Department of Mathematics & Statistics
Concordia University

MATH 494 (MAST 680//MAST 837), Sec. C
Topics in Pure & Applied Mathematics
Winter 2021

Preface: **Due to exceptional circumstances, this course will be taught and all assessments will be done completely ONLINE**.

Instructor: Dr. S. Brugiapaglia
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Lectures: Tuesdays, 14:45-17:30, ONLINE.
Lectures will be given in live Zoom meetings, accessible through the course Moodle website, recorded and posted for later viewing.

Office Hours: Thursdays, 9:30-11:00 AM, ONLINE.
Individual Zoom meetings at different times can be scheduled by appointment.

Description: Sparsity is a key principle in real-world applications such as signal compression, statistical data analysis, machine learning, inverse problems, and scientific computing. Compressed sensing is the art of reconstructing sparse signals from a minimal number of linear measurements and using efficient recovery techniques.

This course is an introduction to the mathematical foundations of sparse recovery and compressed sensing. It will provide students with the essential tools needed to begin their study and research journey in these fields.

Topics covered include:
- Sparsity and compressibility
- l1 minimization
- Sparse recovery via iterative and greedy algorithms
- Uncertainty principles
- Null space and restricted isometry properties
- Random Gaussian sampling
- Random sampling from bounded orthonormal systems
- Applications in signal processing and computational mathematics

Textbook: *A Mathematical Introduction to Compressive Sensing* by Simon Foucart and Holger Rauhut. Springer, 2013.
Available online through the Concordia library website:
https://link-springer-com.lib-ezproxy.concordia.ca/book/10.1007%2F978-0-8176-4948-7

Other References: *Sparse and Redundant Representations* by Michael Elad, Springer, 2010.
Available online through the Concordia library website:
https://link-springer-com.lib-ezproxy.concordia.ca/book/10.1007%2F978-1-4419-7011-4

Compressive Imaging: Structure, Sampling, Learning by B. Adcock and A. C. Hansen, Cambdridge University Press, to appear.
Selected parts of the book are available online at:
https://www.compressiveimagingbook.com/

Statistical Learning with Sparsity: The Lasso and Generalizations by Trevor Hastie, Robert Tibshirani, and Martin Wainwright Taylor and Francis Group, 2015.
Available online at:
https://web.stanford.edu/~hastie/StatLearnSparsity/

Pre-requisites: Good knowledge of linear algebra, analysis, and introductory probability. Basic programming skills (ideally, but not necessarily, with Matlab/Octave). Previous exposure to numerical analysis can be useful.

Assignments: Homework will be assigned approximately every other week, on Moodle, via Assignments, and submitted on Moodle. Assignments might contain both theoretical and computational problems. Matlab/Octave will be the programming language used in class, but students can use other languages.

Exams: There will be no examinations. Instead, students will be required to complete an independent project on a topic approved by the instructor and based on recent research papers in the field. The project will be presented in the form of an oral presentation via Zoom and submitted as a written report. The focus of the project can be theoretical or computational, based on student's background and interests.

Evaluation: Homework assignments: 30%
Project (oral presentation + written report): 70%

PhD students will be required to do additional work (to be determined) compared with their MA/MSc classmates.

If the grading scheme for this course includes graded assignments, a reasonable and representative subset of each assignment may be graded. Students will not be told in advance which subset of the assigned problems will be marked and should therefore attempt all assigned problems.

Communication: Communication between the students and the instructor will take place online via Zoom meetings, Moodle announcements, email messages, and Microsoft Teams. Students are responsible for reading and taking note of all electronic communication from the instructor and the University.

Academic Integrity and the Academic Code of Conduct
This course is governed by Concordia University's policies on Academic Integrity and the Academic Code of Conduct as set forth in the Undergraduate Calendar and the Graduate Calendar. Students are expected to familiarize themselves with these policies and conduct themselves accordingly. "Concordia University has several resources available to students to better understand and uphold academic integrity. Concordia's website on academic integrity can be found at the following address, which also includes links to each Faculty and the School of Graduate Studies: concordia.ca/students/academic-integrity." *[Undergraduate Calendar, Sec 17.10.2]*

Behaviour
All individuals participating in courses are expected to be professional and constructive throughout the course, including in their communications.

Concordia students are subject to the Code of Rights and Responsibilities which applies both when students are physically and virtually engaged in any University activity, including classes, seminars, meetings, etc. Students engaged in University activities must respect this Code when engaging with any members of the Concordia community, including faculty, staff, and students, whether such interactions are verbal or in writing, face to face or online/virtual. Failing to comply with the Code may result in charges and sanctions, as outlined in the Code.

Intellectual Property
Content belonging to instructors shared in online courses, including, but not limited to, online lectures, course notes, and video recordings of classes remain the intellectual property of the faculty member. It may not be distributed, published or broadcast, in whole or in part, without the express permission of the faculty member. Students are also forbidden to use their own means of recording any elements of an online class or lecture without express permission of the instructor. Any unauthorized sharing of course content may constitute a breach of the Academic Code of Conduct and/or the Code of Rights and Responsibilities. As specified in the Policy on Intellectual Property, the University does not claim any ownership of or interest in any student IP. All university members retain copyright over their work.

Extraordinary circumstances
In the event of extraordinary circumstances and pursuant to the Academic Regulations the University may modify the delivery, content, structure, forum, location and/or evaluation scheme. In the event of such extraordinary circumstances, students will be informed of the change.