Carleton University
Department of Systems and Computer Engineering
SYSC4505 Automatic Control Systems Fall 2019

Instructor:
Professor John Lambadaris, Room 4448 ME, 520-2600 x1974, Email: ioannis@sce.carleton.ca

Office Hours
Tue and Thu from 12:00-1:00pm i.e. immediately after class in room ME4448 or by appointment.

Calendar Information
Course Number: SYSC4505
Course Title: Automatic Control Systems
Includes: Experiential Learning Activity
http://calendar.carleton.ca/undergrad/courses/SYSC/

Class Schedule
Lectures: Tuesdays and Thursdays from 10:00 am to 11:30pm in room Southam Hall (SA) 517
Labs: Fridays (L1O) 8:30-11:30am and Thursday (L2E) 2:30-5:30pm. Lab location MC6070.

Course Web Page: The course web page will be found at: http://www.sce.carleton.ca/courses/sysc-4505/f19/, login:syse4505, password:iel2019

Teaching Assistants:
Afsoon Nejati Aghdam (email: afsoonnejatiaghdam@cmail.carleton.ca). TA's availability will appear in the web site.

Course Objectives:
The objective of the course is to teach the student the fundamental concepts of control system design and analysis. The course reviews linear systems theory and presents how linear systems theory is used to both specify performance requirements and how to design the control system. A number of electromechanical examples are used to illustrate control system analysis and design. The course focuses on the engineering design process to achieve required specifications.

Learning outcomes:
At the end of the course the students will
1. Understand control system diagrams, feedback loops and identify the processing of signals through block processors (such as amplifiers, integrators, differentiators etc.).
2. Be able to model control systems and create simulation experiments for analyzing their performance.
3. Be able to propose alternate designs and/or fine tune system parameters to achieve design goals.
4. Be able to design suitable control blocks (compensators) to be used in feedback loops and/or feed-forward configurations to achieve required performance characteristics.
5. Be able to compare and assess the performance of control systems and propose design procedures for optimizing their response
6. Be trained to use various simulation softwares (matlab, simulink, Analog Devices PLL modelling and analysis software etc.) to assess and design practical control systems (e.g. Phase Locked Loops).

Graduate Attributes
Graduate Attributes measured in this course are:

<table>
<thead>
<tr>
<th>Graduate Attribute</th>
<th>Learning outcome</th>
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</thead>
<tbody>
<tr>
<td>1.6.S-Knowledge Base: Discipline-specific concept: Discipline specific Signals and Systems SCE-3.</td>
<td>1</td>
</tr>
<tr>
<td>3.2 - Investigation: Design of experiment</td>
<td>1,2</td>
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<tr>
<td>3.3 - Investigation: Experimental procedure</td>
<td>3</td>
</tr>
<tr>
<td>4.4 - Design: Design solution(s)</td>
<td>3,4</td>
</tr>
<tr>
<td>4.5 - Design: Design implementation / task(s) definition</td>
<td>3,45</td>
</tr>
<tr>
<td>5.3 - Use of engineering tools: Tools for design, experimentation, simulation, visualization, and analysis</td>
<td>6</td>
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The Canadian Engineering Accreditation Board requires graduates of engineering programs to possess 12 attributes. Activities related to the learning outcomes listed are intended to develop students' competence in GA 1.6.S (a knowledge base in Signals and Systems as they apply to control theory for Electrical and Computer Engineering. Furthermore the abovementioned GAs 3.2-5.3 subset will be measured in the class by means of exam and/or lab questions. The learning outcomes from these GAs are intended to prepare students to undertake learning activities that develop competence in experimental procedures and measurements for the analysis/design of control systems along with the use of appropriate engineering tools.

Prerequisites:
MATH 2004 and (SYSC 3500 or 3600 or 3610). Students should have prior exposure to elementary transforms and differential equations.

Textbook:

Labs:
Labs are three hours on alternate weeks. We will have six (6) labs which include an introductory pre-lab and followed by five (5) labs with experiments. labs happen in odd (O) and even (E) . A detailed lab schedule will be included in the web site.

Grading Scheme:
- Assignments 10%
- Labs 15%
- Quiz 10%
- First in-class Exam 30%
- Second in-class Exam 35%
Exam Schedule
The first in class exam will take place on Thursday October 17, during the class time. The second in class exam will take place Thursday November 21, during the class time. The quiz will take place in class on Thursday December 5, it will last approx. 30-40 minutes.

Please try not to miss the exams/quiz. Re-scheduling an exam/quiz is logistically demanding not to mention that repeat exams will be significantly harder since the student will have more time to prepare.

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

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/. 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/ For an accommodation request, the processes are as follows:

- **Pregnancy or Religious 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

- **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 (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/.

- **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

**Copyright on Course Materials:** The materials created for this course (including the course outline and any slides, posted notes, labs, project, assignments, quizzes, exams and solutions) are intended for personal use and may not be reproduced or redistributed or posted on any web site without prior written permission from the author(s).
Week by Week outline

**Week 1** – Review of Laplace transforms, transfer functions, dynamics of linear systems and frequency response. (Appendix A and B, pp.159 – 182 & pp. 398 - 415)

**Week 2** - Review of modeling of dynamic systems. (Course Notes)

**Week 3** - Review of block diagram reduction and Op-Amp circuits (Course Notes and pp. 78-79)

**Week 4** – Steady state errors, system types, stability and Routh-Hurwitz criteria. (pp. 225-230 & pp. 212-218)

**Week 5** – The effect of feedback on system dynamics. Construction of root loci. Real axis segments, asymptotic angles, centroids of asymptotes. (pp. 269-308)

**Week 6** – Construction of root loci continued. Root locus design examples. (pp. 269-308)

**Week 7** – Time domain controller design. The PD and PID controllers (pp. 567-572)

**Week 8** – Frequency response analysis. Nyquist polar plots, The Nichols chart, gain margin and phase margin. (pp. 427-450 & pp. 477-485)

**Week 9** – Compensation design. Phase lead compensation in time domain and frequency domain. (pp. 311-320, 493-501)

**Week 10**- Phase lag compensator design in the time and frequency domain. (pp. 321-329 & pp. 502-511)

**Week 11**- Compensator design continued. Design of lead-lag compensation. (pp. 330-341 & pp. 511-517)

**Week 12**– State space techniques, matrix formulation. (pp. 648-652 & 660-667)

**Week 13**- Special topics (time permitting) and Review