Instructor: Prof. Sreeraman Rajan  
Room 4480ME, Telephone: (613) 520-2600 x4169, E-mail: sreeramanr@sce.carleton.ca  
Office Hours: Tuesdays and Thursdays 4.00-5.00 PM (walk in permitted and will entertain if I am free.)

Teaching Assistants: Abdallah Jarwan Email: Abdallah@cmail.carleton.ca  
Mr. Hanif Juma Email: HanifJuma@cmail.carleton.ca  
Office Hours: TBD, Office: TBD

Course Description and Objectives: The course provides an introduction to digital signal processing (DSP). It covers the basic DSP concepts and methods, such as sampling, discrete-time systems, FIR filters, IIR filters and DFT/FFT algorithms. Emphasis will be on digital infinite impulse response (IIR) and finite impulse response (FIR) filters and applications of the fast Fourier transform (FFT). 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.

Prerequisites: SYSC 2500 or SYSC 3500 or SYSC 3600. Students who have not satisfied the prerequisites must either (a) withdraw from the course or (b) obtain a prerequisite waiver from www.sce.carleton.ca/ughelp. Students not meeting these conditions may be deregistered from the course after the last day for course registration.

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.

Recommended Course Material:
- SYSC 4405: Introduction to DSP – Lecture Notes (Lecture notes will be made available)
Other Resources (not mandatory):


**Grading:**

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignments</td>
<td>10%</td>
<td>(up to 5 assignments max)</td>
</tr>
<tr>
<td>Quizzes</td>
<td>5%</td>
<td>(up to 10 quizzes max)</td>
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<tr>
<td>Labs</td>
<td>5%</td>
<td></td>
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<tr>
<td>Midterm Examination</td>
<td>20%</td>
<td>(10% each. Midterm 1: Oct 13 or 14 Midterm 2: Nov 11)</td>
</tr>
<tr>
<td>Final Examination</td>
<td>60%</td>
<td>(Scheduled by University)</td>
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CU Learn will be used for the course web page, which is accessible at [http://culearn.carleton](http://culearn.carleton). The web page will list your official midterm, laboratory, and quiz grades throughout the semester. Under cases where reevaluation of midterm exams need to be done, it would be performed without student’s presence. It is your responsibility to double check that the grades are recorded correctly for your work. Check the course web page regularly for announcements and postings. Final exam is for evaluation purposes only and will not be returned to the students. It is your responsibility to submit Instructor Verification Points document to the TA at the end of every lab. Failure to submit the Instructor Verification Points document to the TA will be treated as lab not done. Use of cell phones is strictly prohibited during lectures/exams/quizzes/tests/labs.

To obtain a final grade higher than F,
• students must obtain a passing grade on the final exam AND
• have attended and completed all laboratory requirements

Please make a note of the following:
• If a midterm is missed, procedure laid out by Carleton must be followed when you seem readministration (please check Carleton’s Exam policies)
• If no valid documentation as per Carleton University guideline is provided for not taking midterms due to unavoidable circumstances, a zero grade will be given.
• If valid documentation is provided, then equivalent weight would be shifted to the final examination.
• All midterm exams will be administered outside of the class hours. Date, time and place will be announced in the class.
• Assignments submitted late will not be graded. Students may consult during working out their assignments but will not submit individual scribed assignments.
• Problems will be provided for practice. Solutions may be given only for selected problems.
• It is your responsibility to submit Instructor Verification Points document to the TA at the end of every lab.
• Failure to submit the Instructor Verification Points document to the TA will be treated as lab not done.
• Any bonus point obtained by a student will be included in grade calculation only if the student obtains a passing grade on the final exam is obtained.
Final Exam, Midterm Exams and Quizzes will be closed book. Duration of final exam will be 3 hours. Only non-programmable calculating devices will be allowed.

Cheat sheets are generally not allowed. If there are changes to the policy during the course of the semester, it will be announced in the class before the test/exam.

Health and Safety: Every student should have a copy of our Health and Safety Manual. An electronic version of the manual can be found at http://www.sce.carleton.ca/courses/health-and-safety.pdf

Attendance: Students are expected to attend all lectures and lab periods as required. The Faculty of Engineering and Design requires students to have a conflict-free timetable, so requests to accommodate missed exams, assignment due dates, project milestones, etc., because of conflicts with other courses, jobs or vacation plans will not be considered.

Plagiarism: Plagiarism (copying and submitting for credit someone else’s work) is a serious instructional offense that will not be tolerated. Please refer to the section on instructional offenses in the Undergraduate Calendar for additional information.

Midterm Policy: The midterm is to be written at the scheduled announced time. A missed midterm will be recorded as a zero. If the midterm is missed for circumstances beyond your control, you should submit appropriate documentation within 5 business days for consideration.

Final Exam Policy: The final exam is for evaluation purposes only and will not be returned to the student. You are allowed to have a look at the corrected exams and no discussion would be entertained regarding the evaluation process. For re-evaluation, students would be directed to follow Carleton University’s procedures.

Laboratories: Lab attendance is a compulsory component of this course. Laboratories will be three hours alternate weeks as per the registration schedule. Check the calendar on the course webpage for the lab schedule. The labs will be held in the Texas Instruments Embedded Processing Lab in CB 5107. Five lab sessions are planned for each student and will consist of programming in MATLAB™, developing filter models in SIMULINK™, and using the TI TMS320C6713 DSP starter kit board.

Course Outline (anticipated):

- Introductory concepts to digital signal processing
  - 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

Important Details

Academic Accommodation

You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:

Pregnancy/parental leave obligation: write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website:

http://www.carleton.ca/equity/accommodation/academic/

Religious obligation: Kindly email me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website:

http://www.carleton.ca/equity/accommodation/academic/

Academic Accommodations for Students with Disabilities: The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). Requests made within two weeks will be reviewed on a case-by-case basis. After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website http://www.carleton.ca/pmc for the deadline to request accommodations for the formally-scheduled exam (if applicable).

You can visit the Equity Services website to view the policies and to obtain more detailed information on academic accommodation at http://www.carleton.ca/equity/academic/

Academic Integrity

Carleton demands academic integrity from all its members. Academic Integrity Policy governs the academic behaviour of students. Students should be aware of their obligations with regards to Academic Integrity. For details of the policy, visit (http://carleton.ca/studentaffairs/academic-integrity/).

Course material copyright

Classroom teaching and learning activities, including lectures, discussions, presentations, etc., by both instructors and students, are copy protected and remain the intellectual property of their respective author(s). All course materials, including PowerPoint presentations, outlines, labs, case studies, assignments, exams and other materials, are also protected by copyright and remain the intellectual property of their respective author(s). Students registered in the course may take notes and make copies of course materials for their own educational use only. Students are not allowed to make electronic recordings (voice and / or video) or take photographs in the class room without the express written consent of the course instructor. The Students are not permitted to reproduce or distribute lecture notes and course materials publicly for commercial or noncommercial purposes without express written consent from the copyright holder(s).