Fall 2023 -- Department of Computer Science, University of Western Ontario

CS3331 - Foundations of Computer Science

Course description (course web site)

We live during the computer revolution, which is changing fast everything around us. While programming languages change quickly, the fundamental underlying theory does not. This course covers the basic concepts of the theory of computation. To study computation thoroughly, we need models, ideally, the simplest models that can solve the problem at hand. This is what the theory of computation is about: computational models and their power, with a vast array of applications. The practical models we study in this course include finite state machines, regular expressions, push-down automata, and context-free grammars. A crucial aspect is studying the limits of computations, which involves investigating all powerful models, such as Turing machines. Some problems are intractable, that is, it takes ages to solve them, others are provably impossible to solve even on an infinitely powerful computer. Good news: ChatGPT cannot solve all problems! Computability theory sheds light on these issues of fundamental importance to anyone attempting to understand what computers can do for us.

Topics

- Regular Languages
  - Finite State Machines (FSM), Deterministic (DFSM), Nondeterministic (NDFSM), Regular Expressions, Regular Grammars
  - Minimizing DFSM, Conversions between DFSM, NDFSM, Reg. Exp., and Reg. Grammars
  - Proving regularity, Closure properties
  - Proving nonregularity, Pumping theorem, Using closure properties
  - Decision Problems, Membership, Emptiness, Totality, Finiteness, Equivalence, Minimality
- Context-free Languages
  - Pushdown Automata (PDA), Context-free Grammars (CFG)
  - Conversions, PDA ↔ CFG, CFG → Chomsky Normal Form
  - Ambiguity
  - Proving context-freeness, Closure properties
  - Proving noncontext-freeness, Pumping theorem, Using closure properties
  - Decision Problems, Membership, Emptiness, Finiteness
- Turing Machines and Undecidability
  - Turing Machines (TM), Deterministic TM
  - Decidable languages (D), Semidecidable languages (SD)
  - Multi tape TM, Nondeterministic TM
  - Universal TM, Halting Problem
  - D and SD, Enumeration
  - Reduction, Using reduction to prove undecidability
  - Rice's Theorem, Non-SD languages
  - Unrestricted Grammars
  - Non-TM Problems, Post Correspondence Problem (PCP), Context-free language problems

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Prerequisites

- Computer Science 2214A/B or Mathematics 2155F/G

Instructor

- Prof. Lucian Ilie
    - Office hours: Wednesdays, 10:30am - 12:30pm, MC378

Class time

- Tuesdays, 3:30 - 5:30pm, MC-110
- Wednesdays, 2:30 - 3:30pm, MC-110

TAs and office hours

- TBA

Class email

- All questions are to be sent to this email address: cs3331@uwo.ca. For long questions, please attend the office hours.

Textbook (required)

- Elaine Rich, *Automata, Computability, and Complexity. Theory and Applications,* © Person Prentice Hall (2008), ISBN 978-0-13-228806-4.
    - The textbook is out of print. A free PDF is available from the author's web site. You can find a hard copy from previous students or from AbeBooks.

Tools

- JFLAP (You are allowed to use any external tools, such as JFLAP, ChatGPT, etc., to help you solve the assignments. Make sure you understand the solutions as no tools will be available during the exams!)

Evaluation -- Assignments will be available in OWL

- Assignments -- best 3 out of 4 will be considered; these due dates are tentative - the date on the assignment supersedes this:
    - Assignment 1 (10%) -- due Oct. 10
    - Assignment 2 (10%) -- due Oct. 20
    - Assignment 3 (10%) -- due Nov. 28
    - Assignment 4 (10%) -- due Dec. 4

- Exams - written format, closed book, no cheat sheet, no devices
  - Midterm Exam (31%) - - Tuesday, Oct. 24, 3:30 - 5:30pm, MC-110
    - Material required for midterm: everything taught in class before the exam
    - *There is no midterm makeup (see below)*
  - Final Exam (39%) - TBA
    - Material required for final: everything taught in class during the entire term
  - Final exam makeup: TBA

Evaluation rules

- **Exam passing rule**
  - In order to pass the course you must pass the exams, that is, your weighted average grade for the two exams should be at least 50/100. Otherwise, your final grade for the course will be the weighted average of the exam grades.
- **Missed homework or exam**
  - There is no midterm makeup. In case of missed midterm, you need approved accommodation from the Dean's office for the weight of the midterm to be moved to the final. All documentation must be submitted to the Academic Counselling office of a student's Home Faculty.
  - In case of missed assignment, you need also approved accommodation from the Dean's office for the weight to me moved to the exams as follows: the weight of assignments 1 and 2 is moved to the midterm exam, the weight of assignments 3 and 4 is moved to the final exam. (This effectively means that, with approved accommodation, A1 and A2 will get the grade of the midterm exam, A3 and A4 will get the grade of the final exam.)
- **Best 3 out of 4**
  - The best 3 assignments will be considered. If some assignments are missing, with accommodation from Dean's office, then their grade is the grade of the corresponding exam, as explained above. (Assignments missed without accommodation receive 0.) Therefore, in the end, every student will have 4 assignment grades, of which the best 3 are chosen for the final grade computation.
- **Mark inquiries**
  - The goal is to make grading as objective and consistent as possible. The assignments and exams will have detailed evaluation schemes. For consistency, the same question will be graded, whenever possible, by the same grader for all students.
  - Inquiries for marks will be addressed first to the TA who graded the question. In case of disagreement, the complaint will be resolved by the instructor. In case of multiple complaints for one exam from a student, the entire exam of that student will be regraded from scratch by the instructor.
  - Mark inquiries can be made only within **one week** from the day the marks are made available.

Assignments

- The assignments will consist of a set of exercises related to the material covered in class. The solutions for the exercises should be neatly written or typed.
- All assignments will be made available in OWL. The availability of assignments will be announced by OWL messages. Students are responsible for checking the course OWL site and their e-mail on a regular basis.

Appeals of Assignment Marks

- Appeals of assignment marks should be addressed to the T.A. first. If you and the T.A. cannot agree, then the T.A. will discuss the situation with the instructor.
- Appeals must occur within 1 week from the first day that the marked assignments were made available to students. After that 1 week period has gone by, no more appeals will be considered.

Computing Facilities

Each student will be given an account on the Computer Science Department senior undergraduate computing facility, GAUL. In accepting the GAUL account, a student agrees to abide by the department's; Rules of Ethical Conduct.

Student Absences

If you are unable to meet a course requirement due to illness or other serious circumstances, please follow the procedures below. For work totalling 10% or more of the final course grade, you must provide valid medical or supporting documentation to the Academic Counselling Office of your Faculty of Registration as soon as possible. For further information, please consult the University's medical illness policy at https://uwo.ca/univsec/pdf/academic_policies/appeals/academic_consideration.pdf. The Student Medical Certificate is available at https://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf.
Absences from Final Examinations If you miss the Final Exam, please contact the Academic Counselling office of your Faculty of Registration as soon as you are able to do so. They will assess your eligibility to write the Special Examination (the name given by the University to a makeup Final Exam).
You may also be eligible to write the Special Exam if you are in a "Multiple Exam Situation" (e.g., more than 2 exams in 23-hour period, more than 3 exams in a 47-hour period).
If a student fails to write a scheduled Special Examination, the date of the next Special Examination (if granted) normally will be the scheduled date for the final exam the next time this course is offered. The maximum course load for that term will be reduced by the credit of the course(s) for which the final examination has been deferred. See the Academic Calendar for details (under Special Examinations).

Accommodation and Accessibility

Religious Accommodation When a course requirement conflicts with a religious holiday that requires an absence from the University or prohibits certain activities, students should request accommodation for their absence in writing at least two weeks prior to the holiday to the course instructor and/or the Academic Counselling office of their Faculty of Registration. Please consult University's list of recognized religious holidays (updated annually) at https://multiculturalcalendar.com/ecal/index.php?s=c-univwo.
Accommodation Policies Students with disabilities work with Accessible Education (formerly SSD), which provides recommendations for accommodation based on medical documentation or psychological and cognitive testing. The policy on Academic Accommodation for Students with Disabilities can be found at: https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic Accommodation_disabilities.pdf.

Academic Policies

The website for Registrarial Services is http://www.registrar.uwo.ca.
In accordance with policy, https://www.uwo.ca/univsec/pdf/policies_procedures/section1/mapp113.pdf, the centrally administered e-mail account provided to students will be considered the individual's official university e-mail address. It is the responsibility of the account holder to ensure that e-mail received from the

University at his/her official university address is attended to in a timely manner.
Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following Web site: http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf.

Support Services

Please visit the Science & Basic Medical Sciences Academic Counselling webpage for information on adding/dropping courses, academic considerations for absences, appeals, exam conflicts, and many other academic related matters: https://www.uwo.ca/sci/counselling/.
Please contact the course instructor if you require lecture or printed material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Accessible Education at (519) 661-2147 if you have any questions regarding accommodations.
Students who are in emotional/mental distress should refer to Mental Health@Western (http://www.health.uwo.ca/mentalhealth) for a complete list of options about how to obtain help.
Additional student-run support services are offered by the USC, http://westernusc.ca/services.