St. Francis Xavier University
Department of Computer Science

CSCI 356: Theory of Computing
Course Outline
Fall 2025

1 Course Overview

An introduction to the theoretical foundations of computer science, examining finite automata, context-free grammars, Turing machines, decidability and undecidability, and complexity theory. Strategies will be developed to help categorize problems as tractable or intractable.

Prerequisites. CSCI 255 (Advanced Data Structures), CSCI 277 (Discrete Structures).

2 Learning Objectives

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

- For each formal model:
    - Explain its definition comparing its characteristics with others.
    - Explain example inputs that are and cannot be accepted by the language/grammar.
- For each formal automaton, explain its deterministic and nondeterministic capabilities.
- Given a problem, develop an appropriate automaton that addresses the problem.
- Develop a regular expression for a given regular language expressed in natural language.
- Explain the difference between regular expressions and the regular expressions used in programming languages.
- Convert among equivalently powerful notations for a language, including among DFAs, NFAs, and regular expressions, and between PDAs and CFGs.
- Apply pumping lemmas, or alternative means, to prove the limitations of finite state and pushdown automata.
- Explain a universal Turing machine and its operation.
- Apply arithmetization and diagonalization to prove the halting problem for Turing machines is undecidable.
- Explain examples of classic uncomputable problems.
- Explain the Church-Turing thesis and its significance for algorithmic computation.
- Given a known undecidable language, apply a mapping reduction or computational history to prove that another language is undecidable.

Objectives from *Computer Science Curricula 2023*, ACM/IEEE-CS/AAAI.

3 Instructor

Taylor J. Smith

- Email: `tjsmith@stfx.ca`
  I check my inbox Monday to Friday, 9am–5pm. I aim to reply within 24 hours.
- Office location: Annex, Room 9A
- Office hours: Monday 11:30am–12:20pm/Wednesday 10:30am–11:20am/Friday 9:30am–10:20am, or by appointment

4 Class Time and Location

- Monday, 1:30pm–2:20pm
- Wednesday, 12:30pm–1:20pm
- Friday, 11:30am–12:20pm

All lectures are held in the Annex, Room 23A.

5 Evaluations

Your final grade will be based on the following components:

- Four assignments (12.5% each, total 50%)
- Midterm examination (25%)
- Final examination (25%)

Assignments 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.

With the prior approval of the instructor, the weight of a missed midterm examination will be shifted to the weight of the final examination (i.e., the midterm examination will be worth 0% and the final examination will be worth 50%). Weights of missed assignments will not be shifted.

If you have a concern over how your assignment or midterm examination was marked, you may submit a remark request by contacting the professor. You must wait at least 24 hours after assignment or midterm papers are returned to students and you must consult the posted solutions before submitting a remark request. All remark requests must clearly state your concern and must be submitted within one week of receiving the assignment or midterm paper. Submitting a remark request does not guarantee a change in your earned mark.

You must write the final examination in order to pass the course, even if the weighted sum of your assignment and midterm examination grades is at least 50%.

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 two assignments and your midterm examination.

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	Topic	Due Dates
Week 1	Introduction to course, regular expressions	
Week 2	Finite automata, nondeterminism	**Assn. 1** (Sep. 19)
Week 3	Conversions between regular models	
Week 4	Closure properties of regular languages, proving nonregularity	
Week 5	Context-free grammars, ambiguity	**Assn. 2** (Oct. 10)
Week 6	Normal forms, pushdown automata	
Week 7	Conversions between CF models, mid-course review	**Midterm Exam**
Week 8	Closure properties of CF languages, proving non-CFness	
Week 9	Turing machines and variants	**Assn. 3** (Nov. 7)
Week 10	Universal Turing machines, Church–Turing thesis	
Week 11	Decidability and undecidability	
Week 12	Reducibility, course review	**Assn. 4** (Dec. 5)

8   Course Materials and Resources

The required course textbook includes all material that will be discussed in each lecture. The recommended course textbook can be used as an optional supplement.

Required Text. T. J. Smith. *Theory of Computing: An Open Introduction.* Self-published open educational resource, α pre-publication edition, 2024. `taylorjsmith.xyz/tocopen/`.

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 four assignments will consist of questions relating to material covered in the course between the assignment being issued and the due date. Assignments must be completed individually.

Midterm and Final Examinations. These components will serve as a diagnostic to gauge your individual understanding of course material. Each examination will consist of questions relating to material covered in the course up to the date of that exam. You will have 50 minutes (i.e., the duration of one lecture) to complete the midterm examination. The final examination will be scheduled by the university.

Opportunity for Bonus Marks!

The required course textbook, *Theory of Computing: An Open Introduction*, is in a pre-publication edition and will undergo several additions and revisions in the future. In order to make the book as good as it can be, I am seeking your feedback on the material we cover as we progress through the course.

I am offering the following rewards for your feedback on the book:

- **1 bonus mark** for any error found in the book, whether it be technical, mathematical, typographical, grammatical, historical, or otherwise.
- **0.5 bonus mark** for helpful suggestions or comments (where "helpful" is defined below).

A suggestion or comment will be deemed helpful if you provide sufficient information about why and how you believe something in the book could be improved. Thus, unhelpful feedback looks like "This paragraph is hard to read", while helpful feedback looks like "The paragraph following Theorem X took me a few passes to understand it, and I still didn't fully understand the idea because I'm not clear on what Word Y means; maybe add an example using Concept Z here".

You may earn a **maximum of 5 bonus marks total** across the term, and you may apply the bonus marks you earn to any of your assignment grades or your midterm examination grade. You may not apply bonus marks to your final examination grade. You may not transfer bonus marks to other students.

Before submitting feedback, please check the errata file on the book's website to ensure that your feedback has not already been submitted by someone else. Bonus marks will only be granted to the first reporter of an error, suggestion, or comment.

To submit your feedback, send an email to `tjsmith@stfx.ca` with the phrase "TOCOpen Feedback" in the subject line. You must submit your feedback by 11:59pm on Dec. 6, 2024 to earn bonus marks.

To show my appreciation, I will acknowledge the names of those who submit feedback in future editions of the book. You may choose to opt out of this acknowledgement if you wish.

All decisions pertaining to bonus marks are final and cannot be contested or appealed.

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Supplemental Statements
for Course Outline

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A   Prerequisite Checking

Unless you have either the requisites for this course or written special permission from your Dean to enrol in it, you may be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

Refer to the current StFX Academic Calendar at `https://www.stfx.ca/applications-admissions/registrars-office/academic-calendar`.

B   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 honour 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 `https://www.stfx.ca/human-rights-equity/policies`.

C   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.*

D   Copyright

The required course textbook, *Theory of Computing: An Open Introduction* by T. J. Smith, is released under a Creative Commons BY-SA license and its use is subject to the terms of this license found at `https://creativecommons.org/licenses/by-sa/4.0/`.

All other materials in this course are designed for use in CSCI 356: Theory of Computing at StFX University and are the property of the instructor, unless otherwise stated by the instructor. Copying these materials for distribution, online posting, or selling of this material to third parties without permission is subject to Canadian Copyright Law and is strictly prohibited.

E Policy on Academic Integrity

StFX recognizes that academic integrity is essential to scholarship and learning, and as such students are expected to understand the meaning and consequences of plagiarism and other forms of cheating. These are defined in Section 3.8 of the Academic Calendar and in the StFX Academic Integrity Policy.

Potential offences include:

1. Using someone else's words, ideas, or any other form of intellectual property without proper acknowledgement;

2. Submitting material for assessment that already has been submitted elsewhere;

3. Falsifying sources or facts;

4. Using or possessing unauthorized aids in a test setting;

5. Misrepresenting your identity in a test setting;

6. Falsifying any official document or record;

7. Collaborating with someone else in the production of work for assessment.

The university takes seriously its responsibility to preserve academic integrity, and the consequences of these acts and others outlined in the policy can be severe, often including the loss of grade value for an assignment and the loss of credit for the courses in which the offence happened. Learn the rules and find help at the following site: `https://www.stfx.ca/student-services/academic-services/academic-success-centre/academic-integrity`.

Statement on the Use of Generative Artificial Intelligence Tools. You may use generative AI tools to learn and practice the concepts presented in this course, but you may NOT use these tools to complete academic work in this course.

The use of generative AI tools in any form of academic work for this course, as well as copying, paraphrasing, or representing as one's own any idea that was generated by AI, will be considered a violation of academic integrity.

This course policy is designed to promote your learning and intellectual development and to help you reach the course learning outcomes.

F 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://www.stfx.ca/human-rights-equity`.

G 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: `https://tramblecentre.stfx.ca/user/appt/default.aspx`.

Phone: (902) 867-5349
Email: `tramble@stfx.ca`

H   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-support/student-services`

2. Office of the Registrar: `https://www.stfx.ca/applications-admissions/registrars-office`

3. Health & Counselling Centre: `https://www.stfx.ca/student-life-support/health-counselling-centre`

4. Academic Advising: `https://www.stfx.ca/student-life-support/academic-advising`

5. Student Success Centre: `https://www.stfx.ca/student-life-support/student-services/academic-success-centre`

6. Student Career Centre: `https://www.stfx.ca/student-life-support/student-services/student-career-centre`

7. Office of Internationalization: `https://www.stfx.ca/student-life-support/internationalization`

8. Financial Aid Office: `https://www.stfx.ca/applications-admissions/financial-support/financial-aid-office`

I   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-support/campus-life/campus-recreation`) for opportunities including intramural sports. Numerous cultural events are offered throughout the year. Please check out the Department of Music web page (`https://www.stfx.ca/department/music/visiting-artist-program`), the StFX Art Gallery (`https://www.stfx.ca/art-gallery`) or Theatre Antigonish (`https://www.festivalantigonish.ca/theatreantigonish/`) for various events.

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