St. Francis Xavier University
Department of Computer Science

CSCI 541: Theory of Computing
Written Report
Fall 2021

The written report is the major assessment of this course. This assessment consists of two components: a topic proposal and the report itself.

The topic proposal is worth a total of 10% of your final grade. The report component is worth a total of 30% of your final grade. You must complete both components in order to pass the course.

Do not leave these assessments until the last minute! Start as soon as possible!

Topic Proposal

Due October 29, 2021 in lecture

The topic proposal is a short document meant to serve as a summary of your chosen topic and what you plan to discuss in your report. Your topic proposal should include, at a minimum, the following information: your chosen topic, one or two paragraphs outlining the big ideas you plan to discuss in your report, a broad outline of the structure of your report (e.g. sections, subsections, etc.), and 2–3 preliminary references that you will use to begin your literature review. (Existing survey articles or textbooks are great preliminary references, as they often include a large bibliography of related papers. If you need pointers to such preliminary references, let me know and I can try to help.)

Your topic proposal should be a 1–2 page double-spaced document written in 12-point text. It will be marked in terms of completeness and organization.

Report

Due December 7, 2021 in lecture

The report is a general survey-style paper introducing your chosen topic, presenting clear definitions, reviewing main results in the area, and providing references to further reading. If you mention important theorems or results, you do not need to include proofs.

Your report should be a 10–20 page double-spaced document written in 12-point text. Your report should also include full references to papers, books, and other literature that you use. The references do not count toward the page limit, so feel free to include as many references as you need.

Your report will be marked in terms of three broad categories: quality (e.g., focused on topic, good number of relevant references), accuracy (e.g., correct summary of main results, material all related to topic), and organization (e.g., good report structure, polished writing, ease of reading).

Lastly, remember that *quality is better than quantity*. A very well-written 10 page report that covers everything you want to discuss is better to read than a disorganized, messy 20 page report that touches on anything even remotely related to your topic.

Suggested Topics

Below, I offer a (non-comprehensive) selection of suggested topics that you can choose for your report topic. You do not have to choose your topic from this list; these are only some ideas. You are welcome to study and write about a topic related to this course that is not on this list.

- **Formal Languages**
  - Applications of formal languages to the study of natural languages, such as English
  - Deterministic context-free languages and deterministic PDAs
  - Generalizations of the pumping lemma: Ogden's lemma, etc.
  - Kolmogorov complexity
  - Learning regular languages from queries and counterexamples
  - ω-languages: languages that consist of words of infinite length
- **Automata Theory**
  - Alternating automata and their properties
  - Applications of automata theory to game theory/economics
  - Applications of automata theory to number theory
  - Cellular automata and connections to regular languages
  - Probabilistic automata and their properties
  - Procedures for minimizing finite automata
  - Quantum finite automata and quantum computation
  - State complexity of finite automata: how many states are needed to recognize a language
  - Two-dimensional automata theory
  - Unambiguous automata and their properties
- **Grammars**
  - Graph grammars: using grammars and rules to specify two-dimensional objects
  - L-systems and connections between formal languages and computer graphics
  - Normal forms of grammars: Greibach normal form, Backus-Naur form, etc.
- **Computability and Complexity Theory**
  - Circuit complexity, complexity classes AC, NC, $\mathsf{P/poly}$, etc.
  - Communication complexity and information theory
  - Descriptive complexity and connections between complexity theory and formal logic
  - Exponential time hypothesis
  - Immerman-Szelepcsényi theorem
  - P-complete problems, logspace reductions
  - Polynomial time hierarchy
  - Provably intractable problems: problems outside of PSPACE, classes beyond PSPACE
  - Time/space hierarchy theorems, Savitch's theorem, etc.
- **Algorithms and Decision Procedures**
  - Approximation algorithms, randomized algorithms, associated complexity classes
  - Computational complexity of decision problems for finite automata
  - Efficient algorithms for deciding word properties: repetition, primitivity, overlap, etc.
  - Software to manipulate finite automata/regular expressions: `Grail+`, `REGPACK`, etc.