Course Syllabus

Instructor: Prof. Sreeraman Rajan
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Office Hours: Tuesdays 4.00-5.00 PM (walk in permitted and will entertain if I am free.)

Teaching Assistants: Abdallah Jarwan Email: Abdallah@cmail.carleton.ca
Office Hours: TBD, Office: TBD

Calendar Information
Course Number: SYSC 4405
Course Title: Digital Signal Processing

Calendar description

Includes: Experiential Learning Activity
Prerequisite(s): SYSC 3500 or SYSC 3600 or SYSC 3610.

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

Prerequisites Students who have not satisfied the prerequisites for this course must either withdraw from the course or obtain a prerequisite waiver by visiting the Engineering Undergraduate Academic Support Office.

As part of prerequisites students should have strong math background: good knowledge of complex numbers, differential and integral calculus, differential equations, series and sequences. Students should have a good grasp of linear systems, Laplace transforms and Fourier series and transforms in continuous time domain, system level concepts of block diagrams, impulse response, stability, transfer function, poles and zeros and continuous time and frequency system responses. As this DSP course will make require recalling the fundamentals learnt from earlier years, it is mandatory that students refresh their memory. NO TIME will be spent in the class to go through the forgotten aspects of pre-requisites. It is the responsibility of the students to remember all the pre-requisites.

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.

Learning Outcomes By the end of this course students should be able to

1. Understand the differences between analog, discrete time and digital signals.
2. Describe and analyze discrete time signals in the time and frequency domains.
3. Apply digital signal processing techniques to design discrete time systems.
4. Learn the z-transform and its applications in the analysis and design of discrete time systems, and how to use for frequency response computation
5. Design digital filters, meeting given specifications, using windowing techniques.
6. Design digital filters using transformation techniques from analog designs.

7. Use the Discrete Fourier Transform (DFT) and the FFT for the analysis of arbitrary signals.

8. Program digital signal processing algorithms in MATLAB.

Graduate Attribute (GA) 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/

Table 1: Graduate Attribute for SYSC 4405.

<table>
<thead>
<tr>
<th>Graduate Attribute</th>
<th>Learning Outcomes</th>
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</thead>
<tbody>
<tr>
<td>1 Knowledge base 1.6S Signals and Systems</td>
<td>1-8</td>
</tr>
<tr>
<td>2 Problem Analysis 2.1 Problem Definition</td>
<td>3,5,6,8</td>
</tr>
<tr>
<td>2 Problem Analysis 2.2 Approach to the problem</td>
<td>3-8</td>
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<tr>
<td>2 Problem Analysis 2.3 Use of assumptions</td>
<td>3-7</td>
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<tr>
<td>2 Problem Analysis 2.4 Interpreting the solution, validity of results</td>
<td>3-8</td>
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<tr>
<td>3 Investigation 3.1 Complex problem assessment</td>
<td>2,7</td>
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<tr>
<td>3 Investigation 3.4 Data reduction methods and results</td>
<td>2,7,8</td>
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<tr>
<td>3 Investigation 3.5 Interpretation of data (synthesis) and discussion</td>
<td>2,4,7, 8</td>
</tr>
<tr>
<td>4. Design 4.5 Design implementation/ task(s) definition</td>
<td>5,6,8</td>
</tr>
<tr>
<td>4. Design 4.6 Alternate solution(s) definition</td>
<td>3,4,5,6,7</td>
</tr>
<tr>
<td>5. Use of Engineering Tools 5.3 Tools for design</td>
<td>7,8</td>
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</tbody>
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Recommended Course Material:
- SYSC 4405: Introduction to DSP – Lecture Notes (Lecture notes will be made available)

Other Resources (not mandatory):

Evaluation and Grading:
The following requirement needs to be met to obtain a final grade higher than F: a student must have obtained a passing grade on the final exam AND attended and completed all laboratory requirements.

<table>
<thead>
<tr>
<th>Grading Details</th>
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<tbody>
<tr>
<td>Assignments:</td>
<td>10% (up to 5 assignments max)</td>
</tr>
<tr>
<td>Quizzes:</td>
<td>5% (Best 10 quizzes)</td>
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<tr>
<td>Labs:</td>
<td>5%</td>
</tr>
<tr>
<td>Midterm Examination:</td>
<td>20% (10% each. Midterm 1: Oct 7, Midterm 2: Nov 11)</td>
</tr>
<tr>
<td>Final Examination:</td>
<td>60% (Scheduled by University)</td>
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</table>
CU Learn will be used for the course web page. [http://culearn.carleton.ca](http://culearn.carleton.ca).

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.

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.

Please make a note of the following:

- Midterm exams may be administered outside of the class hours. Date, time and place will be announced in the class at least in two weeks advance.

- 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.

- Quizzes will be unannounced and will be given at any time during the class.

- 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](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):

– Week 1: Introductory concepts to digital signal processing
  Weeks 1-2: Discrete-time signals and sequences, unit impulse and unit step functions, properties of systems, filters described by difference equations and block diagrams

– Week 2-4: Impulse response, convolution, discrete-time linear convolution, stability in time

– Week 4,5: Spectrum representation, sampling, Shannon sampling theorem, Nyquist rate, aliasing

– Weeks 5-6: Frequency response, sinusoidal filtering, \( z \)-transform representation of sequences and filters

– Weeks 6-8: Transfer functions, pole-zero plots, \( z \)-domain \( \Leftrightarrow \) frequency domain relationship

– Week 9: Stability in \( z \)-domain, frequency response \( \Rightarrow \) impulse response

– Week 9-11: FIR filter design, ideal frequency selective filters, FIR filter transformations, FIR windowed filtering, linear phase filters, group delay

– Week 11-13: IIR filter design, Butterworth filters, analog filter transformations

– Week 13: IIR filter design by impulse invariance, bilinear transformation

– Week 14-15: Filter structures, Direct Form I and II structures, cascade structures, parallel structures, discrete Fourier series (DFS), discrete Fourier transform (DFT)

– Week 14-15: Discrete Fourier transform (DFT), signal analysis with the DFT, fast Fourier transform (FFT)

– Week 15: Introduction to time-frequency analysis issues and spectrograms

General Regulations

Attendance
Students are expected to attend all lectures and lab periods. The University requires students to have a conflict-free timetable. For more information, see the current Undergraduate Calendar, Academic Regulations of the University, Section 2.1.3, Course Selection and Registration and Section 2.1.7, Deregistration.

Health and Safety
Every student should have a copy of our Health and Safety Manual. A PDF copy of this manual is available online: [http://sce.carleton.ca/courses/health-and-safety.pdf](http://sce.carleton.ca/courses/health-and-safety.pdf).

Deferred Term Work
Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for missed term work are held responsible for immediately informing the instructor concerned and for making alternate arrangements with the instructor and in all cases this must occur no later than three (3.0) working days after the term work was due. The alternate arrangement must be made before the last day of classes in the term as published in the academic schedule. For more information, see the current Undergraduate Calendar, Academic Regulations of the University, Section 4.4, Deferred Term Work.

Appeal of Grades
The processes for dealing with questions or concerns regarding grades assigned during the term and final grades is described in the Undergraduate Calendar, Academic Regulations of the University, Section 3.3.4, Informal Appeal of Grade and Section 3.3.5 Formal Appeal of Grade.

Academic Integrity
Students should be aware of their obligations with regards to academic integrity. Please review the information about
academic integrity at [https://carleton.ca/registrar/academic-integrity/](https://carleton.ca/registrar/academic-integrity/). This site also contains a link to the complete Academic Integrity Policy that was approved by the University’s Senate.

### Plagiarism
Plagiarism (copying and handing in for credit someone else’s work) is a serious instructional offense that will not be tolerated.

### Academic Accommodation
You may need special arrangements to meet your academic obligations during the term. 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/](http://www.carleton.ca/equity/). For an accommodation request, the processes are as follows:

**Pregnancy/parental leave obligation:** Please contact your instructor 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 see [https://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf](https://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf).

**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/](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](http://www.carleton.ca/pmc) for the deadline to request accommodations for the formally-scheduled exam (if applicable).

**Survivors of Sexual Violence**
As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton’s Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: [https://carleton.ca/sexual-violence-support/](https://carleton.ca/sexual-violence-support/)

**Accommodation for Student Activities**
Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact your instructor 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, see [https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf](https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf).

**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 classroom without the express written consent of the course instructor. 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).

03/09/2019