Western University
Faculty of Engineering
Department of Electrical and Computer Engineering

ECE 9031: Advanced Digital Signal Processing

Course Outline 2023 – 2024

Description: Digital Signal Processing (DSP) is at the heart of many applications in a wide array of fields: speech and audio processing, system monitoring and fault detection, biomedical signal analysis, mobile and internet communications, radar and sonar, vibration measurement and analysis, seismograph analysis, image/video coding and decoding etc. The objective of this course is to strengthen the students' knowledge of DSP fundamentals, and to familiarize them with the practical aspects of DSP algorithm development and implementation.

Enrollment Restrictions: Enrollment in this course is restricted to graduate students in Electrical and Computer Engineering, as well as any graduate student that has obtained special permission to enroll in this course from the course instructor as well as the Graduate Chair (or equivalent) from the student's home program.

Contact Hours: 3 lecture hours, ~2 laboratory hours every other week, 0.5 course.

Prerequisite: ECE 3331A/B or equivalent

Anti-requisite: ECE 4429

Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you will 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.

Recommended Textbook: Tan, L., & Jiang, J. (2013). Digital Signal Processing: Fundamentals and Applications. Boston, USA: Academic Press.

Reference Textbook: Orfanidis, S. J. (2010). Introduction to signal processing. Prentice-Hall, Inc. http://www.ece.rutgers.edu/~orfanidi/intro2sp/orfanidis-i2sp.pdf

Topics and Specific Learning Objectives

NOTE: This course will be offered in "blended" format. A set of video lectures related to each topic listed below will be released to students in a timely manner. Students are required to watch and understand the material in video lectures prior to the lecture time on Tuesdays. The lecture time will be devoted to solving a set of problems based on the corresponding video lectures. Instructor support will be available before and during the lecture time to answer questions related to videos and to assist with problem-solving.

1. **Sampling and quantization**
   At the end of this section, students will be able to:
   a. Understand the theory behind sampling and quantization processes.
   b. State the sampling, quantization and signal conditioning requirements for a given DSP application.
2. **Discrete Fourier Transform (DFT) and its applications**
   At the end of this section, students will be able to:
   a. Understand the theory behind DFT and Fast Fourier Transform (FFT)
   b. Apply FFT for spectrum analysis, convolution, and correlation.
   c. Apply FFT for filtering applications using overlap-add and overlap-save methods.
3. **Z-transform and its applications**
   At the end of this section, students will be able to:
   a. Understand Z-transform and related topics such as transfer function, frequency response, and pole-zero analysis.
   b. Design digital filters based on pole-zero placement.
4. **Design of FIR filters**
   At the end of this section, students will be able to:
   a. Understand the importance of linear phase and the different types of FIR filters.
   b. Design lowpass, highpass, bandpass, and bandstop FIR filters using the Kaiser window, frequency sampling and optimal design methods.
   c. Design FIR filters with arbitrary frequency response using frequency sampling method.
5. **Design of IIR filters**
   At the end of this section, students will be able to:
   a. Understand IIR filters and the structures for their implementation.

b. Design lowpass, highpass, bandpass, and bandstop IIR filters using Butterworth and Chebyshev prototypes.

6. **Multirate Signal Processing**

At the end of this section, students will be able to:

a. Understand the theory behind interpolators, decimators, and sampling rate converters.

b. Design and application of filterbanks.

Specific Learning Outcomes

Degree Level Expectation	Weight	Assessment Tools	Outcomes
Depth and breadth of knowledge	35%	• Quizzes • Project • Midterm • Labs	• Understanding of advanced concepts and theories • Awareness of important current problems in the field of study • Understanding of computational and/or empirical methodologies to solve related problems
Research & scholarship	15%	• Project	• Ability to conduct critical evaluation of current advancements in the field of specialization • Ability to conduct coherent and thorough analyses of complex problems using established techniques/principles and judgment
Application of knowledge	30%	• Quizzes • Project • Midterm • Labs	• Ability to apply knowledge in a rational way to analyze a particular problem
Professional capacity / autonomy	10%	• Project	• Awareness of academic integrity • Ability to implement established procedures and practices in the coursework • Defends own ideas and conclusions • Integrates reflection into his/her learning process
Communication skills	10%	• Project • Labs	• Ability to communicate (oral and/or written) ideas, issues, results, and conclusions clearly and effectively

Evaluation

Course Component	Weight
Online or in-class quizzes (4 quizzes)	15%
Midterm	25%
Laboratory (5 labs)	25%
Project	35%

To obtain a passing grade in the course, a mark of 60% or more must be achieved on the final examination, midterm, quizzes and on the laboratory reports. A final examination, midterm, quiz, or laboratory mark < 60% will result in a final course grade of 58% or less.

Online or in-class quizzes: Students are expected to complete online, or in-class quizzes based on the video lectures throughout the term. The schedule of these quizzes will be posted to OWL course site.

Midterm: The midterm will take place in October. The exact date, time, and location will be announced on OWL before the end of September 2023. The midterm is open book.

Laboratory: The laboratory portion of this course will consist of MATLAB-based experiments. Students are required to successfully complete the experiments and submit their MATLAB session (code & data) to OWL course site before the deadline.

Project: Students are expected to complete a project related to digital signal processing and submit a report by December 20, 2023. The project topic must be approved by the instructor.

Activities in which collaboration is permitted: Collaboration during the laboratory activities is permitted. However, the lab report must be submitted individually.

Activities in which students must work alone: Collaboration is not permitted for online quizzes, midterm, and the final project.

Late Submission Policy: Lab reports will be penalized by 50% of the available marks per day for late submission. *Late project reports will not be accepted and given a grade of 0.*

Use of English: In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

Attendance: All classes, laboratories, and tutorials are mandatory unless otherwise stated. Any student who, in the opinion of the instructor, is absent too frequently from class, laboratory, or tutorial periods will be reported to the Dean (after due warning has been given). On the recommendation of the department, and with the permission of the Dean, the student will be debarred from taking the regular final examination in the course.

Course Content

The lecture notes and online lecture videos are copyrighted to the instructor and legally protected. Do not post these videos and lecture notes on any other website or online forums. The recording of the live/synchronous sessions of the course without the permission from the instructor is prohibited. The illegal posting and sharing of the copyrighted course content could be subjected to legal actions.

Cheating, Plagiarism/Academic Offences

Academic integrity is an essential component of learning activities. Students must have a clear understanding of the course activities in which they are expected to work alone (and what working alone implies) and the activities in which they can collaborate or seek help; see information above

and ask instructor for clarification if needed. Any unauthorized forms of help-seeking or collaboration will be considered an academic offense. University policy states that cheating is an academic offence. If you are caught cheating, there will be no second warning. Students must write their essays and assignments in their own words. Whenever students take an idea or a passage of text from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence. Academic offences are taken seriously and attended by academic penalties which may include expulsion from the program. Students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence at the following website:
https://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_grad.pdf

All required papers may be subject to submission for textual similarity review to the commercial plagiarism-detection software under license to the University for the detection of plagiarism. All papers submitted for such checking will be included as source documents in the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between The University of Western Ontario and Turnitin.com (http://www.turnitin.com).

Synchronous Learning Activities
Students are expected to participate in synchronous learning activities as outlined in the course syllabus and/or described by the instructor. If you have issues that will impede your ability to participate in synchronous activities, please discuss with the course instructor at the beginning of the course.

Conduct
Students are expected to follow proper etiquette during synchronous and asynchronous activities to maintain an appropriate and respectful academic environment. Any student who, in the opinion of the instructor, is not appropriately participating in the synchronous and asynchronous learning activities and/or is not following the rules and responsibilities associated with the online learning activities, will be reported to the Associate Dean (Graduate) (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Associate Dean (Graduate), the student could be debarred from completing the assessment activities in the course as appropriate.

Health/Wellness
As part of a successful graduate student experience at Western, we encourage students to make their health and wellness a priority. Western provides several health and wellness related services (remotely accessible) to help you achieve optimum health and engage in healthy living while pursuing your graduate degree. Information regarding health- and wellness-related services available to students may be found at http://www.health.uwo.ca/.

Students seeking help regarding mental health concerns are advised to speak to someone they feel comfortable confiding in, such as their faculty supervisor, their program director (graduate chair), or other relevant administrators in their unit. Campus mental health resources may be found at
http://www.health.uwo.ca/mental_health/resources.html
https://www.uwo.ca/health/psych/index.html

Sickness
Students should immediately consult with the Instructor (for a particular course) or Associate Chair (Graduate) (for a range of courses) if they have problems that could affect their performance. The student should seek advice from the Instructor or Associate Chair (Graduate) regarding how best to deal with the problem. Failure to notify the Instructor or the Associate Chair (Graduate) immediately (or as soon as possible thereafter) will have a negative effect on any appeal. Obtaining appropriate documentation (e.g., a note from the doctor) is valuable when asking for accommodation due to illness.

ACCESSIBLE EDUCATION WESTERN (AEW)
Western is committed to achieving barrier-free accessibility for all its members, including graduate students. As part of this commitment, Western provides a variety of services devoted to promoting, advocating, and accommodating persons with disabilities in their respective graduate program. Graduate students with disabilities (for example, chronic illnesses, mental health conditions, mobility impairments) are strongly encouraged to register with Accessible Education Western (AEW): http://academicsupport.uwo.ca/accessible_education/index.html

AEW is a confidential service designed to support graduate and undergraduate students through their academic program. With the appropriate documentation, the student will work with both AEW and their graduate programs (normally their Graduate Chair and/or Course instructor) to ensure that appropriate academic accommodations to program requirements are arranged. These accommodations include individual counselling, alternative formatted literature, accessible campus transportation, learning strategy instruction, writing exams and assistive technology instruction.