In the last few decades, algebraic methods have proven to be extremely powerful in several areas of computer science. Many of the recent and important advances in the field have relied on very simple properties of polynomials. In this course we will see many interesting and often surprising applications of linear algebra and polynomials to complexity theory, cryptography, combinatorics, and algorithm design. We will develop all the algebraic tools that we need along the way.

The main prerequisite is mathematical maturity. It might be helpful to have some familiarity with discrete math/algorithms and linear algebra. Students with an interest in discrete mathematics and/or theoretical computer science are welcome.

A tentative (and partial) list of topics that we will cover:

- Applications of linear algebra
  - Rank and dimension arguments, expander graphs
- Polynomials methods in combinatorics and discrete geometry
- Polynomials and error correcting codes
• Algebraic methods in complexity theory and cryptography
  o Interactive proofs
  o Polynomial identity testing
  o Primality testing
  o Circuit lower bounds
• Introduction to arithmetic circuits/arithmetic computation

**Marking Scheme:** 80% homework and 20% scribe notes and class participation. There is no exam.

**Homework:** There will be 3 or 4 problem sets over the semester

Students are permitted to attend lectures and tutorials online for the first two weeks (September 13–23, 2021). During this time, lectures will be recorded on Zoom (link available at quercus).

The University of Toronto requires us to write: *Please note that due to the ongoing COVID-19 pandemic, the course delivery method may change after term has started and this may alter the course organization. Students are expected to check the course site for updates as the contents of this syllabus may change.*

**Technical requirement:** In order to participate in this course, students will be required to have: • Reliable internet access. It is recommended that students have a high speed broadband connection (LAN, Cable, or DSL) with a minimum download speed of 5 Mbps. • A computer satisfying the minimum technical requirements: https://www.viceprovoststudents.utoronto.ca/covid-19/tech-requirements-online-learning/
Other recommended items include headphones, microphone, webcam, and a tablet or printer. If you are facing financial hardship, you are encouraged to contact your college or divisional registrar (https://future.utoronto.ca/current-students/registrar/) to apply for an emergency bursary

**Email Policy:** Should you have a question that is not answered on the course site (please check there first!) please note that all communications with the Course Instructor must be sent from your official utoronto email address, with the course number included in the subject line. If these instructions are not followed, your email may not be responded to.
Institutional Policies and Support

Academic Integrity

All suspected cases of academic dishonesty will be investigated following procedures outlined in the Code of Behaviour on Academic Matters (https://governingcouncil.utoronto.ca/secretariat/policies/code-behaviour-academic-matters-july-1-2019). If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, please reach out to your Course Instructor. Note that you are expected to seek out additional information on academic integrity from me or from other institutional resources (for example, the University of Toronto website on Academic Integrity http://academicintegrity.utoronto.ca/).

Copyright: This course, including your participation, will be recorded on video and will be available to students in the course for viewing remotely and after each session.

Course videos and materials belong to your instructor, the University, and/or other sources depending on the specific facts of each situation and are protected by copyright. Do not download, copy, or share any course or student materials or videos without the explicit permission of the instructor.

For questions about the recording and use of videos in which you appear, please contact your instructor.

Accessibility: The University provides academic accommodations for students with disabilities in accordance with the terms of the Ontario Human Rights Code. This occurs through a collaborative process that acknowledges a collective obligation to develop an accessible learning environment that both meets the needs of students and preserves the essential academic requirements of the University’s courses and programs.

Students with diverse learning styles and needs are welcome in this course. If you have a disability that may require accommodations, please feel free to approach your Course Instructor and/or the Accessibility Services office as soon as possible. The sooner you let us know your needs the quicker we can assist you in achieving your learning goals in this course.

Link to Accessibility Services website:
https://studentlife.utoronto.ca/departments/accessibility-services/
**Equity, Diversity and Inclusion:** The University of Toronto is committed to equity, human rights and respect for diversity. All members of the learning environment in this course should strive to create an atmosphere of mutual respect where all members of our community can express themselves, engage with each other, and respect one another’s differences. U of T does not condone discrimination or harassment against any persons or communities.

**Important Academic Dates & Deadlines**

The academic dates include enrolment dates, drop deadlines, exam periods, petition deadlines and more. https://www.artsci.utoronto.ca/current/dates-deadlines/academic-dates