

Carleton University

Department of Systems and Computer Engineering

Optimization for Engineering Applications—SYSC 5004

Winter 2022

Course Outline

Instructor Ramy Gohary, Office: ME4474, T. 613-520-2600 Ext. 5595, Email: gohary@sce.carleton.ca, Office hours: Monday and Wednesday 1:30–3:00.

Course Description This course is designed to prepare the student to perform research and write papers that revolve around optimizing nonlinear objective functions over constrained sets. The course focuses on identifying convex sets and convex functions, and on developing mathematical insight into their structure.

Calendar Description Introduction to algorithms and computer methods for optimizing complex engineering systems. Includes linear programming, networks, nonlinear programming, integer and mixed-integer programming, genetic algorithms and search methods, and dynamic programming. Emphasizes practical algorithms and computer methods for engineering applications.

Prerequisites This course requires strong background in linear algebra.

Students who have not satisfied the prerequisites for this course must either a) withdraw from the course, or b) submit an override request on Carleton Central, which will be considered on a case by case basis.

Course Objective To jump-start the student to perform research and to read and write mathematically-sound research papers in various areas of engineering, e.g., electrical, communications, mechanical and civil.

Learning Outcomes This course will teach the student to:

1. recognize and formulate convex optimization problems;
2. identify hidden convexity in some originally non-convex problems;
3. characterize optimal solutions and provide performance limits.

Website The course will use the SYSC 5004 Winter 2022 website on Brightspace. Course materials will be placed on the website for student personal use, and students are responsible for checking the website frequently. Student, TA or professor materials created for this course (including presentations and posted notes, labs, case studies, assignments and exams) remain the intellectual property of the author(s). They are intended for personal use and may not be reproduced or redistributed without prior written consent of the author(s).

Textbooks

- “Convex Optimization”, by Stephen Boyd and Lieven Vandenberghe, available at <https://web.stanford.edu/~boyd/cvxbook/>. Lecture slides available at: <https://web.stanford.edu/~boyd/cvxbook/>.
- Nonlinear Programming, by Dimitri P. Bertsekas.

Attendance Lectures will be in-person unless stipulated otherwise by the university. Students are expected to attend all lectures. The Faculty of Engineering and Design requires its students to have a conflict-free timetable, so requests to accommodate missed exams, assignment due dates, etc., because of conflicts with other courses, jobs or vacation plans will not be considered.

Study Questions Study questions from the textbook will be posted on Brightspace, but will not be collected and graded.

Quizzes Students will be expected to participate in in-class discussions and to write short quizzes. Quiz times will be announced beforehand as the course progresses.

Midterm Exam There will be one midterm exam. Exact time and location will be announced in class.

Final Exam There will be one final exam. The final examination is for evaluation purposes only and will not be returned to students. You will be able to make arrangements with the instructor or with the department office to see your marked final examination after the final grades have been made available.

Students who miss the final exam may be granted permission to write a deferred examination (see the Graduate Calendar for regulations on deferred exams).

Grading Scheme

- Quizzes and Attendance: 30%
- Midterm Exam: 25%
- Final exam: 45%

Medical Certificates A medical certificate must adhere to the format required by the Registrar. The format is available as a PDF form through the Registrar's website <http://www.carleton.ca/registrar/forms>. All medical certificates must be presented immediately upon return from the illness; they will not be accepted after the fact.

Lecture Content The following themes are interwoven in the lectures throughout the course.

- Week 1: Review of linear algebra and vector spaces.
- Week 2: Review of derivatives.
- Week 3: Norms.
- Week 4: Convex sets
- Week 5: Separating and supporting hyperplanes.
- Week 6: Convex functions.
- Week 7: Quasiconvex functions.
- Week 8: Convex optimization problems.
- Week 9: Geometric programming.
- Week 10: The Lagrange dual function.
- Week 11: Optimality conditions.
- Week 12: Unconstrained minimization.
- Week 13: Equality constrained minimization.

General Regulations

Student Responsibility:

It is the student's responsibility to remain informed of all rules, regulations and procedures required by their program and by the Faculty of Graduate and Postdoctoral Affairs. Ignorance of regulations will not be accepted as a justification for waiving such regulations and procedures.

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.

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 *Graduate Calendar, Academic Regulations of the University, Section 9.3*.

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 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 see <https://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf>.

Religious 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 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). After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult <https://carleton.ca/pmc/students/dates-and-deadlines/> 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).

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>.

Students from the University of Ottawa: You can request to have access to cuLearn: please see <http://gradstudents.carleton.ca/forms-policies/>.