Carleton UNIVERSITY | Department of Systems and Computer Engineering

SYSC 4405
Digital Signal Processing

Calendar description

Discrete time signal and system representation: time domain, z-transform, frequency domain. Sampling theorem. Digital filters: design, response, implementation, computer-aided design. Spectral analysis: the discrete Fourier transform and the FFT. Applications of digital signal processing.

Includes: Experiential Learning Activity.

Lectures three hours a week, laboratory three hours alternate weeks.

http://calendar.carleton.ca/undergrad/courses/SYSC/

Prerequisites

SYSC 3500 or SYSC 3600 or SYSC 3610.

Prior knowledge

Students should have knowledge of:

- System analysis using Laplace/Fourier techniques.
- System modeling using impulse response and convolution.
- Programming techniques (e.g. Matlab, C and or Python).

Course objectives

The relationship between discrete-time and continuous-time signals and systems is emphasized throughout the course. Students will have the opportunity to apply the theory in several laboratory sessions that deal with the design and implementation of basic DSP functions such as FIR and IIR filters as well as spectral analysis using the FFT.

List of topics

- Discrete-time signals and sequences, unit impulse and unit step functions, properties of systems, filters described by difference equations and block diagrams.
- Impulse response, convolution, discrete-time linear convolution, stability in time.
- Spectrum representation, sampling, Shannon sampling theorem, Nyquist rate, aliasing.

- Frequency response, sinusoidal filtering, z-transform representation of sequences and filters.
- Transfer functions, pole-zero plots, z-domain, frequency domain relationship.
- Stability in z-domain, frequency response, impulse response.
- FIR filter design, ideal frequency selective filters, FIR filter transformations, FIR windowed filtering, linear phase filters, group delay.
- IIR filter design, Butterworth filters, analog filter transformations.
- IIR filter design by impulse invariance, bilinear transformation.
- Filter structures, Direct Form I and II structures, cascade structures, parallel structures, discrete Fourier series (DFS), discrete Fourier transform (DFT).
- Discrete Fourier transform (DFT), signal analysis with the DFT, fast Fourier transform (FFT).
- Introduction to time-frequency analysis issues and spectrograms.

Learning outcomes

By the end of this course, students should be able to:

- Understand the differences between analog, discrete time and digital signals.
- Describe and analyze discrete time signals in the time and frequency domains.
- Apply digital signal processing techniques to design discrete time systems.
- Learn the z-transform and its applications in the analysis and design of discrete time systems, and how to use for frequency response computation.
- Design digital filters, meeting given specifications, using windowing techniques.
- Design digital filters using transformation techniques from analog designs.
- Use the Discrete Fourier Transform (DFT) and the FFT for the analysis of arbitrary signals.
- Program digital signal processing algorithms in MATLAB.

Graduate Attributes (GAs)

The Canadian Engineering Accreditation Board requires graduates of engineering programs to possess 12 attributes at the time of graduation. Activities related to the learning outcomes listed above are measured throughout the course and are part of the department's continual improvement process. Graduate attribute measurements will not be taken into consideration in determining a student's grade in the course. For more information, please visit: https://engineerscanada.ca/.

Graduate Attribute	Learning outcome(s)
1.6.S: Knowledge Base: Applied: Signals and systems	All
2.1: Problem Analysis: Applied: Problem definition	All
2.2: Problem Analysis: Applied: Approach to the problem	All
2.3: Problem Analysis: Applied: Use of assumptions	5-8
2.4: Problem Analysis: Applied: Interpreting the solution – validity of results	5-8
3.1: Investigation: Developed: Complex problem assessment	All
3.4: Investigation: Applied: Data reduction methods and results	All
3.5: Investigation: Applied: Interpretation of data (synthesis) and discussion	5-8

4.5: Design: Applied: Design implementation / task(s) definition	5-8
4.6: Design: Applied: Alternate solution(s) definition	5-8
5.3: Use of Engineering Tools: Applied: Tools for design, experimentation, simulation, visualization, and analysis	All

Accreditation Units (AUs)

For more information about Accreditation Units, please visit: https://engineerscanada.ca/.

The course has a total of 46 AUs, divided into:

- Engineering Science: 50%
- Engineering Design: 50%

Instructor and TA contact

Specific to course offering (tbd)

Textbook (or other resources)

Specific to course offering (tbd)

Evaluation and grading scheme

Specific to course offering (tbd)

Breakdown of course requirements

Specific to course offering (tbd)

Tentative week-by-week breakdown

Specific to course offering (tbd)

General regulations

Specific to course offering (tbd)