Course Change Request

New Course Proposal

Date Submitted: 04/25/21 4:39 pm

Viewing: MATH 462 : Mathematics of Machine Learning and Industrial Applications I

Last edit: 04/29/21 7:53 am

Changes proposed by: csausvil

In Workflow

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

Approval Path

1. 04/25/21 10:35 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: 462

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: Undergraduate Regular

Recommended Prerequisite(s):

Recommended Corequisite(s):

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

Math 203 and Math 213 and CS 112

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 optimization and probability theory in the context of classical learning and gradient based methods including neural networks. Incorporates modern tools such as Python, shell tools, and version control. Includes industrial 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 either a job or a graduate program 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 on attached syllabus.

Attach Syllabus
math462_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 concentrations in Applied Mathematics and Mathematical Statistics as well as our new concetration in Data Science which is under development.

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 more accessible to our undergradute students.

Additional Comments:

Reviewer Comments

Key: 17199

Math 462 : Mathematics of Machine Learning with Industrial Applications - I

- **Required Prerequisites:** Math 203, Math 213, 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.

Learning Outcomes: Students will gain a mathematical introduction to the topics listed below. Graded assignments will be testing students' ability to grasp such main mathematical ideas and apply them in specific settings using analytical and computational methods discussed in class. Students will be expected to use the computational routines provided in class to test performance 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

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.