



Fall 2023

Digital Signal Processing

ECE431F

The Edward S. Rogers Sr. Department of Electrical & Computer Engineering

University of Toronto

Instructor

Prof. Dimitrios Hatzinakos, BA 4144, dimitris@ece.utoronto.ca
<http://www.comm.utoronto.ca/~dimitris>

TA information

Aaron Curtis (aarond.curtis@mail.utoronto.ca)
Milad Soltanzadeh (milad.soltanzadeh@mail.utoronto.ca)
Behrad Taghibeyglou (behrad.taghibeyglou@mail.utoronto.ca)



Course Description

ECE431 is an introductory course in digital filtering and applications and covers the following topics: 1) introduction to real world signal processing, 2) review of sampling and quantization of signals, 3) introduction to the discrete Fourier transform, 4) fast Fourier transform, 5) Fourier analysis of signals using the discrete Fourier transform, 6) structures for discrete-time systems, 7) design and realization of digital filters: finite and infinite impulse response filters, 8) DSP applications in areas such as communications, multimedia, and video coding.

Learning Objectives

Digital signal processing (DSP) is the mathematical manipulation of an information signal to enhance or simply modify it in some way. It is characterized by the representation of discrete time, discrete frequency,

or other discrete domain signals by a sequence of numbers or symbols and the processing of these signals. The objective of this course is to introduce students to fundamental concepts of DSP, including sampling and reconstruction, the z-Transform, the Discrete Fourier Transform (DFT) and its implementation, finite impulse response (FIR) and infinite impulse response (IIR) digital filtering, multirate signal processing, and applications in digital media. The course includes weekly lectures (3 hours total), weekly 1-hour tutorials, and biweekly lab sessions.

- Understand fundamental concepts of DSP and the physical interpretation of its mathematical basis
- Understand tradeoffs in digital representation of signals: sampling rate, quantization
- Understand implementation of the fast Fourier transform
- Check stability of filters
- Analyze minimum phase, linear phase, and all-pass discrete-time systems
- Analyze and design filters based on pole/zero placement
- IIR filter design from continuous-time filters
- FIR linear-phase filter design
- Design filters using Matlab (via laboratory exercises)
- Implementation considerations
- Multirate processing and its application in efficient filtering, subband coding, communications, etc.
- Application of DSP to audio, image, and video processing

Textbook

A. V. Oppenheim and R. W. Schaffer, *Discrete-Time Signal Processing*, 3rd Ed., Prentice Hall, 2010. ISBN-10: 0131988425, ISBN-13: 9780131988422.

Lectures

Tuesday	4:00 pm – 5:00 pm	BA2175 (LEC 01)
Wednesday	4:00 pm – 5:00 pm	BA1200 (LEC 01)
Friday	4:00 pm – 5:00 pm	GB248 (LEC 01)

Tutorials

Tuesday	5:00 pm – 6:00 pm	SF3202 (TUT 01)
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Tutorials begin on September 12. Solutions to problem questions assigned the week before will be covered during the tutorial.

Labs

Thursday	12:00 pm – 3:00 pm	SF2201
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Lab(s) will begin on September 14, 2023 and will take place in room SF2201 (Photonics Lab).

Lab content can be found at: <https://www.comm.utoronto.ca/~bkf/comm/ECE431/>.

Labs will be executed by teams of at most 2 students. One lab report per group should be prepared and submitted by the end of the experiment. (Please note that lab preparation if any is marked individually). Please refer to lab scheduling for more details.

The five laboratory sessions will cover the following:

- Exp01 – Sampling and Quantization
- Exp02 – Z-transform
- Exp03 – Fast Fourier Transform
- Exp04 – FIR Filters
- Exp05 – Multirate Processing

Tentative Lab Schedule

PRA 0102: Thursdays 12-3 pm, SF 2201

Date	Lab	
Sept. 14	Lab1	
Sept.. 28	Lab2	
Oct. 26	Lab3	
Nov. 16	Lab4	
Nov. 30	Lab5	

PRA 0101: Thursdays 12-3 pm, SF 2201

Date	Lab	
Sept. 21	Lab 1	
Oct. 5	Lab 2	
Oct. 19	Lab 3	
Nov. 2	Lab 4	
Nov. 23	Lab 5	

Office hours: By appointment (virtual sessions are preferred whenever possible)

Composition of Final Mark

Lab(s):	20 %
Test(s)	30 %
Final Exam:	50 %

Two Midterm tests will be scheduled tentatively on October 13 and November 17, 2023 during class time. Each will count for 15% of the final mark.

Course Website

The course will make use of Quercus (<http://q.utoronto.ca>). *All students must register on Quercus.* Course notices, handouts, office hours and important communications will be administered using this site.

Course Policies and Information

- All tests and the final exam make use of a (**Type 1**) calculator. The final exam is **Type C** (candidates may prepare, bring to the exam and use a single standard aid sheet supplied by the registrar's office).
- The ECE Undergraduate (UG) Office's policy on Petition for Consider in Course Work will be employed for missed tests and late assignments. Official supporting documentation must be provided and the completed petition must be filed with the UG Office.
- Questions regarding marking must be formally written on a piece of paper and submitted along with the associated test/assignment to the cognizant TA. There is a 48-hour limit from the time the test/assignment is first returned in which you may request a recheck.
- Please note that late assignments (e.g., lab write-ups) will be deducted 15% per business day.
- Academic integrity is of utmost important. Any issues of plagiarism and inappropriate collaboration will be taken seriously and reported to the appropriate higher authority.
- Students with diverse learning styles and needs are welcome in this course. In particular, if you have a disability/health consideration that may require accommodations, please feel free to approach me and/or Accessibility Services at (416) 978 8060; <http://accessibility.utoronto.ca>.

Academic Integrity policies

<http://www.academicintegrity.utoronto.ca/https://governingcouncil.utoronto.ca/secretariat/policies/code-behaviour-academic-matters-july-1-2019>

Land Acknowledgement

I (we) wish to acknowledge this land on which the University of Toronto operates. For thousands of years it has been the traditional land of the Huron-Wendat, the Seneca, and most recently, the Mississaugas of the Credit River. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.

Statements

- **Syllabus Statements on Inclusivity, Accommodations & Mental Health Support**
- Inclusivity Statement:
- All students and faculty at the University of Toronto have a right to learn, work and create in a welcoming, respectful, inclusive and safe environment. In this class we are all responsible for our language, action and interactions. Discriminatory comments or actions of any kind will not be permitted. This includes but is not limited to acts of racism, sexism, Islamophobia, anti-Semitism, homophobia, transphobia, and ableism. As a class we will work together to create an inclusive learning environment and support each other's learning.
- If you experience or witness any form of discrimination, please reach out to the Engineering Equity Diversity & Inclusion Action Group [online](#), an [academic advisor](#), a [U of T Equity Office](#), or any U of T Engineering faculty or staff member that you feel comfortable approaching.
- Accommodations:
- If you have a learning need requiring an accommodation the University of Toronto recommends that students immediately register at Accessibility Services at www.studentlife.utoronto.ca/as.
- Location: 4th floor of 455 Spadina Avenue, Suite 400
- Voice: 416-978-8060
- Fax: 416-978-5729
- Email: accessibility.services@utoronto.ca
- The University of Toronto supports accommodations of students with special learning needs, which may be associated with learning disabilities, mobility impairments, functional/fine motor disabilities, acquired brain injuries, blindness and low vision,

chronic health conditions, addictions, deafness and hearing loss, psychiatric disabilities, communication disorders and/or temporary disabilities, such as fractures and severe sprains, recovery from an operation, serious infections or pregnancy complications.

- Mental Health:
- As a university student, you may experience a range of health and/or mental health issues that may result in significant barriers to achieving your personal and academic goals. The University of Toronto offers a wide range of free and confidential services and programs that may be able to assist you. We encourage you to seek out these resources early and often.
- Health & Wellness Resources: undergrad.engineering.utoronto.ca/advising-and-wellness/health-wellness/
- U of T Health & Wellness Website: studentlife.utoronto.ca/hwc
- If, at some point during the year, you find yourself feeling distressed and in need of more immediate support, visit the **Feeling Distressed Webpage**: www.studentlife.utoronto.ca/feeling-distressed, for more campus resources.
- Off campus, immediate help is available 24/7 through **Good2Talk**, a post-secondary student helpline at 1-866-925-5454.
- All students in the Faculty of Engineering have an Academic Advisor who can advise on academic and personal matters. You can find your department's Academic Advisor here: uoft.me/engadvising

Absence Declaration

***A Verification of Illness Form* (also known as a "doctor's note") is currently not required for missed academic work. Faculties or campuses may require documentation in some circumstances.**

Students who are absent from academic participation for **any reason** (e.g., COVID, cold, flu and other illness or injury, family situation) and who require consideration for missed academic work should report their absence through the online absence declaration. The declaration is available on **ACORN** under the **Profile and Settings menu**. Students should also advise their instructor of their absence.

Please check with your faculty or campus for specific procedures regarding absence declarations. In some situations, documentation will be required.