

# COMP 455 Models of Languages and Computation

Fall 2024

## Course information:

Department: COMP  
Course Number: 455  
Course Sections: 001 and 002  
Course Title: Models of Languages and Computation  
Term: Fall 2024  
Days and Time: Tue/Thu 9.30 -10.45am  
Location: Sitterson 014  
Website: <https://uncch.instructure.com/courses/65125>

## Instructor:

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## Catalog Description

Introduction to the theory of computation. Finite automata, regular languages, pushdown automata, context-free languages, and Turing machines. Decidable and undecidable problems. Basic complexity theory notions

## Prerequisites

COMP 210 (data structures) and COMP 283 or MATH 381 (discrete mathematics). A grade of C or better is required in both courses.

## Target Audience

This is a required course for undergraduate computer science majors, typically taken in the sophomore, junior, or senior year.

This course is a prerequisite to some upper-level electives such as COMP 520 Compilers, COMP 524 Programming Language Concepts, and COMP 655 Cryptography. Students planning to take any of these courses or students generally interested in formal verification or text

processing will find the topics covered in this course particularly relevant.

### **Teaching Mode**

This is an in-person, on campus only, offering of COMP 455. In-person attendance at lectures is expected.

### **Textbook**

Course topics will follow sections from Introduction to Automata Theory, Languages, and Computation, 3rd edition, by Hopcraft, Motwani, and Ullman. Students are not required to purchase the textbook, but it is a valuable reference and supplemental study resource.

### **Grading**

30% 6 Homework Assignments

35%. 2 Mid-Term exams

35%. 1 Final exam

### ***Homework Assignments***

Homework assignments will be handed out approximately every 2-3 weeks.

Students may work together but must submit individually. All the submissions ***must*** be original, individual work.

Completed work must be submitted through Gradescope. Submissions physically handed in as paper or sent through email, Piazza, or any other channel will not be accepted. To submit a solution written on download an app like Tiny Scanner which takes photos using a

smartphone and converts them to a pdf which can then be submitted through Gradescope.

***The solutions must be written in the spaces provided in the assignment, scanned and uploaded. Submissions written on a paper will incur a penalty of 50%.***

***No late submissions will be allowed.***

## **Midterm Exams**

Two (2) in person, on paper midterm exams will be administered during the term. Each midterm exam is worth 17.5% of the overall course grade. Exams are timed and must be completed in 75 minutes. During this time no access will be allowed to notes, textbooks, slides, electronics, internet, etc.

Students who are unable to attend a midterm exam in person for any reason receive a score of zero (0) for the assessment. Make-up exams are offered only to students who have a university approved absence (UAA), at the time and place of the instructor's choosing. See <https://uaao.unc.edu> for more information about how to obtain a UAA.

Students who are connected with ARS for approved accommodations for tests/quizzes/exams may elect to take them at the ARS Testing Center. ARS requires testing appointments to be scheduled at least one week in advance—it is the student's responsibility to do this in the ARS Hub. Appointments must be scheduled to overlap with the class period in which the rest of the class takes the exam—for example, if the class is taking the exam from 9-10:15 am, then the start time should fall within that timeframe. Deviations must be approved by the instructor beforehand. Exams scheduled with ARS which do not follow these scheduling policies will not be accepted or graded for credit.

## **Final Exam**

This course has a cumulative, in person, on paper final exam. The final exam is worth 35% of the overall course grade. The exam is timed and must be completed in 180 minutes. During this time, no access will be allowed to notes, textbooks, slides, electronics, internet, etc. The final exam is given in compliance with UNC final exam regulations and according to the UNC Final Exam Calendar.

Students who are unable to attend the final exam in person for any reason will receive either an AB or a FA as their final course letter grade. Make-up final exams are offered only to students who have a university approved final exam excuse.

## **Incomplete Letter Grades**

UNC offers the “incomplete” (IN) letter grade as an accommodation for students who have unexpected challenges arise during the semester which directly make completion of some course requirements by the end of the semester difficult. More information about the incomplete letter grade can be found here:

<https://catalog.unc.edu/policies-procedures/attendance-grading-examination/#text>

In this offering of COMP 455, incomplete grades are offered solely at the instructor’s discretion, but only when all of the following conditions are met.

1. The incomplete offer is made in writing from the instructor to the student
2. Every assignment to be made up is associated with a new due date

3. No make up work besides that designated in the written offer are accepted for credit
4. The student is not absent from the final exam.

### **Honor Code Statement**

Students must work alone on exams and submit original answer sheets for homework assignments.

Any of the following actions with regard to worksheets constitute an honor code violation:

1. Submit work originally produced by someone else
2. Post solutions that you wrote for this class to Piazza, Chegg, a public GitHub repository, any collaborative or publicly accessible internet location, or any public physical location
3. Share solutions that you wrote for this class with anybody else

Any of the following actions with regard to exams constitute an honor code violation:

1. Post one or more exam questions to Piazza, Chegg, or any other online or physical location
2. Speak with another student about exam questions
3. Collaborate with another student on an exam
4. Share exam answers with any other student
5. Look at exam answers from another student
6. Look at exam questions and/or answers for this course online

### **Lecture Plan**

This offering of COMP 455 consists of 28 lectures, roughly split into 15 weeks. The following topics will be discussed.

1. Overview
2. Preliminaries
3. Alphabets and Languages

4. Deterministic Finite-State Automata (DFAs)
5. Regular languages
6. Closure properties of regular languages.
7. Non-Deterministic Finite-State Automata (NFA)
8.  $\epsilon$ -NFA
9. Regular Expressions
10. Converting Between Regular Expressions and Finite-State Automata
11. The Pumping Lemma for Regular Languages

*12 Mid-term exam m01*

13. Context-Free Grammars (CFG) and context-free languages
14. Derivations, Parse Trees, Ambiguous Grammars
15. Pushdown Automata (PDA)
16. PDA Acceptance by Empty Stack and Final State
17. Equivalence of Pushdown Automata and Context-Free Grammars
18. The Pumping Lemma for Context-Free Languages
19. Closure Properties of Context-Free Languages

*20. Midterm Exam m02*

21. Turing Machines (TM)
22. The Church-Turing Thesis
23. Decidability, the Universal Language, the Halting Problem
24. Complexity classes
25. Reducibility

**Key Dates**

Tue, Aug 20      First day of class

Thu, Sep 3      No class (Wellness day)

***Tue, Sep 24          mid-term exam m01***

Tue, Oct 17          No class (Fall break)

***Thu, Oct 24          mid-term exam m02***

Thu, Nov 28          No class (Thanksgiving)

Tue, Dec 3          Last lecture

***Sat, Dec 6          Final exam (12-3pm) (section 02)***

***Fri, Dec 12          Final exam (8-11am) (section 01)***

### **Student Learning Outcomes**

A student successfully completing COMP 455 will have a sound grasp of the following topics:

1. Alphabets, Languages, and acceptance problems.
2. Finite-State Automata (DFA, NFA, and  $\epsilon$ -NFA models)
3. Regular languages and their closure properties
4. Regular expressions
5. Context-free grammars and context-free languages
6. Pushdown automata
7. Closure properties of context-free languages
8. Turing machines and the Church-Turing thesis
9. The halting problem
10. Decidability and undecidability
11. Complexity classes
12. Reducibility

### **Syllabus Changes**



The instructor reserves the right to make changes to the syllabus, including assignment due dates and exam dates. These changes will be announced as early as possible.

### **Syllabus Insert**

The remainder of this document is a required syllabus insert provided by the university. The insert lists the university policies and support services available for all undergraduate courses at UNC.

## **University of North Carolina at Chapel Hill Information for Undergraduate Classes Summer & Fall 2022**

### **Attendance Policy**

University Policy: As stated in the University's Class Attendance Policy, no right or privilege exists that permits a student to be absent from any class meetings, except for these University Approved Absences:

1. Authorized University activities
2. Disability/religious observance/pregnancy, as required by law and approved by Accessibility Resources and Service and/or the Equal Opportunity and Compliance Office (EOC)
3. Significant health condition and/or personal/family emergency as approved by the Office of the Dean of Students, Gender Violence Service Coordinators, and/or the Equal Opportunity and Compliance Office (EOC).

### **Class Policy:**

Instructors may work with students to meet attendance needs that do not fall within University approved absences. For situations when an absence is not University approved (e.g., a job interview or club activity), instructors determine their own approach to missed classes and make-up assessment and assignments.

### **University Approved Absence Office (UAAO):**

The UAAO website provides information and FAQs for students and faculty related to University Approved Absences.

Note: Instructors have the authority to make academic adjustments without official notice from the UAAO. In other words, it is not required for instructors to receive a University Approved Absence notification in order to work with a student. In fact, instructors are encouraged to work directly with students when possible.

### **Honor Code**

All students are expected to follow the guidelines of the UNC Honor Code. In particular, students are expected to refrain from “lying, cheating, or stealing” in the academic context. If you are unsure about which actions violate the Honor Code, please see me or consult [studentconduct.unc.edu](http://studentconduct.unc.edu).

### **Optional Mask Use Statement**

UNC-Chapel Hill is committed to the well-being of our community – not just physically, but emotionally. The indoor mask requirement was lifted for most of campus on March 7, 2022. If you feel more comfortable wearing a mask, you are free to do so. There are many reasons why a person may decide to continue to wear a mask, and we respect that choice.

## **Acceptable Use Policy**

By attending the University of North Carolina at Chapel Hill, you agree to abide by the University of North Carolina at Chapel Hill policies related to the acceptable use of IT systems and services. The Acceptable Use Policy (AUP) sets the expectation that you will use the University's technology resources responsibly, consistent with the University's mission. In the context of a class, it's quite likely you will participate in online activities that could include personal information about you or your peers, and the AUP addresses your obligations to protect the privacy of class participants. In addition, the AUP addresses matters of others' intellectual property, including copyright. These are only a couple of typical examples, so you should consult the full Information Technology Acceptable Use Policy, which covers topics related to using digital resources, such as privacy, confidentiality, and intellectual property.

Additionally, consult the University website "Safe Computing at UNC" for information about the data security policies, updates, and tips on keeping your identity, information, and devices safe.

## **Accessibility Resources and Service**

The University of North Carolina at Chapel Hill facilitates the implementation of reasonable accommodations, including resources and services, for students with disabilities, including mental health disorders, chronic medical conditions, a temporary disability or pregnancy complications resulting in barriers to fully accessing University courses, programs and activities.

Accommodations are determined through the Office of Accessibility Resources and Service (ARS) for individuals with documented qualifying disabilities in accordance with applicable state and federal laws. See the

ARS Website for contact information: <https://ars.unc.edu> or email [ars@unc.edu](mailto:ars@unc.edu).

## **Counseling and Psychological Services**

UNC-Chapel Hill is strongly committed to addressing the mental health needs of a diverse student body. The Heels Care Network website is a place to access the many mental resources at Carolina. CAPS is the primary mental health provider for students, offering timely access to consultation and connection to clinically appropriate services. Go to their website <https://caps.unc.edu/> or visit their facilities on the third floor of the Campus Health building for an initial evaluation to learn more. Students can also call CAPS 24/7 at 919-966-3658 for immediate assistance.

## **Title IX Resources**

Any student who is impacted by discrimination, harassment, interpersonal (relationship) violence, sexual violence, sexual exploitation, or stalking is encouraged to seek resources on campus or in the community. Reports can be made online to the EOC at <https://eoc.unc.edu/report-an-incident/>. Please contact the University's Title IX Coordinator (Elizabeth Hall, [titleixcoordinator@unc.edu](mailto:titleixcoordinator@unc.edu)), Report and Response Coordinators in the Equal Opportunity and Compliance Office ([reportandresponse@unc.edu](mailto:reportandresponse@unc.edu)), Counseling and Psychological Services (confidential), or the Gender Violence Services Coordinators ([gvsc@unc.edu](mailto:gvsc@unc.edu); confidential) to discuss your specific needs. Additional resources are available at [safe.unc.edu](http://safe.unc.edu).

## **Policy on Non-Discrimination**

The University is committed to providing an inclusive and welcoming environment for all members of our community and to ensuring that educational and employment decisions are based on individuals' abilities and qualifications. Consistent with this principle and applicable laws, the University's Policy Statement on Non-Discrimination offers access to its educational programs and activities as well as employment terms and conditions without respect to race, color, gender, national origin, age, religion, genetic information, disability, veteran's status, sexual orientation, gender identity or gender expression. Such a policy ensures that only relevant factors are considered and that equitable and consistent standards of conduct and performance are applied.

If you are experiencing harassment or discrimination, you can seek assistance and file a report through the Report and Response Coordinators (see contact info at [safe.unc.edu](https://safe.unc.edu)) or the Equal Opportunity and Compliance Office, or online to the EOC at <https://eoc.unc.edu/report-an-incident/>.

### **Diversity Statement**

I value the perspectives of individuals from all backgrounds reflecting the diversity of our students. I broadly define diversity to include race, gender identity, national origin, ethnicity, religion, social class, age, sexual orientation, political background, and physical and learning ability. I strive to make this classroom an inclusive space for all students. Please let me know if there is anything I can do to improve. I appreciate suggestions.

### **Undergraduate Testing Center**

The College of Arts and Sciences provides a secure, proctored environment in which exams can be taken. The center works with instructors to proctor exams for their undergraduate students who are

not registered with ARS and who do not need testing accommodations as provided by ARS. In other words, the Center provides a proctored testing environment for students who are unable to take an exam at the normally scheduled time (with pre-arrangement by your instructor). For more information, visit <http://testingcenter.web.unc.edu/>.

## **Learning Center**

Want to get the most out of this course or others this semester? Visit UNC's Learning Center at <http://learningcenter.unc.edu> to make an appointment or register for an event. Their free, popular programs will help you optimize your academic performance. Try academic coaching, peer tutoring, STEM support, ADHD/LD services, workshops and study camps, or review tips and tools available on the website.

## **Writing Center**

For free feedback on any course writing projects, check out UNC's Writing Center. Writing Center coaches can assist with any writing project, including multimedia projects and application essays, at any stage of the writing process. You don't even need a draft to come visit. To schedule a 45-minute appointment, review quick tips, or request written feedback online, visit <http://writingcenter.unc.edu>.

## **Grade Appeal Process**

If you feel you have been awarded an incorrect grade, please discuss with me. If we cannot resolve the issue, you may talk to our departmental director of undergraduate studies or appeal the grade through a formal university process based on arithmetic/clerical error, arbitrariness, discrimination, harassment, or personal malice. To learn more, go to the Academic Advising Program website.