

St. Francis Xavier University
Department of Computer Science
CSCI 541: Theory of Computing
Course Outline
Fall 2022

1 Course Overview

This course focuses on three areas central to the theory of computation: automata, computability and complexity, to investigate the question: What are the fundamental capabilities and limitations of computers? We study automata (models of computation) e.g., finite state machines, pushdown automata and Turing machines and the languages recognized by them. We investigate complexity theory, to classify problems as easy or hard and computability theory to classify problems as solvable or not.

2 Learning Objectives

By the end of this course, you will be able to:

- Determine a language's place in the Chomsky hierarchy.
- Convert among equivalently powerful notations for a language, including among DFAs, NFAs, and regular expressions, and between PDAs and CFGs.
- Explain the Church-Turing thesis and its significance.
- Explain Rice's Theorem and its significance.
- Provide examples of uncomputable functions.
- Prove that a problem is uncomputable by reducing a classic known uncomputable problem to it.

Objectives from *CS2013: Curriculum Guidelines for Undergraduate Programs in Computer Science*, ACM/IEEE.

3 Instructor

Taylor J. Smith

- Email: tjsmith@stfx.ca
- Office location: Annex, Room 9A
- Student hours: Tuesdays, 9:15am–11:15am

4 Class Time and Location

- Tuesday, 8:15am–9:05am
- Wednesday, 10:15am–11:05am
- Friday, 9:15am–10:05am

All lectures are held in Mulrone Hall, Room 4032.

5 Evaluations

Your final grade will be based on the following components:

- Two assignments (15% each, total 30%)
- Two quizzes (12.5% each, total 25%)
- Written report (total 40%): a topic proposal document (10%) and the report itself (30%)
- Participation in lectures (5%)

Assignments and quizzes are due at the beginning of class on the due date. Late assignments will be accepted up to the beginning of the first class following the due date. Late assignments are subject to a penalty of 10% deducted from the earned mark. Late quizzes will not be accepted.

Your mid-term grade will be communicated to you by the deadline specified in the university's Academic Regulations. Your mid-term grade will consist of the weighted sum of the grades of your first assignment and your first quiz.

You must complete both the topic proposal and the written report in order to pass the course, even if the weighted sum of your other submissions is at least 50%.

6 Method of Instruction

This course will be delivered face-to-face (i.e., all contact between instructor and students is in a physical classroom on campus). Course materials will be posted to the instructor's website.

7 Tentative Course Schedule

Week/Date	Topic	Due Dates
Week 1	Introduction to course, mathematical preliminaries	
Week 2	Regular langs.: finite automata, nondeterminism, nonregularity	
Week 3	Context-free langs.: pushdown automata, grammars, unary CFLs	
Week 4	Context-free langs.: ambiguous grammars, non-CFness	
Week 5	Deterministic context-free langs., parsing	Quiz 1 (Oct. 5)
Week 6	Parsing, state complexity	Assn. 1 (Oct. 11)
Week 7	Beyond context-free: Turing machines, variants of the model	
Week 8	Decidability, undecidability, mapping reducibility	Proposal (Oct. 25)
Week 9	Mapping reducibility, Turing reducibility, Kolmogorov complexity	Quiz 2 (Nov. 2)
Week 10	Complexity theory basics: algorithm analysis, P, NP	
Week 11	NP-completeness, reducibility, space complexity	Assn. 2 (Nov. 22)
Week 12	PSPACE, L, NL, completeness, course review	Report (Dec. 6)

8 Course Materials and Resources

Course notes will be provided for each lecture. The course textbook will be used as an optional supplement.

Required Text. None.

Recommended Text. M. Sipser, *Introduction to the Theory of Computation*. Cengage, 3rd edition, 2012.

9 Method of Evaluation

Assignments. This component will give you an opportunity to both demonstrate your understanding of course material and apply your understanding to a variety of problems. Each of the two assignments will consist of questions relating to material covered in the course between the assignment being issued and the due date. Assignments may be completed either individually or in groups of up to two people; however,

if an assignment is completed as a group, each member of the group will receive the same grade for that assignment.

Quizzes. This component will serve as a diagnostic to gauge your individual understanding of course material. Each quiz will consist of questions relating to material covered in the course up to the date of that quiz, and will generally be shorter than an assignment. Quizzes will be distributed at the end of Tuesday's lecture and will be due at the beginning of Wednesday's lecture (i.e., 25 hours later). Quizzes must be completed individually; collaboration or group work is not permitted.

Report. This component consists of two submissions: a topic proposal document and the report itself.

- The topic proposal is a one- to two-page document meant to serve as a summary of your chosen topic and what you plan to discuss in your report.
- The report itself will be a survey-style paper introducing your chosen topic and reviewing the big results in the area. It is expected to be about 10 to 20 pages, including full bibliographic references.

The written report component will be an individual submission. Further details will be distributed later in the term.

Participation. This component is designed to encourage active engagement with the course material during lectures; for example, by asking questions or by involving yourself in discussions. As long as you consistently attend lectures and engage with the material, you will receive the full 5% for this component.

Supplemental Statements for Course Outline

A Statement on Preferred Pronouns

Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, culture, religion, politics, sexual orientation, gender, gender variance, and nationalities. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records.

See policies at <http://www2.mystfx.ca/equity/policies>.

B Statement on Electronic Devices

During Exams: Unless you have medical accommodations that require you to do so, or explicit permission from the instructor of the course, you may not use any of the following electronic devices during ANY of the tests, midterms, examinations, or other in-class evaluations: cellphones, smart phones, smart watches, smart glasses, audio players or recorders of any sort, video cameras, video games, DVD players, televisions, laptop/notebook/netbook computers, flashlights or laser pointers.

During Lectures and Tutorials: Course instructors may permit the use of a computer during lecture and tutorial periods. If so, you are expected to use the computer for scholastic purposes only, and refrain from engaging in any activities that may distract other students from learning. From time to time, your professor may ask the class to turn off all computers, to facilitate learning or discussion of the material presented in a particular class. Unless explicitly noted otherwise, you may not make audio or video recordings of lectures – nor may you edit, re-use, distribute, or re-broadcast any of the material posted to the course website.

C Copyright

The materials in CSCI 541: Theory of Computing at StFX are the property of the instructor, unless stated otherwise by the instructor. Online posting or selling this material to third parties for distribution without permission is subject to Canadian Copyright law and is strictly prohibited.

Please visit the StFX copyright guide for more information: http://sites.stfx.ca/library/campus_copyright.

D Policy on Academic Integrity

Please ensure that you are aware of the policy on Academic Integrity. Details can be found at: http://www.sites.stfx.ca/registrars_office/academic_integrity. Please make note of the change in wording of the section on 'Cheating' passed by Senate this year. Section 3.8.2b (v) now reads "Possession of unauthorized aids or assistance". This means that the students do not need to be caught USING a device like a cell phone or smart watch (for example) during a test or exam to be in violation of the policy. Simply having the unauthorized device on your person during the test or exam is a violation of the policy.

E Statement on Equitable Learning

Everyone learns more effectively in a respectful, safe and equitable learning environment, free from discrimination and harassment. Instructors and students are invited to work together to create a classroom space – both real and virtual – that fosters and promotes values of human dignity, equity, non-discrimination, and respect for diversity. Please feel free to talk with your course instructor about your questions or concerns about equity in our classroom or in the StFX community in general.

Should students have additional questions, they are encouraged to talk to the Chair/Coordinator of the Department/Program or the Human Rights and Equity Advisor. Contact information can be found at <https://www2.mystfx.ca/equity/staff>.

F Information about Requesting an Accommodation at StFX

If you have a different learning ability and would like to request accommodations, please contact the instructor during the first week of the semester so that your accommodations may be provided in a timely manner. Centre for Accessible Learning (CAL) provides assistance in determining and facilitating appropriate accommodations for students with verified disabilities.

The Tramble Center for Accessible Learning welcomes students with documented permanent disabilities and offers them a student-centered program of support. Located in Room 108 of the Angus L. MacDonald Library, new and returning students meet with program staff to discuss options for support. Deadline for registering with the Center is two weeks prior to the end of classes each semester and three business days notice is required for booking all accommodated tests and exams.

To book an appointment, please use the following link: stfxcal.mywconline.com.

Phone: (902) 867-5349

Email: tramble@stfx.ca

G Support Services

There are various support services around campus and these include, but are not limited to:

1. Student Life: <https://www.stfx.ca/student-life>
2. Office of the Registrar: <https://www2.mystfx.ca/registrars-office/>
3. Health & Counselling Centre: <https://www.stfx.ca/student-life/health-and-wellness>
4. Academic Advising: <https://www2.mystfx.ca/academic-advising/>
5. Student Success Centre: <https://www2.mystfx.ca/student-success/>
6. Student Career Centre: <https://www2.mystfx.ca/scc/>
7. Office of Internationalization: <https://www.stfx.ca/international/support-international-students>
8. Financial Aid Office: <https://www2.mystfx.ca/financial-aid/>

H Health and Wellness

As part of a successful undergraduate experience at St. Francis Xavier University, we encourage you to make your health and wellness a priority. StFX provides several on-campus health-related services to help you achieve optimum health and engage in healthy living while pursuing your degree. For example, to support physical activity, all students receive membership to the StFX Athletics & Recreation Centre as part of their registration fees. Please visit the Athletics & Recreation website (<https://www.stfx.ca/student-life/athletics-and-recreation>) for opportunities including intramural sports. Numerous cultural events are offered throughout the year. Please check out the Department of Music web page (<https://www2.mystfx.ca/music/visiting-artist-program>), the StFX Art Gallery (<https://www2.mystfx.ca/art-gallery/>) or Theatre Antigonish (<https://www.theatrens.ca/producers?c=theatre-antigonish>) for various events.

Further information regarding health and wellness-related services available to students may be found at <https://www.stfx.ca/student-life/health-and-wellness>. If you are in emotional or mental distress please refer to the various mental health supports provided through Health & Counselling at <https://www2.mystfx.ca/health-and-counselling/>.