Western Engineering

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

AISE 3351 – Digital Systems & Signal Processing

COURSE DESCRIPTION: The course covers: 1) Nyquist sampling and reconstruction of signals. State-space model of discrete systems. z-Transform and system function. 2) Autoregressive (AR), autoregressive–moving-average (ARMA), infinite impulse response (IIR) systems, their description and frequency response. Basic algorithms for AR/ARMA estimation, feature extractions and implementation. 3) Sensors and data collection. Selected topics in sensor integration across the cyber space: data transfer, compression, and protection.

Sampling and reconstruction of signals, discrete signals and systems, difference equations and state-space models of digital systems, z-transform and system functions, finite impulse response (FIR) and infinite impulse response (IIR) systems, their mathematical description and frequency response, Fast Fourier transform, filter structures, basics of spectral analysis, data collection.

https://www.westerncalendar.uwo.ca/Courses.cfm?CourseAcadCalendarID=MAIN_030975_1&SelectedCalendar=Live&ArchiveID=

PRE OR COREQUISITES: AISE3350A/B or the former ECE3350A/B

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.

ANTIREQUISITES:

ECE3331A/B or the former ECE3351A/B

CEAB ACADEMIC UNITS: Engineering Science 100%

CONTACT HOURS: Timetable information is available at https://draftmyschedule.uwo.ca/.

Three lecture hours occur weekly

Two hour laboratory sessions occur weekly 8 times per term

RECOMMENDED/REQUIRED TEXT: J. G. Proakis and D. G. Manolakis, *Digital Signal Processing; Principles, Algorithms and Applications*, 5th Ed., Pearson Prentice Hall, (2021) is recommended, but not required. E-copy available for $78.00.

RECOMMENDED/ REQUIRED SOFTWARE: Matlab (user license is included with your tuition) is required for completing the laboratory exercises.

RECOMMENDED RESOURCES/REFERENCES: None.

GENERAL LEARNING OBJECTIVES (CEAB GRADUATE ATTRIBUTES)

Knowledge Base	D	Engineering Tools	D	Impact on Society	
Problem Analysis	D	Individual & Teamwork		Ethics and Equity	
Investigation		Communication	A	Economics and Project Mgmt.	
Design		Professionalism		Life-Long Learning	

Notation: x represents the content level code as defined by the CEAB. blank = not applicable; I = introduced (introductory); D = developed (intermediate) and A = applied (advanced).

Rating: 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 MATERIALS: Weekly content and guides for the laboratories will be available on the course OWL site. The material for this course will be taught in both lectures and labs; therefore, it is imperative that you attend each lecture and lab.

UNITS: SI

COURSE TOPICS AND SPECIFIC LEARNING OUTCOMES: The major learning outcome in this course is obtaining an understanding of digital signal analysis, and the ability to analyze and design simple digital filters.

The following table summarizes the course learning outcomes along with CEAB GAIs where the GAIs in bold indicate ones to be measured and reported annually.

COURSE TOPICS AND SPECIFIC LEARNING OUTCOMES	**(CEAB) Graduate Attribute**
Introduction to Digital Systems and Signal Processing Signals, systems, and signal processing. Classification of signals. At the end of this section, students will be able to: a. Understand the concept of signal and explain the difference between continuous-time, discrete-time, and digital signals. b. Identify the basic elements of a digital signal processing system.	KB3, KB4
Sampling and reconstruction of signals The concept of frequency, periodic sampling of continuous-time signals, and aliasing. Practical methods of signal reconstruction. At the end of this section, students will be able to: a. Describe the basic properties of discrete-time sinusoidal signals. b. Determine a discrete-time signal obtained from a continuous-time signal by periodic sampling. c. Determine a minimum sampling frequency that is required to avoid aliasing. d. Understand practical methods of reconstruction of a continuous-time	KB3, KB4

signal from its sampled version.	
Digital Signals and Systems in Time Domain Discrete-Time Signals and discrete-Time Systems. Analysis of Discrete-Time Linear Time-Invariant (LTI) Systems. Discrete-Time Systems Described by Difference Equations. State-space models of digital systems. At the end of this section, students will be able to: a. Describe digital signals mathematically. b. Distinguish between different types of discrete-time systems (linear vs. nonlinear, time-varying vs. time-invariant, causal vs. non-causal, etc.). c. Determine analytically the response of a discrete-time system to a given input using convolution sum. d. Calculate numerically the response of a discrete-time system described by linear constant-coefficient difference equation.	KB3, KB4, ET3
Z-Transform and System Functions Rational z-transforms and properties of z-transform. System functions of LTI systems. Auto-regressive moving average (ARMA) models. Inversion of the z-transform. Analysis of LTI systems in the z-domain. Structures and implementation of discrete-time systems. At the end of this section, students will be able to: a. Convert time-domain signals into z-domain using z-transform. b. Compute zero-state response of an LTI system using z-transform methods. c. Describe relation between pole location and time-domain behaviour of an LTI system. d. Determine implementation of a discrete-time system that requires the minimum possible amount of memory and sketch the corresponding block diagram.	KB4, ET3
Frequency-Domain Analysis of Digital Signals and Systems Frequency Analysis of Discrete-Time Signals. Properties of the Fourier Transform for Discrete-Time Signals. Frequency-Domain Characteristics of LTI Systems. Frequency Response of LTI Systems. LTI Systems as Frequency-Selective Filters. Design of basic finite impulse response (FIR) and infinite impulse response (IIR) filters. At the end of this section, students will be able to: a. Calculate the Fourier transform of a given discrete-time signal. **b.** Determine the steady-state response of an LTI system to sinusoidal, complex exponential, periodic, and aperiodic signals using the frequency response function. **c.** Understand how the location of poles and zeros of the system function determine the magnitude and phase response of an LTI system. **d.** Design simple FIR and IIR digital filters	KB3, KB4, PA2, PA3, ET3
Data Collection, Transfer, Compression, and Protection Selected topics on these subjects, time permitting.	KB3, KB4

Laboratories Using Matlab to investigate digital signals using the theoretical techniques described in the course.	KB3, ET3, CS3

EVALUATION:

Name	% Worth	Due Date	CEAB GAs ASSESSED
Labs (Total = 8)	32%	One week after posting date	KB3, ET3, CS3
Quizzes (Total = 3)	18% to 0%	45 minutes after start	KB3, KB4, PA2, PA3
Final Examination	50% to 68%	Three hours after start	KB3, KB4, PA2, PA3

Note that the dates listed above are **tentative** and may be adjusted if needed. Marks will be assigned on the basis of method of analysis and presentation, correctness of solution, clarity and neatness.

COURSE POLICIES:
All work submitted must be of professional quality in the requested format. Material that is handed in dirty, illegible, disorganized, or in an unapproved format will be returned to the student for resubmission and the late submission penalty will take effect. An additional penalty of 10% may be deducted for poor grammar, incoherence, or lack of flow in the written reports.

Laboratories: The laboratories will be completed remotely. Students must use Matlab to complete the lab exercises. Students may work together to complete the lab exercises, but each student is responsible for completing an individual laboratory report to be submitted on OWL.

All laboratory exercises must be completed. Extensions on the due dates may be granted when warranted by academic considerations, but under no circumstances will the grade portion for a laboratory exercise be redistributed or waived.

To obtain a passing grade in the course, an average mark of 50% or more must be achieved on all laboratories. If the final average laboratory mark is < 50%, the final course grade will be 48% or less.

Quizzes: Three quizzes will be scheduled during regular lecture hours. These will be written in-class. These will be closed-book, problem-based assessments. Students must work individually under normal examination conditions.

If a student misses a quiz, or does poorly on a quiz, the grade portion for that quiz will be automatically redistributed to the final exam.

Final Examination: The final exam will be scheduled by the Office of the Registrar during the final examination period. Details on the location, mode of delivery, and allowed aids were be posted in advance.

If a student does better on the final examination than on any of the quizzes, the grade from the final exam will be used instead of the quiz grade. The final exam may therefore be worth 50%, 56%, 62%, or 68% of the total grade, depending on how well (or poorly) students perform on the quizzes before the final exam.

To obtain a passing grade in the course, a mark of 50% or more must be achieved on the final examination. A final examination mark < 50% will result in a final course grade of 48% or less. If the above conditions are not met, your final grade cannot be greater than 48%. Students who have failed this course (i.e., final average < 50%) must repeat all components of the course.

Assignment Submission Locker: Submission of any and all course work will be done online using OWL. A submission locker will not be used.

LATE SUBMISSION POLICY:
Advise the instructor if you are having problems completing the assignment on time prior to the due date of the assignment and be prepared to submit an Academic Consideration Request and provide documentation if requested by the instructor at:
https://www.eng.uwo.ca/undergraduate/academic-consideration-for-absences.html
If you are granted an extension, establish a due date with the instructor. The approval of the Chair of your Department is not required if assignments are completed prior to the last day of classes. Extensions beyond the end of classes must have the consent of the instructor, the department Chair and the Associate Dean, Undergraduate Studies.
Documentation is mandatory.

This course employs flexible deadlines for laboratory reports. The report deadlines can be found above in the course outline. For each report, students are expected to submit the assignment by the deadline listed (the “due date” for submission on OWL). Should illness or extenuating circumstances arise, students are permitted to submit their assignment past the deadline without academic penalty according to the grace period indicated on OWL (the “end date” for submission, will be a minimum of 48 hours after the due date). Reports submitted after this grace period will generally not be accepted. **As flexible deadlines are used in this course, requests for academic consideration will not be granted.** If you have a long-term academic consideration or an accommodation for disability that allows greater flexibility than provided here, please reach out to your instructor at least one week prior to the posted deadline.

ATTENDANCE: Attendance is recommended for all lectures. Labs are not generally held in-person, but a TA will be present for selected sessions if students want in-person assistance. See the lab schedule on OWL for full details.