Electrical and Computer Engineering
COMPENG 4TL4
Digital Signal Processing
Fall 2023

McMaster University

ENGINEERING

Instructor Information

Ratnasingham Tharmarasa
Email: tharmr@mcmaster.ca
Office: ITB-A211
Office Hours:
Fridays 12:00pm - 1:30pm in ITB-A211; and by appointment

Teaching Assistants

Names, contact information and office hours are provided on the course website.

Course Information

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

Tutorials: Wednesday 5:30 pm - 6:20 pm

Labs: Lab starts on Sep. 18, from the odd group every other week at 2:30 pm - 5:20 pm – L01 Monday, L02 Monday, L03 Tuesday, L04 Tuesday

Course Dates: 09/05/2023 - 12/06/2023
Units: 4.00
Course Delivery Mode: In Person
Course Description: Discrete time signals and systems including z-transform, DFT and

FFT; Classical filter theory, FIR and IIR digital filters; effects of finite precision; implementation of DSP systems; adaptive filtering; spectral analysis, signal compression. Three lectures, one tutorial, one lab every other week; first term Prerequisite(s): ELECENG 3TP4 or ELECENG 3TP3 or IBEHS 3A03

Pre-Requisite(s) and Anti-Requisite(s)

Pre-requisite(s): ELECENG 3TP4 or ELECENG 3TP3 or IBEHS 3A03

Anti-requisite(s): None

Important Links

- [Mosaic](#)
- [Avenue to Learn](#)
- [Student Accessibility Services - Accommodations](#)
- [McMaster University Library](#)
- [eReserves](#)

Course Learning Objectives

For accreditation reasons, these learning outcome statements must be tied back to CEAB graduate attributes (GAs), including those that are measured in this course. If you are unsure how to do this, please contact the Associate Chair Undergraduate in your department.

- Learn the fundamentals of processing discrete-time systems

- Perform various processing operations on the signals and systems

- Gain knowledge in implementation of linear shift-invariant discrete-time systems, frequency domain representations, digital filtering and adaptive systems

- Gain an appreciation of the operation of DSP processors

CEAB Graduate Attributes (GAs)

The CEAB Graduate Attributes (GAs) defined in this section are measured throughout the course and form part of the Department's continuous improvement process. They are a key component of the accreditation process for the program and will not be taken into consideration in determining a student's actual grade in the course. For more information on accreditation, please ask your instructor or visit: http://www.engineerscanada.ca

Attributes	Indicators		Measurement Method(s)
	Number	Description	
Knowledge Base for Engineering	1.1	Competence in Mathematics	Exam questions
Knowledge Base for Engineering	1.4	Competence in Specialized Engineering Knowledge	Exam questions and labs
Design	4.3	Develops models/prototypes; tests, evaluates, and iterates as appropriate	Labs
Use of Engineering Tools	5.2	Successfully uses engineering tools	Labs
Professionalism	8.2	Integrates appropriate standards, codes, legal and regulatory factors into decision making.	Lab safety quiz and labs

Assumed Knowledge

Linear algebra and calculus, complex variables (EE2CI5, EE2CJ4), frequency domain decompositions (EE3TP4), circuit theory (EE2CI5 and 2CJ4), knowledge of MATLAB, knowledge of C (CoE2SH4)

Course Learning Goals

- Understand the discrete time and digital signals

- Analyze discrete time signals in the time and frequency domains

- Learn design techniques for FIR and IIR digital filters

- Analyze random signals

- Gain experience in implementing and analyzing digital systems within MATLAB

- Understand the analytical tools needed for digital signal processing: Fourier transform, Discrete Fourier transform, Fast Fourier Transform and Z-Transform

- Program DSP hardware to perform signal processing tasks using MATLAB

- Gain experience in creating projects in CCS5 and running programs on the TMS 320 DSP processor

Required Materials and Texts

Textbook Listing: https://textbooks.mcmaster.ca

Discrete-Time Signal Processing
ISBN: 0131988425
Authors: Alan V. Oppenheim and Ronald W. Schafer
Publisher: Pearson Prentice Hall
Publication Date: Aug. 18 2009
Edition: 3rd
2nd edition is also fine

Optional Course Materials

Textbook Listing: https://textbooks.mcmaster.ca

Digital Signal Processing

ISBN: 0131873741

Authors: John G. Proakis and Dimitris G. Manolakis

Publisher: Pearson Prentice Hall

Publication Date: Mar. 28 2006

Edition: 4th

DSP First
ISBN: 0136019250

Authors: James H. McClellan, Ronald Schafer and Mark Yoder

Publisher: Pearson

Publication Date: Aug. 2 2015

Edition: 2nd

Class Format

In Person

Lectures, tutorials, laboratory sessions, midterm test, and the final exam will be carried out in person.

Course Schedule

Note: all timings are approximate.

Week	Topic	Readings
1 – 2	Introduction, discrete-time signals and systems	Text Chapters 1 and 4
3	Linear time-invariant systems and properties	Text Chapter 2 and lecture notes
4	Frequency domain analysis of discrete-time systems and the DTFT	Text Chapters 2 & 4 and lecture notes
5	The z-transform	Text Chapter 3 and lecture notes
6	The discrete Fourier transform	Text Chapters 8 & 9 and lecture notes
7	Computation of the discrete Fourier transform	Text Chapter 9 and lecture notes

8	Classical filter theory and discrete-time filtering implementations	Text Chapters 5 & 7 and lecture notes
9	FIR filter designs	Text Chapters 6 & 7 and lecture notes
10	IIR filter designs	Text Chapters 6 & 7 and lecture notes
11-12	Random Signal Analysis	Text Chapter 10 and Lecture notes

At certain points in the course, it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

Laboratory Overview

Lab	Topic
1	Introduction to Digital Signals using MATLAB
2	Discrete-time Fourier Analysis and Sampling
3	Resampling, Reconstruction and the DFT
4	FIR Digital Filter Design
5	IIR Digital Filter Design

Laboratory Operation

- Each student in the course is required to pass the lab safety quiz prior to attempting any of the laboratories. The quiz will be available on Avenue to Learn.

- Access to all labs is restricted in the interest of security and safety. Information on accessing and using the lab can be found on this webpage: https://www.eng.mcmaster.ca/ece/labs-and-health-safety#Labs-Access-and-Use

- The labs for this course will be held in ITB 157 using MATLAB and TMS 320 DSP processor.

- The first lab will be performed individually, and the other four labs will be performed in groups of two students.

Course Evaluation

1. Five labs (5% per lab) = 25%
2. Quizzes = 10%
    - This weight will be transferred to the final exam if the final mark is better than the mark of the quizzes.
3. One mid-term test = 30%
    - For students with a higher mark on the final than their midterm mark, the midterm weight becomes 0%, and the final weight becomes 65%.
4. One final exam = 35%

Component	Weight
Labs (5)	25%
Max(Quizzes, Final Exam)	10%
Max(Mid-term Test (1), Final Exam)	30%
Final Exam (1)	35%
Total	100%

Grading and Evaluation Policies

- There will be one midterm test (mid-October to early November). No make-up midterm tests will be granted. The weight of the midterm test will be transferred to the final exam.
- The weight of any missed labs **will not be** transferred to the final exam.

Course Evaluation Details

All laboratories must be successfully executed for completion of the course. Specifically, the labs must be completed even by individuals who are repeating the course.

Grading Scale

Grade	Equivalent Grade Point	Equivalent Percentages
A+	12	90-100
A	11	85-89
A-	10	80-84
B+	9	77-79
B	8	73-76
B-	7	70-72
C+	6	67-69
C	5	63-66
C-	4	60-62
D+	3	57-59
D	2	53-56
D-	1	50-52
F	0	0-49

Late Assignments

- Late submissions of lab code and reports are subject to 50% penalty per day (less than one day is counted as one day).

Absences, Missed Work, Illness

- Attendance and active engagement at all classes is expected.
- Students must contact the instructor for an alternative lab session for missed labs.
- There will be no accommodation for any missed quizzes. The average of the best 70% of the quizzes will be taken. The quiz weight will be transferred to the final

exam if the final mark is better than the quiz mark.

- No make-up midterm tests will be granted. The weight of the midterm test will be transferred to the final exam.

Turnitin.com

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.

Generative AI: Use Prohibited

Students are not permitted to use generative AI in this course. In alignment with McMaster academic integrity policy, it "shall be an offence knowingly to … submit academic work for assessment that was purchased or acquired from another source". This includes work created by generative AI tools. Also state in the policy is the following, "Contract Cheating is the act of "outsourcing of student work to third parties" (Lancaster & Clarke, 2016, p. 639) with or without payment." Using Generative AI tools is a form of contract cheating. Charges of academic dishonesty will be brought forward to the Office of Academic Integrity.

APPROVED ADVISORY STATEMENTS

Academic Integrity

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. **It is your responsibility to understand what constitutes academic dishonesty.**

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the [Academic Integrity Policy,](#) located at https://secretariat.mcmaster.ca/university-policies-proceduresguidelines/

The following illustrates only three forms of academic dishonesty:

- plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
- improper collaboration in group work.
- copying or using unauthorized aids in tests and examinations.

Authenticity / Plagiarism

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. Avenue to Learn, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. **All submitted work is subject to normal verification that standards of academic integrity have been upheld** (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.

Courses with an On-line Element

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn, LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

Online Proctoring

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

Conduct Expectations

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the [Code of Student Rights & Responsibilities](#) (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online.**

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online

platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

Academic Accommodation of Students with Disabilities

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's Academic Accommodation of Students with Disabilities policy.

Academic Advising

For any academic inquires please reach out to the Office of the Associate Dean (Academic) in Engineering located in JHE-Hatch 301.

Details on academic supports and contact information are available from:

https://www.eng.mcmaster.ca/programs/academic-advising

Requests for Relief for Missed Academic Term Work

In the event of an absence for medical or other reasons, students should review and follow the Policy on Requests for Relief for Missed Academic Term Work.

Academic Accommodation for Religious, Indigenous, or Spiritual Observances (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office **normally within 10 working days** of the

beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

Copyright and Recording

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors.

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

Extreme Circumstances

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, Avenue to Learn and/or McMaster email.

Electrical and Computer Engineering Lab Safety

Information for Laboratory Safety and Important Contacts

This document provides important information for the healthy and safe operation of ECE instructional laboratories. This document is required reading for all laboratory supervisors, instructors, researchers, staff, and students working in or managing instructional laboratories in ECE. It is expected that revisions and updates to this document will be done continually. A McMaster University lab manual is also available to

read in every laboratory and online: https://hr.mcmaster.ca/app/uploads/2019/07/2019-McMaster-Lab-Manual.pdf

General Health and Safety Principles

Good laboratory practice requires that every laboratory worker and supervisor observe the following whether conducting lab work at school or at home:

1. Food and beverages are not permitted in the instructional laboratories.

2. A Laboratory Information Sheet on each lab door identifying potential hazards and emergency contact names should be known.

3. Laboratory equipment should only be used for its designed purpose.

4. Proper and safe use of lab equipment should be known before using it.

5. The course TA leading the lab should be informed of any unsafe condition.

6. The location and correct use of all available safety equipment should be known.

7. Potential hazards and appropriate safety precautions should be determined, and sufficiency of existing safety equipment should be confirmed before beginning new operations.

8. Proper waste disposal procedures should be followed.

9. Personal ergonomics should be practiced when conducting lab work. https://bit.ly/3fOE71E

10. Current University health and safety issues, and protocols should be known. https://hr.mcmaster.ca/resources/covid19/workplace-health-and-safety-guidance-during-covid-19/

Location of Safety Equipment

Fire Extinguisher

On walls in halls outside of labs

First Aid Kit

ITB A111, or dial "88" after 4:30 p.m.

Telephone

On the wall of every lab near the door

Fire Alarm Pulls

Near all building exit doors on all floors

Who to Contact	
Emergency Medical/Security:	On McMaster University Campus, call Security at extension 88 or 905-522-4135 from a cell phone.
Non-Emergency Accident or Incident:	Immediately inform the TA on duty or Course Instructor.
University Security (Enquiries/Non-Emergency):	Dial 24281 on a McMaster phone or dial 905-525-9140 ext. 24281 from a cell phone.
See TA or Instructor:	For problems with heat, ventilation, fire extinguishers, or immediate repairs.
Environmental & Occupational Health Support Services (EOHSS):	For health and safety questions dial 24352 on a McMaster phone or dial 905-525-9140 ext. 24352 from a cell phone.

In Case of a Fire (On Campus Dial 88)

When calling to report a fire, give name, exact location, and building.

1. Immediately vacate the building via the nearest Exit Route. Do not use elevators!

2. Everyone is responsible for knowing the location of the nearest fire extinguisher, the fire alarm, and the nearest fire escape.

3. The safety of all people in the vicinity of a fire is of foremost importance. But do not endanger yourself!

4. In the event of a fire in your work area shout "Fire!" and pull the nearest fire alarm.

5. Do not attempt to extinguish a fire unless you are confident it can be done in a prompt and safe manner utilizing a hand-held fire extinguisher. Use the appropriate fire extinguisher for the specific type of fire. Most labs are equipped with Class A, B, and C extinguishers. Do not attempt to extinguish Class D fires which involve combustible metals such as magnesium, titanium, sodium, potassium, zirconium, lithium, and any other finely divided metals which are oxidizable. Use a fire sand bucket for Class D fires.

6. Do not attempt to fight a major fire on your own.

7. If possible, make sure the room is evacuated; close but do not lock the door and safely exit the building.

Clothing on Fire

Do not use a fire extinguisher on people.

1. Douse with water from safety shower immediately or

2. Roll on floor and scream for help or

3. Wrap with fire blanket to smother flame (a coat or other non-flammable fiber may be used if blanket is unavailable). Do not wrap a standing person; rather, lay the victim down to extinguish the fire. The blanket should be removed once the fire is out to disperse the heat.

Equipment Failure or Hazard

Failure of equipment may be indicative of a safety hazard - You must report all incidents.

Should you observe excessive heat, excessive noise, damage, and/or abnormal behaviour of the lab equipment:

1. Immediately discontinue use of the equipment.

2. In power labs, press wall-mounted emergency shut-off button.

3. Inform your TA of the problem.

4. Wait for further instructions from your TA.

5. TA must file an incident report.

Protocol For Safe Laboratory Practice

In general, leave equipment in a safe state when you finish with it. When in doubt, consult the course TA.

Defined Roles

TA	The first point of contact for lab supervision	
ECE Lab Supervisor	Steve Spencer- ITB 147	spencers@mcmaster.ca
ECE Chair	Mohamed Bakr- ITB A111	mbakr@mcmaster.ca
ECE Administrator	Shelby Gaudrault- ITB A111/B	gaudraus@mcmaster.ca
ECE Course Instructor	Please contact your specific course instructor directly	