

# Math 597 Fall 2019

## Topics in Applied Math: Mathematics of Machine Learning

**Instructor:** Adam Oberman, [adam.oberman@mcgill.ca](mailto:adam.oberman@mcgill.ca), Burnside 1106

Office hours: TBD

**Teaching Assistant:** TBD

**Schedule:** two 90 minute lectures per week. Tuesday & Thursday 9:35-10:55 in BURN 708

**Grading:** Homework 100%

**Recommended background:**

- Undergraduate Probability/Statistics (central limit theorem)
- Advanced calculus (gradients, directional derivatives)
- Undergraduate analysis and comfort with proofs.
- Previous machine learning course not required.

**Assignments and final:** There will be 5 assignments given approximately every two weeks. The course is primarily theoretical, although will be some simple programming assignments.

**Course Notes:** We will follow notes provided, as well as chapters from “Foundations of Machine Learning” by M. Mohri and “Understanding Machine Learning” by S. Shalev-Shwartz

**Course description:** This is a graduate level topics course on mathematical foundations of machine learning.

### Topics:

- Review
  - Calculus and Vector Calculus
  - Statistics and Probability
  - Analysis: norms for vectors and function, limits and convergence
- Optimization in machine learning
  - Gradient and Stochastic Gradient descent
  - Adversarial Attacks and constrained optimization
- Support Vector Machines
  - Reproducing Kernel Hilbert Spaces
  - Fourier Space
- Regularization
  - Machine Learning Regularization
  - Mathematical Regularization in inverse problems in image processing
- Generalization Theory
  - Rademacher complexity and Deep Neural Networks
  - Generalization via stability
  - Generalization via robustness and regularization
- Adversarial Robustness
- Losses for classification