New Jersey Institute of Technology

Ying Wu College of Computing

Department of Computer Science

CS 341 -Foundations of Computer Science II– Fall-2024

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Tutoring: https://computing.njit.edu/tutoring

Catalog Course Description

This course provides an introduction to automata theory, computability theory, and complexity theory. Theoretical models such as finite-state machines, push-down stack machines, and Turing machines are developed and related to issues in programming language theory. Also, the course covers undecidability and complexity classes P, NP, and NPC.

Detailed Description

This course presents some of the most fundamental results in theoretical computer science. These results attempt to answer, in a precise mathematical sense, the following two questions, which are of practical as well as philosophical interest:

1. Can a given problem be solved by computation?
2. How efficiently can a given problem be solved by computation?

We often focus on *problems* rather than on specific *algorithms* for solving problems. To answer both questions mathematically, we will need to formalize the notion of "computer" or "machine." The course outline breaks naturally into three parts:

1. Models of computation (Automata Theory)
    - Finite automata
    - Push-down automata
    - Turing machines
2. What can we compute? (Computability Theory)
3. How efficiently can we compute? (Complexity Theory)

Specifically, the topics covered will include regular languages (finite automata, regular expressions), nonregular languages, context-free languages (context-free grammars, pushdown automata), non-context-free languages, Turing machines and variants, Church-Turing Thesis, undecidability, reducibility, time complexity, and complexity classes P, NP, and NP-complete.

Text book

Michael Sipser, *Introduction to the Theory of Computation, Third Edition*. Course Technology, 2012, ISBN-10: 113318779X, ISBN-13: 978-1133187790.

Reference Book

Introduction to Automata Theory, Languages, and Computation (3rd Edition) by John E. Hopcroft , Rajeev Motwani , Jeffrey D. Ullman

Detailed Course Contents

Module I: Introduction to Languages and Automata: Formal Grammars and Chomsky Hierarchy, Regular Expression Deterministic and Nondeterministic Finite Automata, Regular Expression, Finite Automata with output, Properties of regular sets, pumping lemma for regular sets.

Module II: Context Free Grammars and Pushdown Automata: CFG: Formal Definition, Derivation and Syntax trees, Simplification Forms, Ambiguous Grammar, Properties: of CFL, Normal Forms (CNF and GNF), Pushdown Automata: Definitions, Relationship between PDA and context free language.

Module III: Turing Machine: The Turing Machine Model, Language acceptability of Turing Machine, Design of TM, Variations of TM, Universal TM, Church's Machine.

Module IV: Undecidability: Turing machine halting Problem, Post correspondence problems (PCP) and Modified Post correspondence problems, Undecidable problems.

Module V: Computability: Partial and Total Functions, Primitive Recursive functions, Recursive functions, Classes P, NP and NP complete.

Course Outcomes

The course outcomes of CS 341 are to

- Explain and prove the capabilities and limitations of different models of computing.
- Categorize and prove what problems can be solved by computation.
- Categorize and prove what problems can be solved efficiently and those for which there is no known efficient solution.

The specific learning objectives are that after completing the course, students will be able to

- Classify and prove a particular language as regular, context-free, decidable, Turing-recognizable or non-Turing-recognizable.
- Design a finite automaton and regular expression for a regular language.
- Prove that a nonregular language is not regular.
- Design context-free grammar and pushdown automaton for a context-free language.
- Prove that a non-context-free language is not context-free.
- Design a Turing machine for a decidable language.

- Prove or disprove closure properties (under union, intersection, concatenation, complementation, Kleene star) of classes of languages.
- Prove that certain languages are undecidable or non-Turing-recognizable.
- Explain nondeterminism and its role in computation and complexity theory.
- Explain the significance of complexity classes P, NP, and NP-complete, and perform reductions to prove NP-completeness of certain languages.

Prerequisites

Before taking CS 341, you must complete all of the following with grades of C or better:

1. A 100-series general undergraduate required course in CS
2. CS 241 (Foundations of Computer Science I)
3. CS 280 (Programming Language Concepts).

Assessment Strategy

The graded assessments in the course are two problem-solving assignments, project(s) (programming assignment(s)), one midterm and a final exam. Your course grade will be based on the following weights:

- Assignments 20%
- Midterm exam 25%
- Project 25%
- Final exam 30%

Course Guidelines & Policies

Attendance: Attendance will be taken in class. Students are expected to attend the lectures in the section that they are registered in. Lectures are a sequence. If you skip one you will not be able to understand the lecture that follows, if you don't catch up with the one you missed. Catching up lectures is your responsibility and is done in your own time. Instructor has the right to modify the grading criteria to include attendance and class participation when necessary. Cell phones must be turned off during class. During class time you may not play games, text, email, browse the web or engage in other activities that are not part of the class.

Course Communication: Canvas (canvas.njit.edu) will be the platform for posting lecture notes, submitting assignments and engaging in course discussions. All communication with the instructor and TA should be conducted through NJIT Canvas or using your NJIT email address. Emails sent from external servers may not be responded to.

Recitation: Attending recitation is an important checkpoint in assuring your grasp of the material being covered and correctly solving assigned problems.

Remake Exams:

- A student can remake either Mid-term Exam or Final Exam.
- Under any circumstances, student will not be allowed to remake both exams.
- *Eligibility:* If a student misses a Mid-term exam/ Final Exam due to a valid, documented reason determined by the dean of students and has informed the instructor beforehand may be eligible for a makeup mid-term exam or Final Exam.
- Requests for remake exams must be submitted before the exam.
- Please note that if remake request is received during or after the Mid-term or Final Exam then there are no makeup Mid-term or Final exams.

Grade Corrections: Check the grades in course work and report errors promptly. Your entire assessment will be regraded, which may result in points being added or subtracted.

- **Prompt Reporting**: Students who have concerns about their grades should contact both the TA and instructor via NJIT Canvas within three days of receiving the grade.
- **Initial Review:** The TA or instructor will review the student's concerns and provide feedback or clarification as needed.
- **Meeting with the TA**: If the issue is resolved or remains unresolved, the student should schedule a meeting with the TA during their immediate next available office hours for discussion and final review.
- **Timely Resolution:** Grade disputes must be addressed within the specified timeframes. Requests received after these deadlines may not be considered.

Late submission Policy: Homework assignments or projects or any other course related work assigned are expected to be submitted by the specified due date and time. Late submissions will only be considered within a specific window of time, which is up to 5 days after the original due date. For each day an assignment is submitted late, a penalty of 10% of the total possible grade for that assignment will be deducted. This deduction will accumulate for each additional day of late submission. The maximum penalty for late submissions is 50% of the total possible grade for the assignment. After the 5-day late submission window has passed, no further submissions will be accepted. It is the responsibility of the student to manage their time effectively and submit assignments within the specified timeframe.

Exam and Proctoring Policy: All exams will be closed book and closed notes. Each midterm is held during regular class meeting times. The final exam will be given during the time slot assigned by the NJIT Registrar. See the NJIT Online Course Exam Proctoring page for information on proctoring tools and requirements. You must bring ID to all exams.

Collaboration and External Resources for Assignments: Some homework problems will be challenging. You are advised to first try and solve all the problems on your own. For problems that persist you are welcome to talk to the course assistant or the instructor. You may consult online resources or collaborate with classmates for problem-solving. However, ensure you fully understand the concepts and solutions before submitting your work. Also make sure to give the appropriate credit and citation.

- **Proper Citation:** Always give credit to any external sources or collaborators as reference in your assignments/ project or any homework submitted for evaluation for this course.
- **Original Work:** Assignments should primarily represent your own work and understanding.
- **Plagiarism:** Any instances of plagiarism or academic dishonesty will be taken seriously and may result in disciplinary action.
- **Student Identification:** All submitted assignments must clearly indicate the names and student IDs of all collaborators involved. Failure to do so may be considered academic dishonesty.

Use of Generative AI: This course expects students to work without artificial intelligence (AI) assistance in order to better develop their skills in this content area. As such, AI usage is not permitted throughout this course under any circumstances.

Eating and Drinking inside Classroom: To maintain a conducive learning environment, eating and drinking are not permitted in the classroom, except for clear water. Please refrain from consuming food or beverages that may create distractions.

Requesting Accommodations: If you need an accommodation due to a disability please contact Scott Janz, Associate Director of the Office of Accessibility Resources and Services, Kupfrian Hall 201 to discuss your specific needs. A Letter of Accommodation Eligibility from the office authorizing student accommodation is required.

NJIT Services for Students, Including Technical Support: Please follow this link.

Canvas Accessibility Statement: Please follow this link.

Academic Integrity: Academic Integrity is the cornerstone of higher education and is central to the ideals of this course and the university. Cheating is strictly prohibited and devalues the degree that you are working on. As a member of the NJIT community, it is your responsibility to protect your educational investment by knowing and following the academic code of integrity policy that is found at: NJIT Academic Integrity Code. Please note that it is my professional obligation and responsibility to report any academic misconduct to the Dean of Students Office. Any student found in violation of the code by cheating, plagiarizing or using any online software inappropriately will result in disciplinary action. This may include a failing grade of F, and/or suspension or dismissal from the university. If you have any questions about the code of Academic Integrity, please contact the Dean of Students Office at dos@njit.edu

Additional Notes:

- The instructor reserves the right to make changes to the course syllabus or policies as needed.
- Students are expected to adhere to the university's guidelines for academic conduct and behavior.