM and by appointment. Office: Smith 432.

*Teaching Assistant:* Pranjal Dhakal, [dpranjal@udel.edu](mailto:dpranjal@udel.edu). Office hours: Thursdays 11:00 AM – 1:00 PM, Smith 102A.

*Text:* Davis, Sigal, and Weyuker, *Computability, Complexity, and Languages*, 2nd ed., Elsevier, 1994. Publisher link:

<https://www.sciencedirect.com/book/9780122063824/computability-complexity-and-languages>

An e-text version can be purchased from

<https://www.elsevier.com/books/computability-complexity-and-languages/davis/978-0-08-050246-5>

The UD library also has a hard copy on reserve and may purchase a limited-user institutional license for the e-text.

*Course Canvas page:* <https://udel.instructure.com/courses/1698913>. The name of the site is 23S-CISC401-010. Canvas will be used for quizzes, the homework, to share documents, and for grades.

*Slack workspace:* <https://cisc601.slack.com>. Join this workspace now: <https://join.slack.com/t/cisc601/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

What exactly does it mean to say a problem is *computable*? What is the precise meaning of *algorithm*, and which problems even admit an algorithmic solution? Which do not? These are the sorts of questions that mathematicians and logicians, such as Alan Turing, Emil Post, and Alonzo Church, tackled in the first half of the twentieth century, forming the theoretical foundations of the emerging science of computation.

Today, theoretical computer science covers a wide range of topics, including automata theory (e.g., finite state automata, pushdown automata, Turing machines), computational complexity (e.g., “Big-O” complexity), type theory, and the formal syntax and semantics of programming languages.

A unifying theme is the use of precise, mathematically rigorous methods to reason about these issues.

Students in this course will learn the standard mathematical language and techniques used in theoretical computer science. We will apply these to a selection of important computational topics, such as definitions of computability, recursive functions, formal languages, and automata theory.

### 3. TOPICS

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

- (1) Mathematical Preliminaries: sets, tuples, functions, basic logic, proof by contradiction, mathematical induction
- (2) Programming Language: formal syntax and semantics
- (3) Computable and Partially Computable Functions
- (4) Primitive Recursive Functions
- (5) Universal Programs, the Halting Problem, and Rice's Theorem
- (6) Turing Machines
- (7) Finite State Automata and Regular Languages: Pumping Lemma and applications, non-deterministic and deterministic FSAs, minimization, complementation
- (8) Context-Free Languages
- (9) Context-Sensitive Languages and the Chomsky Hierarchy

### 4. HOW THIS CLASS WILL OPERATE

Classes will be rather traditional lectures with discussion. Please bring questions, and take notes. There will be assigned reading for most classes, and short Canvas quizzes based on the readings. There will be approximately 6 homework assignments, two midterm in-class exams, and a cumulative final exam during finals week.

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.

Exams are strictly individual work.

The Slack workspace may be used to ask and answer questions, post interesting thoughts, or discuss anything related to this class or computer science theory. 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 (showing up, asking questions, participating in Slack discussion, attending office hours, submitting the final course evaluation): 5%.

Canvas Quizzes: 10%

Homework: 25%.

Midterms:  $2 \times 15\% = 30\%$ .

Final: 30%.

*Late policy for Homework:* Homework is due exactly when class begins. Anything submitted late will receive a penalty of 5% per class. After 1 week, submissions might not be accepted. Hence the penalty is either 5%, 10%, or 15%. Everyone gets two free one-class exceptions.

*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 or exam problems on the internet or anywhere else. 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 Policies on Academic Integrity.

## 7. ENVIRONMENT

Everyone is expected to treat everyone else — students, professor, and TA(s) — with courtesy and respect in all aspects of this course. Violations will be dealt with in accord with the University Conduct Process.

Cell phones must be turned off and stowed out of sight for the duration of the class. Computers and tablets can be used in class for class activities only, such as taking notes. Repeated violators will receive additional problems on their homework, or have their participation or quiz grades docked.