Western University
Faculty of Engineering
Department of Electrical and Computer Engineering

ECE 3331B: Introduction to Signal Processing

Course Outline 2022-23

Description: This course covers the fundamental theories in digital signal processing (DSP). Basic sequences encountered in DSP are presented, and the fundamentals of sampling and system responses are introduced. The differences between the processing of periodic and aperiodic signals are discussed and time domain methods such as convolution of two signals are developed. Frequency domain methods, such as the Discrete Fourier Transform and the Fast Fourier Transform are presented. The z-Transform is introduced as a tool for discrete time signal processing.

Instructor: Dr. Ilia Polushin
ACEB 3464, 519-661-2111 ext. 88575, email: ipolushi@uwo.ca

Consultation hours: TBA

Academic Calendar Copy: Introduction to discrete-time signals and sampled data, linear time-invariant (LTI) systems, frequency response, discrete Fourier transforms, convolution, spectrum analysis, Z-transforms, non-recursive digital filters.

Contact Hours: 3 lecture hours, 3 laboratory hours/week (6 weeks per term), 0.5 course.

Antirequisite: N/A.

Prerequisites: ECE 2233A/B or MSE 2233 A/B

Co-requisite: N/A.

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.

CEAB Academic Units: Engineering Science 80%, Engineering Design 20%.

Recommended References:

1. "Digital Signal Processing; Principles, Algorithms and Applications," 4th Edition, by John G. Proakis and Dimitris G. Manolakis, Pearson Prentice Hall, 2007, or 5th edition, 2021.
2. "Applied Digital Signal Processing," by Dimitris G. Manolakis and Vinay K. Ingle, Cambridge University Press, 2011.

General Learning Objectives (CEAB Graduate Attributes)

Knowledge Base	D	Use of Engineering Tools	D	Impact on Society and the Environment	
Problem Analysis	D	Individual and Team Work		Ethics and Equity	
Investigation		Communication Skills	A	Economics and Project Management	
Design	I	Professionalism		Life-Long Learning	

Notation. I – The instructor will introduce the topic at the level required. It is not necessary for the student to have seen the material before. **D –** There may be a reminder or review, but the student is expected to have seen and been tested on the material before taking the course. **A –** It is expected that the student can apply the knowledge without prompting (e.g. no review).

Course Topics and Specific Learning Outcomes	**CEAB Graduate Attributes Indicators**
1. Introduction • Signals, Systems and Signal Processing • Classification of Signals • The Concept of Frequency in Continuous-Time and Discrete-Time Signals • Analog-to-Digital and Digital-to-Analog Conversion	
At the end of this section, students will be able to:	
a. Identify the basic elements of a digital signal processing system	Taught, but Not Assessed
b. Describe the basic properties of discrete-time sinusoidal signals	Taught, but Not Assessed
c. Determine characteristics of a discrete-time signal obtained by sampling of a continuous-time sinusoidal signal.	**KB 3**, **KB 4**
2. Discrete-Time Signals and Systems • Discrete-Time Signals • Discrete-Time Systems • Analysis of Discrete-Time Linear Time-Invariant (LTI) Systems • Discrete-Time Systems Described by Difference Equations • Implementation of Discrete-Time Systems	
At the end of this section, students will be able to:	
a. Distinguish between different types of discrete-time systems (linear vs. nonlinear, time-varying vs. time-invariant, causal vs. non-causal, etc.)	**KB 4**

b. Calculate response of a discrete-time system to a given input using convolution sum.	**KB 3**, **KB 4**, **ET 3**
c. Determine implementation of a discrete-time system that requires the minimum possible amount of memory and sketch the corresponding block diagram.	**KB 4**
3. The z-Transform and its Application to the Analysis of LTI Systems	
• The z-Transform • Properties of the z-Transform • Rational z-Transforms • Inversion of the z-Transform • Analysis of LTI Systems in the z-Domain • The One-sided z-Transform	
At the end of this section, students will be able to:	
a. Convert time-domain signals into z-domain using z-transform.	**KB 4, ET 3**
b. Compute zero-state response of an LTI system using z-transform methods.	**KB 4, ET 3**
c. Describe relation between pole location and time-domain behaviour of an LTI system.	**KB 4**
4. Frequency Analysis of Signals	
• Frequency Analysis of Continuous-Time Signals • Frequency Analysis of Discrete-Time Signals • Properties of the Fourier Transform for Discrete-Time Signals	
At the end of this section, students will be able to:	
a. Explain differences between Fourier representations for different types of signals.	**KB 3**
b. Calculate the Fourier transform of a given discrete-time signal.	**KB 4**, **ET 3**
5. Frequency-Domain Analysis of LTI Systems	
• Frequency-Domain Characteristics of LTI Systems • Frequency Response of LTI Systems • LTI Systems as Frequency-Selective Filters	
At the end of this section, students will be able to:	
a. Convert time-domain signals into z-domain using z-transform.	**KB 4**
b. Compute zero-state response of an LTI system using z-transform methods.	**KB 4**, **ET 3**

c. Describe relation between pole location and time-domain behaviour of an LTI system. d. Design simple digital filters	**KB 4** **PA2, PA3, D1-D3**
6. The Discrete Fourier Transform • Frequency-Domain Sampling: The Discrete Fourier Transform (DFT) • Properties of the DFT • The Fast Fourier Transform (FFT) At the end of this section, students will be able to:	
a. Explain the relationship between Fourier transform and DFT. b. Compute the response of a FIR filter to a given input signal using DFT. c. Explain the principles behind the FFT algorithms.	**KB 3** **KB 4** Taught, but Not Assessed
7. Laboratories and Lab Project	**KS 3, ET 3**

Evaluation

Course Component	Weight
Laboratories	15%
Laboratory Project	15%
Midterm Test	20%
Final Examination	50%

To obtain a passing grade in the course, marks of 50 % or more must be achieved on both the Final Exam and the laboratory component (Laboratories + Laboratory Project). A Final Exam or laboratory component mark < 50% will result in a final course grade of 48% or less.

Homework Assignments: A maximum of 6 homework assignments will be given. Assignments will be posted on OWL. Homeworks will not be marked. Solutions to the homework assignments will be posted on OWL.

Laboratory exercises: There are three Matlab-based laboratories and one laboratory tutorial in this course. The laboratory manuals will be available on OWL. Students will be required to submit their laboratory reports online.

Laboratory Project: Each student is required to complete a Matlab-based project related to filter design and submit a report. The project is to be done during two weeks period in late March – early April. Details of the project will be posted on OWL. Students will be required to submit their project reports online.

Midterm Test: The midterm test will take place on **Tuesday, March 7th**, during the regularly scheduled lecture hours. Duration: 1 hour 50 minutes. Closed book exam. Necessary equations are

provided. No programmable calculators are allowed. Students will be required to submit their exam solutions online.

Final Examination: The final exam will be scheduled during the regular Winter term examination period in April. Duration: 3 hours. Closed book exam. Necessary equations are provided. No programmable calculators are allowed. Students will be required to submit their exam solutions online. (Check https://studentservices.uwo.ca/secure/Exams/)

Late Submission Policy: All lab reports and the project report are due by 11:59 PM on the specified due date. Late submissions will be penalized 10%. Submissions that are more than 3 days late will not be accepted.

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: 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.

Absence Due to Illness or Other Circumstances: Students should immediately consult with the instructor or department Chair if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented (see the attached "Instructions for Students Unable to Write Tests or Examinations or Submit Assignments as Scheduled"). The student should seek advice from the instructor or department Chair regarding how best to deal with the problem. Failure to notify the instructor or department Chair immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

For more information concerning medical accommodations, see the relevant section of the Academic Handbook:
http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_medical.pdf

For more information concerning accommodations for religious holidays, see the relevant section of the Academic Handbook:
http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_religious.pdf

Academic Consideration for work worth less than 10% of the overall grade in the course: A student seeking academic consideration for any work worth less than 10% of the total course grade must contact the Dean's office and, if applicable, submit the relevant medical documentation to that office.

Missed Midterm Examinations: If a student misses a midterm examination, the exam will not be rescheduled. The student must follow the Instructions for Students Unable to Write Tests and provide documentation to their department within 24 hours of the missed test. The department will

decide whether to allow the reweighting of the test, where reweighting means the marks normally allotted for the midterm will be added to the final exam. If no reasonable justification for missing the test can be found, then the student will receive a mark of zero for the test.

If a student is going to miss the midterm examination for religious reasons, they must inform the instructor in writing within 48 hours of the announcement of the exam date or they will be required to write the exam.

Course Delivery with Respect to the COVID-19 Pandemic: Although the intent is for this course to be delivered in-person, the changing COVID-19 landscape may necessitate some or all of the course to be delivered online, either synchronously (i.e., at the times indicated in the timetable) or asynchronously (e.g., posted on OWL for students to view at their convenience). The grading scheme will not change. Any assessments affected will be conducted online as determined by the course instructor.

When deemed necessary, tests and examinations in this course will be conducted using a remote proctoring service. By taking this course, you are consenting to the use of this software and acknowledge that you will be required to provide personal information (including some biometric data) and the session will be recorded. Completion of this course will require you to have a reliable internet connection and a device that meets the technical requirements for this service. More information about this remote proctoring service, including technical requirements, is available on Western's Remote Proctoring website at: https://remoteproctoring.uwo.ca.

Cheating and Plagiarism: Students must write their essays and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. University policy states that cheating, including plagiarism, is a scholastic offence. The commission of a scholastic offence is attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning.

All required papers may be subject to submission for textual similarity review to commercial plagiarism-detection software under license to the University for the detection of plagiarism. All papers submitted will be included as source documents on 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).

Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, in the relevant section of the Academic Handbook:
http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf

Use of Electronic Devices: Students may use laptops, tablet computers, or smart phones only to access the course OWL site during lectures and tutorials. Use of nonprogrammable calculators only is permitted during tests and examinations. No other electronic devices may be used at any time during lectures, tutorials, or examinations.

Policy on Repeating All Components of a Course: Students who are required to repeat an Engineering course must repeat all components of the course. No special permissions will be granted enabling a student to retain laboratory, assignment, or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted by the student for grading in subsequent years.

Internet and Electronic Mail: Students are responsible for regularly checking their Western e-mail and the course web site (https://owl.uwo.ca/portal/) and making themselves aware of any information that is posted about the course.

Accessibility: Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 519-661-2111 ext. 82147 for any specific question regarding an accommodation.

Support Services: Office of the Registrar, http://www.registrar.uwo.ca/
Student Development Centre, http://www.sdc.uwo.ca/
Engineering Undergraduate Services, http://www.eng.uwo.ca/undergraduate/
USC Student Support Services, http://westernusc.ca/services/

Students who are in emotional/mental distress should refer to Mental Health @ Western, http://www.health.uwo.ca/mental_health/, for a complete list of options about how to obtain help.