

# MATH 9880 Selected Topics in Operations Research: Machine Learning and Optimization

Fall 2019

**Instructor:** Dr. Yuyuan Ouyang ([yuyuano@clemsun.edu](mailto:yuyuano@clemsun.edu)) and  
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**Class Times:** TR 3:30 pm – 4:45pm

**Office:** Martin O-207

**Classroom:** Martin M-302

**Office Phone:** (864) 656-5225

**Tentative office Hours:** TR 2:30 pm-3:30 pm

**Prerequisites:** MATH 2060 (Calculus III) and MATH 3110 (Linear Algebra). Knowledge of a programming language (e.g., Python, R, FORTRAN, C, MATLAB, etc.) is expected. Background on Machine Learning I (MATH 9810 Spring 2019) is strongly recommended. Background on statistics and nonlinear optimization, e.g., MATH 8050 (Data Analysis), MATH 8100 (Mathematical Programming) and MATH 8110 (Nonlinear programming) is also recommended.

**Objectives:** This course will introduce the basics on machine learning models and related optimization algorithms.

**Course materials:** This course will be loosely based on the contents in the following books:

- Hastie, T., Tibshirani, R., and Friedman, J. The Elements of Statistical Learning: Data mining, Inference, and Prediction. Copyright 2009, Springer.
- James, G., Witten, D., Hastie, T., and Tibshirani, R. An Introduction to Statistical Learning: with Applications in R. Copyright 2014, Springer.

Other course materials based on a selection of recent research articles and monographs will also be used. Tentative topics to be covered are (not necessarily following the listed order):

- Kernel smoothing methods, radial basis functions
- Model assessment and selection: bias-variance tradeoff, VC dimension, cross-validation
- Model inference and averaging, bootstrap and MLE, EM algorithm, MCMC
- Additive models and trees, PRIM, MARS
- Neural networks, CNN, ResNet, over-parameterization
- SVMs and flexible discriminants
- Unsupervised learning, cluster analysis, nonnegative matrix factorization, PCA, ICA
- Stochastic and randomized first-order methods, SGD, variance reduction, momentum

**Learning outcomes:** Upon successful completion of the course, students should be able to:

- Formulate machine learning models to practical problems
- Understand the performance of optimization algorithms for machine learning
- Write, run, and diagnose machine learning models and optimization algorithms
- Implement machine learning computer programs to solving real world problems

**Course evaluation:** Homeworks and projects based on course materials will be given throughout the semester. Each student is required to give several presentations on selected topics throughout the semester. A comprehensive project, in which students need to choose the topic themselves, perform necessary theoretical analysis and algorithm implementation, and write a formal technical report, will be due at the end of the semester. Late homework and project submissions will not be accepted.

	Homeworks	Presentations	Mid-term Projects	Final Project
Points	20	20	20	40

**Class cancellation:** The class will be dismissed in the case when the instructor or the invited lecturer is not present within 15 minutes of the scheduled start time.

**Final grade:**

Score	Over 85	70–84	60–69	Below 60
Grade	A	B	C	F

**Academic continuity plan:** Clemson has developed an academic continuity plan for academic operations. Should University administration officially determine that the physical classroom facility is not available, class will be conducted in a virtual (online) format. The University issues official disruption notifications through email/www/test notification/social media. When notified, use one of the following links to navigate for Clemson Canvas, where you will find important information about how we will conduct class:

- Primary access link: [www.clemson.edu/canvas](http://www.clemson.edu/canvas)
- Secondary access link, if needed: <https://clemson.instructure.com/>
- You can also use the Canvas Student App.

Our activities for teaching and learning will occur through our Canvas course. This includes assignments, quizzes, and/or student group collaboration.

**Accommodation:** Clemson University values the diversity of our student body as a strength and a critical component of our dynamic community. Students require accommodations should let the professor know, and make an appointment to meet with a staff member in Student Accessibility Services as soon as possible. You can make an appointment by calling 864-656-6848, by emailing [studentaccess@lists.clemson.edu](mailto:studentaccess@lists.clemson.edu), or by visiting Suite 239 in the Academic Success Center building. Appointments are strongly encouraged – drop-ins will be seen if at all possible, but there could be a significant wait due to scheduled appointments. Students who receive Academic Access Letters are strongly encouraged to request, obtain and present these to their professors as early in the semester as possible so that accommodations can be made in a timely manner. It is the student's responsibility to follow this process each semester. You can access further information here: <http://www.clemson.edu/campus-life/campus-services/sds/>.

**Clemson University Title IX (Sexual Harassment) statement:** Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran's status, genetic information or protected activity (e.g., opposition to prohibited

discrimination or participation in any complaint process, etc.) in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972. This policy is located at

<http://www.clemson.edu/campus-life/campus-services/access/title-ix/>.

Mr. Jerry Knighton is the Clemson University Title IX Coordinator. He also is the Director of Access and Equity. His office is located at 110 Holtzendorff Hall, 864.656.3184 (voice) or 864.656.0899 (TDD).

**Academic integrity statement:** As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a "high seminary of learning." Fundamental to this vision is a mutual commitment to truthfulness, honor and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating or stealing in any form.