Course Change Request

New Course Proposal

Date Submitted: 04/25/21 4:40 pm

Viewing: MATH 662 : Mathematics of Machine Learning and Industrial Applications I

Last edit: 04/29/21 7:55 am

Changes proposed by: csausvil

In Workflow

1. **MATH Chair**
2. **SC Curriculum Committee**
3. SC Associate Dean
4. Assoc Provost-Graduate
5. Registrar-Courses
6. Banner

Approval Path

1. 04/25/21 10:36 pm David Walnut (dwalnut): Approved for MATH Chair

Are you completing this form on someone else's behalf?

No

Effective Term: Fall 2021

Subject Code: MATH - Mathematics

Course Number: 662

Bundled Courses:

Is this course replacing another course? No

Equivalent Courses:

Catalog Title: Mathematics of Machine Learning and Industrial Applications I

Banner Title: Math of ML and Indust App I

Will section titles vary by semester? No

Credits: 2

Schedule Type: Lecture

Hours of Lecture or Seminar per week: 2

Repeatable:

May be only taken once for credit, limited to 3 attempts (N3)

Max Allowable Credits: 6

Default Grade Mode: Graduate Regular

Recommended Prerequisite(s):

CS 112 or equivalent.

Recommended Corequisite(s):

Required Prerequisite(s) / Corequisite(s) (Updates only):

Registrar's Office Use Only - Required Prerequisite(s)/Corequisite(s):

And/Or	(	Course/Test Code	Min Grade/Score	Academic Level	)	Concurrency?

Registration Restrictions (Updates only):

Registrar's Office Use Only - Registration Restrictions:

Field(s) of Study:

Class(es):

Level(s):

Degree(s):

School(s):

Catalog Description:

Basic mathematical and probabilistic models and derivations for linear and logistic regression including regularization and application to SVM and PCA. Mathematical and numerical aspects of classical learning methods such as Kernel methods andgradient based methods including neural networks. Incorporates modern tools such as Python, shell tools, and version control. Includes industrial scale applications in satellite imagery, physics, biology and engineering. Computational and analytic assignments are given.

Justification:

This course is being created to meet the ever changing needs of the department. Data Science is a growing domain of study that spans many fields, including Mathematics. This course will allow our students to better prepare for industry, research or acadmic positions where a solid understanding of the mathematics of data science is desired. It will also help support the university's initiative regarding the Tech Talent Investment Program (TTIP) created by the Commonwealth of Virginia.

Does this course cover material which crosses into another department? Yes

Impacted Departments:

Department
CDS - Computational & Data Sciences
CS - Computer Science
STAT - Statistics

Learning Outcomes:

Stated in attached syllabus.

Attach Syllabus

math662_rev4282021.pdf

Additional Attachments

Staffing:

H. Antil, M. Emelianenko, T. Berry, T. Sauer, E. Sander, I. Griva, C. Rautenberg, P. Seshaiyer

Relationship to Existing Programs:

This course will supplement our current graduate offerings for our Master and PhD students.

Relationship to Existing Courses:

We have successfully run previous special topics courses that cover much of the content of this course. We would like to make these topics into a permanent course for our graduate students and industry partners.

Additional Comments:

Reviewer Comments

Key: 17203

Math 662 : Mathematics of Machine Learning with Industrial Applications - I

- **Suggested Prerequisites:** CS 112 or permission of the instructor.
- **Office:** TBA
- **Office hours:** TBA
- **Course Website:** TBA
- **Possible Textbooks:**
  George Lan, "First-order and Stochastic Optimization Methods for Machine Learning"
  Gilbert Strang, "Linear Algebra and Learning from Data"
  Ian Goodfellow, Yoshua Bengio and Aaron Courville, "Deep Learning"
- **Classroom:** TBA

Overview: The course provides mathematical foundation of deep learning and hands-on experience on industry applications. Special emphasis is given to the basics of optimization algorithms and probability with applications to machine learning. These abstract concepts are widely applicable. The theoretical concepts will lead to new research directions and the computational aspects will lead to direct applications of the existing and new concepts to industrial applications. Collaborations with industries will provide job/internship opportunities to GMU students. **This graduate course will include additional assignments and mathematical proofs (not needed for Math 462) that require a higher degree of mathematical maturity.**

Learning Outcomes: Students will gain a deep understanding of the topics listed below and mathematical connections between them. Graded assignments will be testing students' ability to produce rigorous mathematical proofs, synthesize methods and develop codes using computational and analytical methods discussed in class. Independent reading and open ended exploration projects will be given. Students will be expected to develop their own computational routines to explore the numerical performance and limitations of specific algorithms.

Tentative schedule:

(1) WEEKS 1-1.5: *Stochastic Optimization:* Linear and logistic regression, SVMs, Regularization, Lasso, and Ridge Regression, Gradient based methods, Stochastic approximations, Stochastic descent methods, Gradient and splitting methods, Matrix sketching, Basics of Fourier analysis, Graph Laplacian, Basics of probability.

(2) WEEK 1.5-3: *Tools and languages:* Python, Code editors and environments, Shell tools and scripting, Version control.

(3) WEEK 4: *Classical Unsupervised/Supervised learning:* K-means clustering, Mixture models and expectation maximization, Kernel density estimation.

(4) WEEKS 5-6: *Neural networks:* Brief history, Universal approximation theorem, Types of NN (CNN, RNN, LSTM, Autoencoder, GAN, PINNs), Architectures: forward, backward propagation, Activation functions (ReLU, Sigmoid, Softmax etc.), Single layer neural networks.

(5) WEEK 7-7.5: *Applications:* Industrial scale applications of the concepts learnt during the class to problems coming from Satellite imagery, Physics, Biology and Engineering.

Grading: Grades will be based on

- Homework exercises
- Computational projects

- Mathematical proofs

Tentative grading scale:

- Homework assignments and group projects: 60%
- Take-home final exam: 30%
- Class participation: 10%

Academic Policies: Mason is an Honor Code university; please see the Office for Academic Integrity for a full description of the code and the honor committee process. With collaborative work, names of all the participants should appear on the work. Collaborative projects may be divided up so that individual group members complete portions of the whole, provided that group members take sufficient steps to ensure that the pieces conceptually fit together in the end product. Other projects are designed to be undertaken independently. In the latter case, you may discuss your ideas with others and conference with peers on drafts of the work; however, it is not appropriate to give your paper to someone else to revise. You are responsible for making certain that there is no question that the work you hand in is your own. If only your name appears on an assignment, your professor has the right to expect that you have done the work yourself, fully and independently.

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In this class we welcome and value individuals and their differences including race, economic status, gender expression and identity, sex, sexual orientation, ethnicity, national origin, first language, religion, age, and disability.