

CO 367: Nonlinear Optimization

Fall 2018 Outline

November 29, 2018

Objective. CO 367 covers both the theoretical and computational aspects of continuous optimization, as well as a few concrete applications. The objective of the course is to give an overview of the various algorithmic tools available for different types of continuous optimization problems.

Textbook. There is no required textbook. The following textbooks are suggested readings and contain some of the material covered in the course:

- *Numerical optimization*, J. Nocedal, S. J. Wright. Springer, 1999.
- *Convex optimization*, S. Boyd, L. Vandenberghe, 2009.

The latter book is freely available online.

Course website. math.uwaterloo.ca/~lpoirrier/.

We will also use UWaterloo's LEARN website (learn.uwaterloo.ca) as an on-line gradebook so you can keep track of all of your grades in the course.

Lectures. PHY 145, Mon-Wed-Fri 13:30 – 14:20

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Assignments and exams. There will be 3 assignments. The questions and due date will be communicated at least one week in advance. No late submissions will be accepted, regardless of circumstances.

There will be two midterms and one final exam. All are closed-book, no calculators. The first midterm will be held on Friday, October 12th. The second midterm will be held on Monday, November 12th. Both will take place during regular class time (1:30pm – 2:20pm) in the regular classroom (PHY 145). The final exam will be comprehensive and will be held (tentatively) Friday, December 14, 2018, 12:30pm – 3:00pm, location TBD.

Missed exams will count as 0 unless suitable medical documentation is provided. There will not be any make-up exams.

Final grade will be homeworks 25%, midterms 25%, final 50%.

Schedule. This is a *tentative* schedule with topics that we plan to cover. The schedule will be adjusted as the term progresses, and it will be updated here accordingly.

Week	Dates	Topics
0	September 7	Types of optimization problems, minimizers, C^k -smoothness, ∇f , $\nabla^2 f$
1	September 10, 12, 14	Ch 1 – Linear algebra: matrix and vector norms, eigenvalues
2	September 17, 19, 21	Ch 1 – Linear algebra: psd. matrices, Ch 2 – Convexity
3	September 24, 26, 28	Ch 2 – Convexity, Ch 3 – Optimality conditions
4	October 1, 3, 5	Ch 3 – Optimality conditions, Ch 4 – Unconstrained quadratic optimization
5	October 12	Midterm 1
6	October 15, 17, 19	Ch 5 – Least squares problems
7	October 22, 24, 26	Ch 6 – Descent algorithms
8	October 29, 31, November 2	Ch 7 – Trust region methods
9	November 5, 7, 9	Ch 8 – Optimality conditions for constrained optimization
10	November 12, 14, 16	Midterm 2, Ch 8 – Optimality conditions for constrained optimization
11	November 19, 21, 23	Ch 9 – Algorithms for constrained optimization
12	November 26, 28, 30	Ch 10 – Nonlinear optimization for neural networks
13	December 3	Review

Book chapters The material of the course is what we see in class. Some of it is taken out of the two reference books, but beware that some of the topics are discussed with a different perspective, and not all of the material is covered in the books. However, if you are interested in additional material for the course, here is a list for each chapter. NW stands for Nocedal/Wright, BV for Boyd/Vandenberghe.

Ch 1 – Linear algebra: /.

Ch 2 – Convexity: /.

Ch 3 – Optimality conditions: Necessary and sufficient conditions: NW 2.1 or BV 4.2.2. Coercivity: /.

Ch 4 – Unconstrained quadratic optimization: /.

Ch 5 – Least squares problems: NW 10.1, 10.2 and BV 6.2.

Ch 6 – Descent algorithms: NW 3 and BV 9.

Ch 7 – Trust region methods: NW 4.

Ch 8 – Optimality conditions for constrained optimization: NW 12.

Ch 9 – Algorithms for constrained optimization: BV 11 and NW 14-17 and 19.

Ch 10 – Nonlinear optimization for neural networks: C. Higham, D. Higham. “Deep Learning: An Introduction for Applied Mathematicians.” arXiv:1801.05894.

Discipline, appeals, accessibility

Academic Integrity. In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. For more information, check <http://www.uwaterloo.ca/academicintegrity>.

Grievance. A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4, <http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm>. When in doubt please be certain to contact the department's administrative assistant who will provide further assistance.

Discipline. A student is expected to know what constitutes academic integrity to avoid committing academic offenses and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offense, or who needs help in learning how to avoid offenses (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course professor, academic advisor, or the undergraduate associate dean. For information on categories of offenses and types of penalties, students should refer to Policy 71, Student Discipline, <http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm>. For typical penalties check Guidelines for the Assessment of Penalties, <http://www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm>.

Appeals. A decision made or penalty imposed under Policy 70, Student Petitions and Grievances (other than a petition) or Policy 71, Student Discipline may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72, Student Appeals, <http://www.adm.uwaterloo.ca/infosec/Policies/policy72.htm>.

Students with disabilities. The AccessAbility Services, located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with them at the beginning of each academic term.